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The Ra's al-Hamra 5 and Daba al Bayah graveyards (Sultanate of Oman): demographic, paleopathological, and mortuary practice assessments

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Summary

This Ph.D. dissertation offers an in-depth bioarchaeological study of the skeletal remains of the Omani sites of Ra's al-Harma 5 (Neolithic period) and Daba al Bayah (Late Bronze Age-PIR). From the site of Ra’s al-Hamra 5 (RH5), skeletal remains from the Area 43 were assessed. Two separate tombs were studied from the funerary complex of Daba al Bayah, the Large Collective Grave 1 (LCG-1) and the Large Collective Grave 2 (LCG-2). The main osteological aims of this study were the reconstruction of the paleodemographic profile, the state of health and lifestyle of the ancient communities. Additional goal of the study was to assess the funerary practices adopted at the sites. Osteological, paleopathological, and histological analyzes were used together with archaeological and taphonomic observations. The interdisciplinary approach made it possible to reconstruct aspects such as mortality and life expectancy, the state of health related to activities in life and diet, the action of fire and the diagenetic changes on human skeletal remains. The funerary contexts of both sites were also studied for a re-examination the taphonomic terminologies used in archaeological contexts and, specifically, the terms relating to "collective burials".

- *Area 43 of Ra’s al-Hamra 5*

Area 43 of the RH5 graveyard was first excavated between 1981 and 1985, it immediately appeared different when compared to the rest of the RH5 graveyard. The RH5 graveyard was characterized by primary and secondary depositions. Area 43, on the other hand, appeared as a vast area of dispersion of partially burned, fragmented, and commingled human remains. Several hypotheses were considered to explain this difference, including catastrophic events (epidemics, conflicts between groups), the presence of different groups or differences within the same group, or movements of skeletal remains related to reorganization of spaces. The anthropological analyzes conducted on the skeletal remains allowed to determine the minimum number of individuals (MNI) within Area 43. The determined MNI is 77, specifically 2 fetuses, 29 sub-adults and 46 adults. Where possible, the sex of adult individuals was determined: 20 individuals are male or probably male, 19 individuals are female or probably female. The sex of seven individuals could not be determined.

Despite the state of conservation of the remains, various skeletal lesions were documented such as metabolic lesions, degenerative joint disease, arthrosis, infections, periostitis, antemortem tooth loss. The frequency of lesions was calculated on the number of skeletal elements analyzed

and not by individuals. Oral pathologies were also calculated on the number of teeth and alveoli analyzed. In general, from a paleopathological point of view, no differences were found between adults and sub-adults regarding the frequency of skeletal lesions, with the only exception of periostitis which appears in significantly higher percentages in adults. This finding suggests greater survival from these lesions in adults than in sub-adults. In addition, more than 93% of sub-adult burials in Area 43 have no skeletal lesions. Hence, the health problems for the younger individuals of this community appear to be acute in origin.

The demographic and paleopathological comparison between the data relating to the remains from Area 43 and those from the burials of the rest of the graveyard did not show any differences that could explain the formation of this area as the result of a catastrophic event. The absence of clear differences between Area 43 and the rest of the RH5 graveyard both in demography and paleopathology allowed to combine the data to make comparisons with other contemporary populations. Data related to age assessment from all the individuals excavated within the RH5 graveyard were used to reconstruct life expectancy and mortality rates. Considering the underestimation of sub-adults between 0-4 years, the formulas proposed by Bocquet and Masset (1977) were used. A Juvenility Index (JI) of 0.2259 was calculated. Based on the JI the life expectancy at birth ($e_0 = 22.07 \pm 1.503$), the mortality rates in the first year of life (${}_1q_0 = 0.293 \pm 0.016$) and in the first 5 years of life (${}_5q_0 = 0.470 \pm 0.041$) were calculated.

The life expectancy value and mortality rates were compared with data from the Neolithic site of Jebel al-Buhais 18 (BHS18). In the BHS18 site too an underrepresentation of sub-adults between 0-4 years of age was highlighted. The application of the formulas proposed by Bocquet and Masset (1977) to the BHS18 site allow to reconstruct a 10-years difference in life expectancy at birth compared to the RH5 graveyard. This difference reflects the difference in percentages of death among the two communities. In Jebel al-Buhais 18 the frequency of adult death between 20 and 34 years of age is higher than RH5. On the contrary, in the RH5 graveyard the number of sub-adults' death between 5 and 14 years of age is higher compared to BHS18. This data might only reflect numerical variations or can be related to an increase in mortality among sub-adults due to the high frequency of spina bifida found in the RH5 site.

Paleopathological data from the RH5 site were also compared with those from other Neolithic sites, distinguishing the different subsistence economies (fisherman-gatherer communities, pastoral communities, agricultural communities). Comparison of oral defects between the RH5 skeletal remains and those of other Omani Neolithic fisherman-gatherer communities highlights similar patterns. None of the teeth on the sites have caries, reflecting a low-sugar and low-carbohydrate diet. The comparison with paleopathological data from the pastoral site of Jebel al-Buhais 18 does not show any differences in oral pathologies. This reflects types of low-sugar diets. Compared to RH5, however, the Jebel al-Buhais 18 site shows significantly higher rates of degenerative pathologies of the spine and joints of the ankle and elbow. This difference between the two communities could be associated with physical stress associated with herding activities and traveling on uneven land to which the individuals from Jebel al-Buhais 18 were subjected. The comparison of paleopathological data from RH5 with those from different Neolithic agricultural communities highlights significantly higher rates of skeletal lesions in agricultural communities. Dental and skeletal lesion frequencies suggest that fishing and gathering as a lifestyle caused individuals of RH5 lower frequencies of chronic conditions than those observed among Neolithic farmers.

The interdisciplinary analysis conducted on the human remains from Area 43 allowed also to reconstruct various funerary practices used by this community. Histological analyzes conducted on rib samples from Area 43 highlighted different percentages of bioerosion in both burned and unburned samples. Considering that the action of fire reduces and interrupts the action of microorganisms that feed on the organic component of the bone, the presence of high percentages of bioerosion even in burnt samples allowed to hypothesize periods of exposure of variable duration before the burning of some of the remains from Area 43. This data confirms what is documented by the observation of the surface of the skeletal remains. Of the total skeletal remains analyzed (917), 20.5% show signs of surface alteration related to the exposure of fresh bones in the open air. Based on anthropological and histological data, it was therefore possible to reconstruct a variety of funerary practices. Some remains were exposed to the open air before deposition although the absence of marks related to animal activity (rodents and carnivores) suggests that the exposition happened in places protected from animal attacks. Other remains were immediately buried. Furthermore, some individuals were burned before deposition. The almost total absence of traces of manipulation allows to exclude that the remains in secondary deposition were previously de-fleshed. Additionally, the study of the archaeological data combined with the analysis of the remains with known location within the excavation area allowed to identify specific sectors of Area 43 in which burnt human remains were found.

In general, anthropological and archaeological data allowed to reconstruct that the formation of Area 43 is not the result of a single event but of a series of actions and practices that happened in the area and contributed to the fragmented and highly commingled state of the human remains.

- *The Daba al Bayah funerary complex*

The second site analyzed was the funerary complex of Daba al Bayah. The complex, still under excavation, currently consists of two large rectangular tombs containing the remains of multiple individuals. The two tombs are dated differently, based on grave goods found. The LCG-1 tomb is dated between the Late Bronze Age and the Early Iron Age. The LCG-2 tomb was used for a longer period from the beginning of the Iron Age to the Pre-Islamic period. The pandemic situation connected to Covid19 allowed to conduct only a preliminary analysis of the human skeletal remains from the burial site.

From the LCG-1 tomb, mandibles and maxillary bones were analyzed. The analysis allowed to determine a minimum number of adult individuals of 79 and a minimum number of sub-adult individuals of 15. The skeletal elements were analyzed for oral pathologies (periapical lesions and antemortem tooth loss). Frequencies were determined based on the number of alveoli available for the study. The comparison between maxillary and mandibular alveoli revealed higher percentages of antemortem tooth loss on almost all lower sockets. Additionally, several permanent teeth (81) were analyzed for dental caries. Twelve teeth exhibit at least one caries each. The paleopathological data collected were compared with those from other Bronze Age sites. The comparison documented similar frequencies of oral defects between Daba LCG-1 and the sites of Bahrain and Shimal, reflecting a diet rich in sugars and carbohydrates, typical of the agricultural subsistence of the Arabian Gulf. Sub-adult skeletal elements and deciduous teeth were also analyzed. Of the deciduous teeth, 5 show caries. Antemortem tooth loss are found on the maxillary bones and mandibles of two sub-adult individuals (15-18 years). These data suggest a high-sugar diet, which involved tooth decay and tooth loss at a young age.

From the LCG-2 tomb of Daba the human remains from primary depositions excavated (73 individuals) were analyzed. Dividing the individuals by general age groupings, 4 individuals are fetal/perinatal individuals, 26 are infants (0-3 years of age), 5 are children (4-8 years), 2 are juvenile (9-12 years), 2 are adolescents (13-19 years) and the remaining 34 individuals are adults. Of the adults, 12 are male or probably male and 19 are female or probably female. It was not possible to determine the sex of 3 adult individuals. Given the continuity of use of the tomb, the remains were then chronologically divided into the three periods of use (Early Iron Age, Late Iron Age and PIR period). The paucity of the sample datable to the PIR period meant that the study focused on the remains of the Iron Age period, although a demographic and paleopathological study was also performed on the PIR burials. The comparison of demographic data between Early Iron Age and Late Iron Age shows higher percentages of infants (0-3 years) compared to the other sub-adult age groups. Based on the ages determined for the Iron Age burials a life table was created. A life expectancy value of about 20 years was calculated. Compared to the Neolithic sites of Ra's al-Hamra 5 and Jebel al-Buhais 18, it appears that the 0-4 age group is not underrepresented. Taphonomic data, burial practices, and the sedentary lifestyle compared to the seasonality of the Neolithic site were considered as explanation for the high number of 0-4 individuals recovered in the Daba LCG-2 tomb.

The analysis of skeletal lesions from the Iron Age burials revealed a general lack of indicators of chronic stressors in sub-adults compared to adult individuals. The difference is high in both periods (Early Iron Age and Late Iron Age). These data allow to hypothesize acute pathologies that participate in the high mortality rate among sub-adults. Statistically higher differences between adults and sub-adults are found for infections and periostitic lesions. Adults have higher percentages compared to sub-adults. The adult skeletal remains from both periods (Early Iron Age and Late Iron Age) show skeletal lesions (OA and DJD) that reflect age and daily work efforts. No statistically relevant differences are found comparing skeletal lesions by sex. The analysis of oral defects (antemortem tooth loss, periapical lytic lesions, and caries) shows higher frequencies of antemortem tooth loss in mandibular sockets compared to maxillary sockets. The analysis of oral lesions by sex shows significant differences for antemortem tooth loss. Females from EIA period showed higher frequencies of oral defects than males. The difference might be the result of a different diet characterized by more cariogenic foods or might reflect a different use of teeth related to life activities.

Paleopathological data related to oral pathologies were then compared with data from other Iron Age sites. In general, data reported for oral and dental pathologies from the Daba LCG-2 burials allowed to reconstruct a subsistence economy for this community based on the consumption of foods high in fermentable carbohydrates since young age. This data is in line with what reported by Littleton and Frohlich (1993) and by Nelson and colleagues (1999) for several sites of the Arabian Gulf and in the Arabian Peninsula.

The archaeological data from the two tombs were studied with the aim of reconstructing funerary actions and practices used by these communities. Data related to archeological and anthropological field excavation and data from previous studies of human skeletal remains were considered. Based on the anthropological data recovered by the anthropologists A. Todero and L. Fattore and based on the number count determined using maxillary and mandibles, a bias in number count was highlighted. High difference between the MNI count and the skeletal element count (hand/foot small bones, maxillary, and mandibles) is found. The limited data related to LCG-1 field excavation makes it difficult to accurately reconstruct the funerary practices and to clearly explain this bias.

As far as the Daba LCG-2 tomb concern, the continuity of use of the tomb is documented both by the archaeological materials found and by the funerary practices recognized by the anthropologists during field excavations. Different actions occurred at different times. These actions appear in the form of accumulations of bones and archaeological materials (Bone Clusters), burial depositions of individuals and creation of new spaces within the structure (Chambers).

- *The terminological problem of "collective burials"*

Different and non-standardized terms are used in literature to describe the burial depositions of several individuals. Some terms focus more on the archaeological aspects of the deposition, and this makes it difficult to search for comparison unless you are dealing with the same culture. Different terms are also used in the anthropological field. Some are simply descriptive while others involve an interpretation of funerary actions and ideologies. The most debated term is the one concerning the so-called "collective burials". This definition is generally used in Archeothanatology and describes the burial depositions, staggered over time, of several individuals within a single structure. This definition is discussed as the term "collective" is related to the interpretation of the burial and suggests social implications in its construction and/or use. The construction of this type of burials, however, implies organization and therefore it is the manifestation of the desire of a group or a community to allocate a structure for funerary use. Based on this and remembering that the funerary terminology does not define all the information that can be obtained by integrating the various archaeological, anthropological, taphonomic, historical and sociocultural data, it is appropriate to use the term "collective burial" for these depositions unless there is a clear absence of social implications.

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Introduction

The terminologies used to describe the burial depositions of several individuals are the subject of an ongoing debate. Sometimes the terms used describe the tomb from the archaeological point of view, focusing more on the structure of the burial rather than the funerary deposit. This also makes difficult to search articles and citations to compare with. In the anthropological field, several terms have been used over the years and this has led to a differentiation between English and French literature. The terms used can be simply descriptive or imply an interpretation of funerary actions and, sometimes, funerary ideologies. This dissertation is focused on two main purposes. The first purpose is to reconstruct the paleodemographic profile, the state of health and the lifestyle of two Omani prehistoric communities through the analysis of the skeletal remains. The remains were also analyzed with the aim of evaluating the funerary practices adopted within the two sites. The selected sites are different both in chronological period and in archaeological features, but they are both characterized by a high number of individuals buried. The funerary contexts and the human skeletal remains selected for this dissertation were analyzed with a multidisciplinary approach. Demographic analyzes, paleopathological assessments, taphonomic and histological studies are used to provide reconstructive information of the two burial contexts. The reconstruction of paleobiology, health conditions, taphonomy and funerary practices of skeletal remains is performed, and the results are compared with several contemporary funerary contexts. Lastly the anthropological and archaeological data from the two burial sites are used for a re-examination of the burial terminology and specifically the long-debated definition of “collective burials".

Organization of the Dissertation

This dissertation has six chapters. In the first chapter the issue related to the nomenclature used to describe the depositions of several individuals is discussed. A comparison between the terminology used in English and French literature is summarized. Additionally, the formation of mortuary deposits and the approach of research adopted in the archaeological and anthropological field are described. The problem related to the use of ethnological models in archeology and the problem related to the use of more interpretative rather than descriptive terms are highlighted. Furthermore, to have a complete picture of the research and the relative problems, the different study phases of a funerary context are summarized. The second chapter consists of an introduction to the archeology and mortuary practices of the Oman Peninsula from the Neolithic to the Pre-Islamic period. Before describing the society and the mortuary practices for each chronological period, a description of the geographical context and of the different types of ecosystems in the Oman Peninsula is provided. This chapter allows to contextualize the skeletal remains analyzed and provides archaeological support for the analysis of the results. The third chapter introduces the two Omani sites whose remains are used in this study: Ra’s al-Hamra 5, specifically Area 43, and Daba al Bayah, specifically the LCG-1 and LCG-2 tombs. History of the site excavations, description of sites and geographical environments, chronology are reported. The fourth chapter provides a detailed description of the methodology used for demographic, paleopathological, histological and taphonomic analyses. The fifth chapter reports the results of the study conducted on human skeletal remains from both Ra's al-Hamra 5 and Daba al Bayah. Chapter six discusses the anthropological results. The results from the study are also used to analyze the problem related to burial terminology. All the results from the dissertation are resumed in the conclusion chapter.

Chapter 1. Terminological problems

Several scholars tried to schematize the types of deposition and the actions related to funerary behaviors found in archaeological contexts (Bray and Trump, 1970; Joukowsky, 1980; Duday, 2006; Knüsel, 2014; Knüsel and Robb, 2016; Schmitt and Déderix, 2018). Each of the terms suggested adds to the confusing vocabulary used to describe these features making comparisons among them difficult. Several terms have been adopted over the years, trying to create a commonly accepted terminology (Bray and Trump, 1970; Joukowsky, 1980; Ubelaker, 1989; Sprague, 2005; Duday, 2006; Knüsel, 2014; White et al., 2012). One of the main problems encountered, however, was the creation of a cross-lingual standardized nomenclature between different academic traditions (Duday, 2006; Knüsel, 2010; 2014; Knüsel and Robb, 2016; Schmitt and Déderix, 2018). One of the classifications that has recently taken hold in the archaeological and anthropological fields is that created by Duday (2006) in the context of French Archeothanatology. He proposed to distinguish human burial deposition types based on the number of individuals, time of use and modality of deposition using terms such as individual burials, funerary sets, primary and secondary burials, multiple and collective burials. While terms such as "individual burial" are commonly accepted and used, other definitions such as "collective burials" are not clearly and univocally used (Sprague, 2005; Duday, 2006; Knüsel, 2014; White et al., 2012; Knüsel and Robb, 2016).

1.1 A BRIEF HISTORY OF TERMS

In the English and French-speaking literature, collective burials are defined based on modalities of use (Bray and Trump, 1970; Joukowsky, 1980; Duday et al., 1990; Duday, 2006). Almost all the definitions are focused on three main aspects: number of individuals, time, and space. Although it is not clear how many individuals are necessary to consider a deposition "collective", clearly it must contain the remains of more than one individual. The deposition of individuals within collective tombs is progressive and spread over time. Space of a collective tomb is often considered a single structure/feature, which must be re-opened to allow for new bodies to be deposited. Although at a first glance there seems to be agreement in terminology when applying these terms to collective burials, a more accurate look highlights the problems underlying this definition and use of these terms (Tab. 1.1).

In the French literature (Masset, 1993; Leclerc, 2003; Duday, 2006) the term "collective burial" was created to distinguish successive funerary deposits from simultaneous depositions of several individuals. The distinction was therefore based on modalities of use of the tombs, without considering the aspects related to the architecture. Often due to scarce documentation, the oldest collective tombs are known only when they have a monumental character, although collective tombs are not always monumental in character (Masset, 1993). This led Leclerc (1999) to stress the importance of studying megalithism and funerary practices separately because not all collective tombs are megalithic in nature. Successively, French scholars introduced other conditions to the definition of collective burials (Chambon, 2003; Leclerc, 2003) to allow different non-megalithic funerary contexts to be classified as "collective". According to Chambon (2003), for example, only built structures or natural structure with a clear anthropic alteration of the structure are easily characterized as collective tombs (Chambon, 2003). The loss of individual integrity of human remains is considered another important condition for the identification of collective burials (Leclerc, 2003).
Chambon (2000, 2003) analyzed several French mortuary contexts. Based on this he divided the French contexts into five types of collective graves. They include 1. burials that are classified as collective tombs, but for which the analysis does not allow to determine whether the burials were successive or simultaneous; 2. collective tombs characterized by a small number of burials and simple funerary rites 3. collective burials in which the formation is characterized by emptying of previous burial deposits. The emptying can be part of the normal up-keep or maintenance of the burial tomb. It can precede a new occupation of the tomb or can take place just before the final closure of it. 4. secondary deposits introduced into tombs; 5. complex deposits characterized by combined evidence of rearranged bones, compartmentation, and partial emptying. According to Chambon (2000), therefore, there are no two identical collective tombs. If the architectures of the graves are analyzed, it is possible to find precise stereotypes. The analysis of the actions, instead, highlights a considerable variety that should be analyzed individually and not generally classified.

In the English-speaking literature, Sprague (2005) proposed five other categories of burial deposits based on state of preservation and articulation of skeletal remains: 1. fragmentary, 2. single, 3. double, 4. multiple and 5. mass graves. The term "collective" according to Sprague (2005) needs to be avoided. Sprague (2005) distinguished between mass grave and multiple burial based on the state of articulation. The term multiple burial implies the presence of articulation, while mass graves are characterized by disarticulation of human skeletal remains.

Based on timing of deposition, he proposed a distinction between two types of multiple deposits: contemporary and consecutive.

According to Dupras and colleagues (2006) a multiple burial is a single grave containing the remains of several individuals. The individuals deposed inside the grave; "*may either have been buried all at once as a primary deposit, or as a combination of primary and disturbed burials due to reentering an existing grave to deposit additional remains*".

White and colleagues (2012) stated that a multiple interment *"is a burial in which more than one individual is present. These burials include ossuaries, burial urns containing more than one individual, and a variety of other possibilitie*s".

Knüsel (2014) stated that "*the term multiple burial relates only to features with more than a single individual in the most general sense with collective, reduction of the corpse and mass burials differentiated on their extent of disarticulation*".

Contrary to the distinct use of "collective" and "multiple" proposed by the French Archeothanatology, the English literature prefers to use the term "multiple" for the depositions of multiple individuals both simultaneous and subsequent (Sprague, 2005; Dupras et al., 2006; White et al., 2012; Knüsel, 2014).

Table 1.1. Summary table of the main terminologies adopted to describe burial depositions of several individuals.

Author(s)	**Description**	**Term(s)**	**Variable(s)***			
			N	**T**	**S**	**A**
Bray and Trump (1970)	Collective tomb: tomb built to contain many burials; often successive depositions spread over a long time	Collective	✓	✓	✓	
Joukowsky (1980)	Collective burial: the burial of a number of bodies, usually over a period of time	Collective	✓	✓		
Sprague (2005)	Multiple (contemporary or consecutive) implying articulation	Multiple	✓			✓
Sprague (2005)	Mass: implying disarticulation	Mass	✓			✓
Duday (2006)	Collective burial: single structure, containing a greater or lesser number of individuals whose deposition was staggered over time	Collective	✓	✓	✓	
Duday (2006)	Multiple burial: deposition of several individuals buried simultaneously or in a very narrow chronological span	Multiple	✓	✓	✓	
Dupras et al. (2006)	Multiple burial: a single grave containing the remains of several individuals, which "may either have been buried all at once as a primary deposit, or as a combination of primary and disturbed burials due to reentering an existing grave to deposit additional remains"	Multiple	✓			
White et al. (2012)	Multiple interment: a burial in which more than one individual is present. These burials include ossuaries, burial urns containing more than one individual, and a variety of other possibilities	Multiple	✓			
Knüsel (2014)	Multiple burial: features with more than a single individual in the most general sense with collective, reduction of the corpse and mass burials differentiated on their extent of disarticulation	Multiple → collective as specification	✓			
Schmitt and Déderix (2018)	Multiple simultaneous deposits and multiple successive deposits	Multiple	✓	✓		

* The variables identified are number of individuals (N); time of deposition (T); defined space of the burial (S); articulation of the skeletal remains (A)

The common definition of collective grave allows to consider collective burials a remarkable variety of archaeological features. The origin of the earliest collective tombs appeared during the Neolithic period. Their appearance was linked to the emergence of an imbalance between population growth of communities, an increase in economic resources and the emergence of corporative groups (Chapman, 1981a; 1981b; Déderix et al., 2018). According to some (Pellegrini et al., 2002; Schmitt and Déderix, 2018) the appearance of collective funerary monuments carried out a functional role by providing a place for the burials and an important role in strengthening social relations within communities. Collective funerary tombs were also used as territorial markers. Some authors suggested (Cauwe, 1996; 1998; Mannermaa et al., 2008; Orschiedt, 2018) that the appearance of collective funerary tombs is Mesolithic in origin. From Neolithic to Bronze Age, communities used different forms of collective tombs: dolmen, megalithic graves, passage graves, hypogea, caves, tholos tombs, *domus de janas,* and giants' tombs (Maggi and Formicola, 1978; Pellegrini et al., 2002; Bocquentin, 2003; Leclerc and Masset, 2006; Malone et al., 2009; Sjögren, 2010; Legarra Herrero, 2012; Rojo-Guerra and Garrido-Pena, 2012; Weiss-Krejci, 2012; Melis, 2014; Bocquentin and Garrard, 2016; Schmitt and Déderix, 2018).

1.2 FORMATION PROCESSES FOR MORTUARY DEPOSITS

The formation of mortuary deposits is often the result of complex and unrelated events. These events may have taken place at any time during the period elapsed between the individual's death and the discovery made by archaeologists. Weiss-Krejci (2011) created a visual scheme that highlights the variety of actions that can lead to the formation of a mortuary deposit (Fig. 1.1). Critically in her scheme, she distinguishes three types of actions: funerary, post-funerary and extra-funerary (Weiss-Krejci, 2011).

With the term "funerary" are identified all the treatments performed by the population on the remains of the deceased, from the moment of death to the moment of final deposition. How communities handle a human corpse after death differs considerably over time and space, and this is based on specific religious and social ideologies. Variability can even be found within a single community and can be influenced by multiple factors (e.g., age of the deceased, manner of death, social status of the deceased).

Occasionally and in relation to various customs (e.g., social position of the deceased, circumstances of death), individuals may be denied a ritualized/community funeral (Weiss-Krejci, 2013; Schmitt and Déderix, 2018). In such cases, it is not possible to speak of funerary treatment, but instead of a non-funerary nature of the deposit (e.g., abandonment of the corpse or the taking of trophies) (Zegwaard, 2012; Weiss-Krejci, 2013; Mirazón-Lahr et al., 2016; Schmitt and Déderix, 2018). The processes to which the body is subjected in these circumstances are defined by Weiss-Klejci (2011) as “extra-funerary”.

As Weiss-Klejci (2011) reported, once the remains of an individual are laid without the need to remove them, the funerary deposition is completed. It may happen that the community members decide to exhume the remains. There are several reasons for doing so. Some are ritual reasons for example, ancestral rites, veneration and commemoration of important individuals, and a cult of relics. Sometimes the reasons for doing so are non-rituals for example, functional and/or maintenance of the tomb, tomb looting, and purposely desecration the remains. These behaviors are considered actions that are "post-funerary”, and they occur after the remains have been buried.

This variety of actions and contexts highlighted by Weiss-Klecji (2011) was developed using historic and ethnographic examples. In historic contexts, an interpretation and reconstruction of the different actions can be supported by written sources, which can accurately reconstruct the exact funerary or non-funerary dynamics that led to the formation of a mortuary deposit. For prehistoric burial contexts, the accuracy of the interpretation is not as good and is subjected to how the available artifacts and other archaeological evidence are used to assess the post-funerary actions.

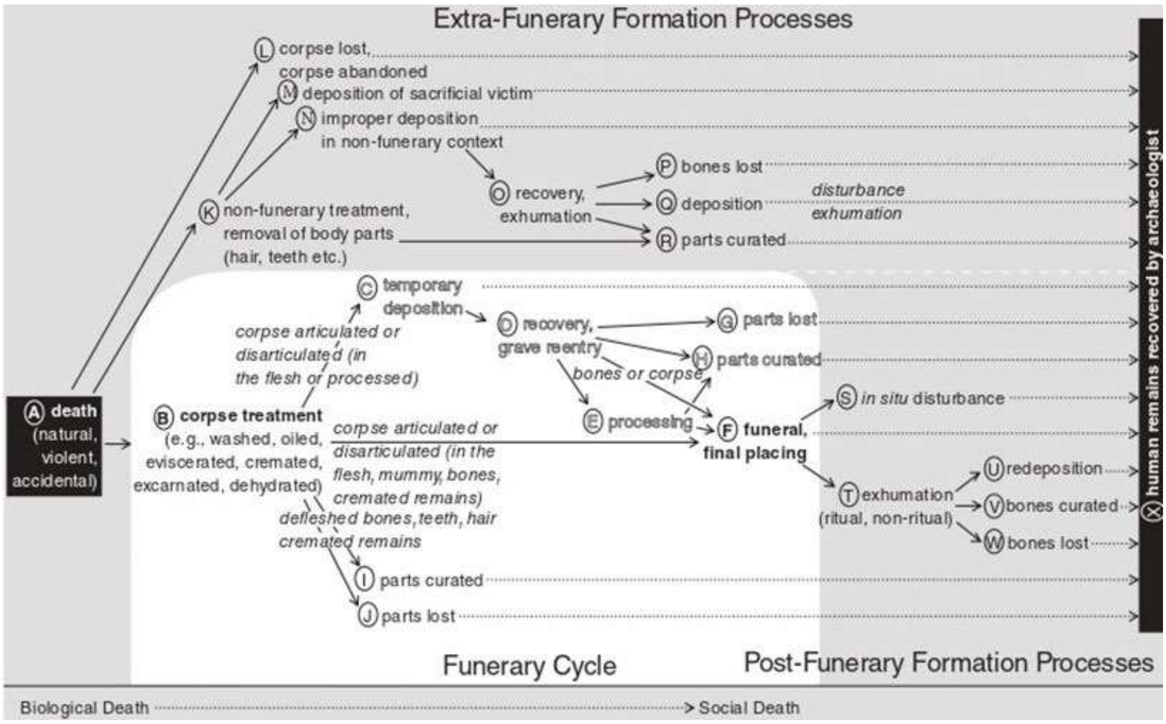


Figure 1.1. Schematic model of the possible formation processes of mortuary deposits (Weiss-Klejci, 2011).

The use of ethnological sources as a comparative model for understanding the past contexts is another difference in academic traditions of Archaeology. For example, the French archaeological tradition of using ethnological examples to interpret the past is relatively limited. While in the English-speaking archaeological tradition research, interpretation is often based on the Binford-Saxe approach (Saxe, 1970; Binford, 1971; Chapman, 1987; Boulestin and Duday, 2006). Based on this approach, the main objective of the research is to reconstruct the social organization of the living through the analysis of funerary practices (Saxe, 1970; Binford, 1971; Chapman, 1987; Boulestin and Duday, 2006). They use ethnological models of behavior as a guide for interpreting past human behavior as viewed by the archaeological evidence. Ethnological references, however, are very far from what some archaeological populations may have practiced. The differences are in part related to time and space and to the variations that can develop as part of the ever changing functional or ritualized practice of handling the death. Hence, archaeologists studying this from prehistoric evidence need to take this into account (Boulestin and Duday, 2006). As Grifoni Cremonesi said "*non è sempre facile comprendere il rapporto tra spazi dei vivi e spazi dei morti e definire in modo sicuro le norme di comportamento delle società neolitiche, se non ricorrendo ad esempi di comunità attuali, con tutti i rischi di un'errata applicazione di modelli, spesso in modo arbitrario, dall'etnografia*" ("it is not always easy to understand the relationship between living spaces and spaces of the dead and to safely define the norms of behavior of Neolithic societies, if not using examples of current communities, with all the risks of an incorrect application of models, often arbitrarily, from ethnography". Grifoni Cremonesi, 2006). Despite the difficulties of applying ethnological models to archaeological contexts, the ethnological comparison shows that it is difficult for a human community to adopt a single funerary ritual and this variety can be linked both to the structuring of society and to individual choice (Favole, 2003).

Recently, Knünsel and Robb (2016) highlighted a fundamental problem, that funerary terminology is more interpretative than it is descriptive. The term "collective" is not a neutral word but it is related to social aspects (in Oxford Dictionary, 2020: "done or shared by all members of a group of people; involving a whole group or society"; Schmitt and Déderix, 2018). As highlighted by Schmitt and Déderix (2018) "the standardization of mortuary terminology between two academic traditions is hardly a simple task, as it involves not only translating concepts but also fusing distinct theoretical frameworks".

1.3 ACTUAL ASSESSMENT

The study of funerary context often consists of three different phases (Schmitt and Déderix, 2018). The first phase takes place in the field. During the excavation, the number, type, and position of the bones in the deposit must be carefully documented. Unfortunately, not all archaeological efforts focused on this issue, often bones were discarded and only the artifacts (grave goods) were carefully collected. Still, when working with the skeletal elements during the recovery phase it is important to document the degree of anatomical articulation of the body. Once the skeletal remains are recovered, the second step is to analyze the data collected in the field. The aim of this phase is to reconstruct the actions and processes that led to the formation of the burial feature. The last phase is that of interpretation. Only after having carefully analyzed all the data collected, it is possible to fully understand the origin of the deposit and whether it is a funerary or non-funerary deposit. During the first phase of studying, the commonly used terms come from the field of human anatomy. Unfortunately, while archaeologists and anthropologists discuss the analysis and interpretative phases, they do not use a common vocabulary and they are not consistent in how they define their terms (Duday, 2006; Knüsel, 2014; Schmitt and Déderix, 2018). In the French Archeothanatology terminology, deposits with more than one individual are called "*pluriel*" if they do not make the distinction as to whether the burial depositions were simultaneous or subsequent (Duday, 2006). In the cases where the time factor is understood concerning simultaneous depositions, they use the term "*sépultures multiple*"/"multiple burial" to describe the feature. If the depositions are successive, they use the term "*sépultures collective*"/"collective burial" (Duday, 2006). The use of these terms to describe burial feature is problematic. To overcome this, Schmitt and Déderix (2018) proposed "*pluriel*" and "multiple" to be used to describe the burial deposits containing the remains of multiple individuals. These deposits would then be distinguished between multiple simultaneous deposits ("*depots pluriels simultanés*") and multiple successive deposits ("*depots pluriels successifs*") based on time. Both these human burial features can be sub-divided into specific types (primary, secondary, and mixed).

However, terms such as "primary deposit" and "secondary deposit" are not interpreted in the same way by current archaeologists and anthropologists (Knüsel, 2014; Schmitt and Déderix, 2018). Ubelaker (1989) defines a primary burial as a complete and articulated skeleton "*buried in the flesh*", while secondary burials are bones that are not in anatomical arrangement and were not buried as an articulated set of remains. For Dupras and colleagues (2006) a primary burial is defined as a deposition in which "*the body remains in its original deposited position and the* *context of the burial has not been disturbed*", while "*a secondary burial consists of skeletal elements that have been removed from their original burial location by human activity, and deposited in another location, thus disturbing their original context*". According to White and colleagues (2012) "*a primary interment is a burial in which all of the bones are in an anatomically 'natural' arrangement*", while "*a secondary interment is a burial in which the bones of a skeleton are not in 'natural' anatomical relationship but have been gathered together some time after complete or partial disarticulation of the skeleton and then buried*". All these definitions are based on the differentiation of the degree of articulation of skeletal remains. However, in some of them, there is confusion between a simple description of the appearance of the skeletal remains at the time of the excavation and interpretation of the funerary actions. The words "primary" and "secondary", therefore, are used at the same time both to describe the appearance of the remains at the time of their discovery, and to interpret the actions of the populations of the past. Furthermore, as Boulestin and Duday (2006) report, definitions such as Ubelaker's do not consider "*cases where the corpse was 'buried in the flesh' but where no anatomical articulation remains without disturbance (for instance, if the corpse decomposed on a funerary bed which later collapsed)*". They said, in fact, that "*articulated bones usually correspond to a primary deposit, but a primary deposit does not mean that the bones will be found articulated. Indeed, the lack of articulation does not necessarily mean a secondary deposit*".

For French Archeothanatology difference between the two deposits is based on the state of the body at the time of deposition and is perceived only based on the skeletal elements. Based on Boulestin and Duday (2006), in fact, "*primary deposit is the deposit of a corpse, or part of a corpse, made when the skeletal elements are still in total anatomical articulation*"; while secondary deposit "*is the deposit of remains made when the skeletal elements are partially or completely disarticulated*". According to Boulestin and Duday (2006), therefore, the use of the term "burial" is also early at the time of description. In fact, funerary archeology provides information on the degree of decomposition of the bodies at the time of the deposition., To affirm that one is in front of a secondary burial, one must demonstrate that the acts deduced from the observations on the field actually refer to moments of the funerary ritual.

As it can be seen funerary terminology is not standardized. There is considerable confusion both in the use and in the interpretation of these terms. Considering this terminological problem and the importance of burial practices for reconstructing funerary behavior and burial deposit's origin, one focus of this research was the analysis of the Omani Neolithic graveyard of Ra's al-

Hamra 5. Specifically, the part of the graveyard called “Area 43” was studied. In this area several individuals were buried during Neolithic period. This area is still undergoing an interpretive assessment by archaeologists (Santini, 2002; Salvatori, 2007). A multidisciplinary approach was used to assess the paleobiology of human skeletal remains from Area 43 and to reconstruct funerary practices at the origin of this burial deposit.

Additionally, a preliminary study of the Omani funerary complex of Daba al Bayah was performed. This site includes two large collective graves dating from the Late Bronze Age to the PIR (*Pré-Islamique Récente*) period. Skeletal remains and data from excavation reports were analyzed to reconstruct demography, health status and funerary practices used by local community.

Before analyzing the sites, a brief picture of the Omani society and the funerary practices used by the local communities from the Neolithic to the PIR period is presented.

Chapter 2. The archaeology of the Oman Peninsula

For this study, two archaeological sites located in the Oman Peninsula, the eastern part of the Arabian Peninsula, were examined. Before describing the sites, the geographical characteristics and the various ecological niches present in the Oman Peninsula are briefly described to identify how geography may have influenced how people survived in the environment. Later a brief chronological overview is given, and the funerary practices are examined in relation to the developments over the centuries.

2.1 Geography

The Arabian Peninsula is in the south-western part of Asia. This region is surrounded by the Nafud desert to the north and this desert isolates the Arabian Peninsula from the Fertile Crescent. To the west it is surrounded by the Red Sea and to the east by the Persian Gulf. To the south, the Arabian Peninsula is encircled by the Indian Ocean. The territory consists of a vast desert interspersed with oases and steppes. The south-eastern part of the Arabian Peninsula is well irrigated naturally. This is because the Hijâz mountain barrier and the Asir geographic formation captures atmospheric moisture. Six modern countries are located on the Arabian Peninsula: Saudi Arabia, Yemen, Oman, the United Arab Emirates, Qatar, and Bahrain.

The sub-region of the eastern portion of the Arabian Peninsula is often referred to as the "Oman Peninsula" (Munoz, 2013). This area is defined by the islands of Abu Dhabi to the northwest, the island of Masirah in the south-east. The Oman Peninsula is also isolated from the rest of Arabian region by the desert of Rub 'al-Khâlî, which constitutes a natural barrier.

The Oman Peninsula is now politically divided between the Sultanate of Oman and the United Arab Emirates (UAE). The Sultanate of Oman occupies a total area of 309,500 km^2 from the Strait of Hormuz in the north to the border with Yemen in the south. It has over 3,000 kilometers of coastline bordered by three seas, the Persian Gulf, the Gulf of Oman, and the Arabian Sea. The region occupied by Emirates, on the other hand, consist of 83,600 km^2 of land. This area includes a coastline of over 1,300 km bordering the Persian Gulf and the Gulf of Oman.

The Oman Peninsula is composed of various topographical areas (Munoz, 2013). The plain occupies 3% of the total territory, while the mountains occupy 15% of the peninsula. The most important mountain range is that of the Hajjar, which extends for over 500 km from Ra's al Musandam in the north to Ra's al-Hadd and Al Qara in the south-east. The remaining Oman

Peninsula territory (82%) is composed of sand and deserts. The Hajjar mountain range constitutes a geographical barrier between the coastal plain and the western part of the territory, which can only be crossed in some points.

The entire Oman Peninsula territory is geographically divided into several large ecosystems: coastal area and western island; piedmont area; Jebel Akhdar and the valleys of the highland; northern coastal area; eastern coastal area; the plains and the sand desert (Munoz, 2013; Cleuziou and Tosi, 2020).

The mountains are a characteristic element of the Omani territory. They consist of a single crest, which is continuous and narrow. The mountain landscape is also interrupted by a number of streams flowing along the tectonic faults. Despite the massive presence of the mountain range, access to the sea from internal territory is possible through inner piedmont plains. It is also possible by crossing the desert. This geographical landscape has allowed for constant human travel between the coast and inland since prehistoric times.

The Oman Peninsula is included in the subtropical zone of arid climates. Rainfall is scarce but it has been enough to create the conditions necessary for a highly successful agriculture. The geological structure of the mountains, in fact, is such that the water is rapidly stored underground for long periods. That allow feeding many upstream ponds that have acted as natural storage facilities. However, most of the water flows along the mountain slopes feeding a complex network of waterways, which evaporate and rarely reaches the sea (Cleuziou and Tosi, 2020).

The study of ancient societies requires consideration of the interactions between humans and the environment. For this reason, different ecological niches of the peninsula are briefly described. In regions of high biological diversity, where many ecological niches are enclosed in small areas, the main strategy of prehistoric people was focused on the control of ecozones, from where they could direct the exploitation of a spectrum of animals and plants inside of a small territory.

Three different types of ecosystems can be identified: marine ecosystems, coastal ecosystems, and continental ecosystems (Munoz, 2013; Cleuziou and Tosi, 2020).

- <u>Marine ecosystems</u>. Three seas surround the Oman Peninsula. The first is the Persian Gulf, which is an inland and shallow sea characterized by significant variations in water temperature over the course of the seasons. The shape of the Persian Gulf means that there is little trade with the neighboring Indian Ocean. This, added to the significant evaporation to which it is subject due to the temperatures of the area, causes a high salinity that results in a low diversity of fish species (Randall, 1995; Munoz, 2013). The second sea surrounding the peninsula is the Indian Ocean, characterized by depths much deeper than the previous one, relatively stable salinity and temperatures that vary significantly depending on the depth. The Indian Ocean is characterized by greater biodiversity. The Arabian Sea, also, is more exposed to the winds of the Indian monsoon and subject to a significant rise of water near the coast and presents a great biodiversity.

- Coastal ecosystems: the coastal area includes lagoons and mangroves, beaches, and rocky cliffs. In these areas live halophytic plant groups. The Oman lagoons are paleo-estuaries, connected to the sea by one or more openings. They are generally poorly fed with fresh water, but they can benefit from the flow of wadis in case of heavy rainfall and their water is brackish. This creates a great biodiversity of fishes, crustaceans, and mollusks. Mangroves are vegetation formations of amphibians and depend on both the marine environment and the supply of fresh water (Tengberg, 2005). In addition to mangroves, these areas are home to numerous succulent plants and halophytes and are famous for the great variety of animal species. Are considered among the most productive ecosystems (Perlman, 1980). The sandy coastal areas are covered by a scant herbaceous and shrubby vegetation and the beaches are the nesting place of the green turtles (*Chelonia mydas*). The rocky coasts are favorable for the installation of many marine mollusks (mussels, oysters, muricides) (Martin and Cleuziou, 2003). The coral reefs host a wide variety of fish species and cephalopods, constituting very advantageous fishing grounds.
- Continental ecosystems: The area formed by slopes and mountains is usually the most wooded and it is characterized by different associations of plants based on altitudes (bushes of xerophyte shrubs at low altitudes, forests open to higher ones). The valley of Dhofar has a dense forest dominated by figs and tamarinds. Some thorny species, such as acacia, are scattered where the valleys open onto the plain. Above 500 meters above sea level, forests of semi-evergreen trees dominate. Many of the plants that characterize these areas have medicinal properties. In general, from the coast to the mountains, it is possible to find different species of wild animals (wild donkey and camel, different species of gazelles, oryx, ibex and mouflon, hares, ostriches, and porcupines) (Munoz, 2013).

2.2 CHRONOLOGY AND SOCIETY

From the Neolithic to the Iron Age, several changes occurred in the societies of the Arabian Peninsula. The transition from a semi-nomadic society based on hunting and gathering to a stable society, producer of primary food goods, brought great changes. There were changes both in the structuring of the settlements and in relationships between populations. These social and economic changes also influenced funerary practices.

2.2.1 Neolithic period (5000-3500 BC)

During the Neolithic, people occupied large territories and modified their subsistence strategy in order to adapt to environmental and climate changes. While the agricultural revolution was underway in other areas such as the Fertile Crescent, most of the Arabian Peninsula moved along a different path. The oldest evidence of human occupation in southeastern Arabia dates to the Holocene, but these are sporadic findings (Gregoricka, 2011; Cleuziou and Tosi, 2020). It is around 5000 BC that a greater number of settlements are attested along the shoreline of eastern Saudi Arabia, Qatar, Bahrain, UAE, and Oman. In this period agriculture and food production were still a very marginal activity in Arabia, strictly limited along the desert boundaries of the Syrian-Palestinian temperate belt, while subsistence was still based on hunting and foraging (Uerpmann et al., 2006; Gregoricka, 2011; Magee, 2014; Cleuziou and Tosi, 2020).

Several Neolithic sites were identified and excavated in Oman: Ra’s al-Hamra RH5, RH6 e RH10; Quryat - Khor Milk; Wadi Shab GAS-1; Ra’s al-Hadd HD-5; Ra’s al-Jinz RJ-2; Ra’s al-Khabbah KHB-1; ar-Ruways; as-Suwayh SWY-1, SWY-2; Ra’s Jibsh; Gorbat al-Mahar (Charpentier and Méry, 1997; Méry and Charpentier, 2002; Charpentier et al., 2003; Usai, 2006; Salvatori, 2007; Marcucci et al., 2014; Borgi and Maini, 2020; Cavulli and Scaruffi, 2020; Charpentier, 2020; Cleuziou and Tosi, 2020).

The archaeological evidence allowed to detect a good degree of cultural homogeneity in this period. In Oman, during the V-IV millennium BC, the settlements were located mostly along the coast, near mangroves, with the aim of making the most of the animal and plant resources found there (Biagi, 1988; Biagi and Maggi, 1990; Berger et al., 2005; Biagi and Nisbet, 2006; Uerpmann and Uerpmann, 2020a). Indeed, the bioarcheological investigations showed that the economy of this period was mainly based on the exploitation of marine and coastal resources (fish, marine mammals, mollusks, turtles) and to a lesser extent on the breeding of goats and sheep and on hunted for land mammals (Uerpmann, 2003; Gregoricka, 2011; Uerpmann and Uerpmann, 2020a).

During the Neolithic period human society of the Oman Peninsula was based on independent local groups which came together to control a territory and its resources (Cleuziou and Tosi, 2020). The basic social entity was the nuclear family. Several nuclear families lived and moved together among seasonal camps. Usually there was no tribal territory, only several hunting areas, each corresponding to a local group. The groups moved during the year between two main seasonal camps (Gregoricka, 2011). The coastal shell middens, the most attested archeological evidence, were predominantly inhabited during fall and winter seasons, due to an abundance of resources. Among Oman's forage societies, the role of agriculture must have remained marginal until the beginning of the Bronze Age.

2.2.2 Hafit period (3200-2500 BC)

At the end of the fourth millennium BC, although there were several elements of continuity with the previous phase, important changes were recognized. Human groups begin to occupy the internal territories (northern Oman and Emirates), and, in the coastal sites, an intensification of fishing and hunting of marine mammals were hypothesized (Gregoricka, 2011; Magee, 2014). The development of new food preservation techniques (smoking, drying, and salting) was documented (ElMahi, 2000; Cleuziou and Tosi, 2020). These changes would have allowed the development of local networks of exchange between the internal and coastal groups (ElMahi, 1998; 2000; Cleuziou and Tosi, 2020). In this period the exploitation of copper minerals located in the ophiolites of Oman is attested. However, one of the most important innovations of this period was documented at the Hili 8 site in the al-Ain oasis. Archaeological surveys revealed important systems for managing agricultural resources that would have allowed the cultivation of cereals and the exploitation of date palms.

For many years, Hili 8 remained the only possible example of an oasis settlement at the beginning of the third millennium BC (Cleuziou, 1982). The excavations conducted at the Ras al-Hadd 6 site (HD-6) have provided information suggesting, as for the Hili 8 site, a transition to sedentary agriculture by 3000 BC. (Monchablon et al., 2003; Magee, 2014; Azzarà and Cattani, 2020; Cleuziou and Tosi, 2020). It is also in this same period, moreover, that the first traces of ceramic production were identified (Cleuziou, 1989b; 1996; 2002; Cleuziou and Tosi, 2020).

Most of the archaeological evidence from the Hafit period is of a funerary type (so-called Hafit-type tombs). Hili 8 and Ra's al-Hadd 6, in fact, are the only settlements of the Hafit period excavated (Cleuziou, 1982, 1989a, 1989b; Cattani, 2003; Azzarà and Cattani, 2020). The scarcity of documentation, therefore, makes it difficult to accurately reconstruct the spread of the settlement model in this period (Magee, 2014). The scarcity of settlement traces led archaeologists to hypothesize several reasons behind this imbalance in the archaeological record. Some thought that one of the reasons could be the fact that the settlements were at lower altitudes than the tombs, levels now covered by alluvial deposits (Potts, 1990). Others identified the cause in the constant restructuring to which oases were subject (Tosi, 1989). The methods of occupation, sedentary or nomadic, of the populations were also questioned (Giraud, 2009; Deadman, 2012).

2.2.3 Umm an-Nar period (2500-2000 BC)

This period takes its name from the Umm an-Nar island, off the coast of the Emirate of Abu Dhabi. On this island, the first tombs and a settlement dating back to this period were found in the late 1950s. During the Umm an-Nar period, a series of important economic, social, productive, and funerary changes occurred (Gregoricka, 2011; Munoz, 2013; Magee, 2014; Bortolini and Munoz, 2015; Cleuziou and Tosi, 2020). Contrary to the Hafit period, a greater number of settlements were found in the Umm an-Nar period. Agricultural settlements are attested both within the Arabian Peninsula (e.g., Bat, Hili and Wadi Munay'i), and along the coast and on the coastal islands (e.g., Shimal, Kalba, Tell Abraq, Umm an-Nar) (Al-Jahwari, 2009; Gregoricka, 2011; Blin, 2020; Cable and Thornton, 2020). A determining factor in the choice of sites was the presence of fresh water. The internal settlements stood near oases, while the coastal ones were in areas where underground aquifers could be reached through the wells (Berthoud and Cleuziou, 1983; Potts, 1990; 2001). Most Umm an-Nar settlements therefore depended on agriculture as a livelihood. The climatic conditions did not allow the development of large, cultivated areas but the archaeological data document the cultivation of date palms, wheat, barley, jujubes, and legumes (Potts, 2001; Blau, 2007). The most archaeologically visible villages are those with large circular fortification towers, made of mud or stone bricks and usually distributed into groups of two to five (e.g., Bat, Hili 1, Hili 8, Kalba, Tell Abraq) (Cleuziou, 1982; 1989a; Potts, 2009; Magee, 2014; Cable and Thornton, 2020). Most of these towers surrounded wells, but they also probably played an effective defensive role. Next to these towers were smaller domestic and productive structures. Most of the population, however, lived in small villages inside oases, without monumental architecture (e.g., Al-Ayn, Umm an-Nar, al-Sufouh: Frifelt, 1991; Blin, 2020). Furthermore, many settlements stood near copper deposits. Indeed, the export of copper from the Omani Mountains to Mesopotamia and the Indus Valley is certified (Frenez, 2020). These exchanges, however, were not one-way as evidenced by the discovery of imported materials in villages and burials (Gregoricka, 2011; Munoz, 2013; Magee, 2014; Frenez, 2020).

The archaeological data attest, for the Umm an-Nar populations, a predominantly sedentary lifestyle, characterized by a mixed economy. In addition to agriculture, in fact, the archeozoological remains attest herding (sheep, goats and domestic coils), hunting (gazelle, oryx and wild birds) and the exploitation of maritime resources (mollusks, fish and marine mammals, green turtles) (Hoch, 1979; Al-Tikriti, 1985; Uerpmann and Uerpmann, 1994; Uerpmann, 2001; Beech, 2003).

2.2.4 Wadi Suq period (2000-1600 BC)

During the Wadi Suq period great changes affected material culture, socio-economic context, and mortuary practices (Cleuziou, 1981; Carter, 1997; Magee, 2014; Cleuziou and Tosi, 2020). These modifications were linked to a climate change that affected the Arabian Peninsula. During the Umm an-Nar period, the climatic conditions were relatively humid, and the populations were able to take advantage of the water supply from the aquifers. During the Wadi Suq period, however, the Arabian Peninsula was hit by an arid and dry climate (Cleuziou, 1989b; Parker et al., 2006; Magee, 2014). This climate change significantly modified the landscape, causing loss of vegetation, formation of the dunes, extension of the salt marshes and a significant drop in sea level and aquifers (Evans et al., 1969; Cleuziou, 1989b; Hellyer, 1998; Parker and Goudie, 2008). The population underwent a decrease and, consequently, the number of settlements present in the territory was reduced (Carter, 1997; Hellyer, 1998; Blau, 2007; Potts, 2009). Settlements stood near sources of water and food. While some large Umm an-Nar settlements (e.g., Tell Abraq and Kalba: Potts, 1990; 1993; 2001) continued to be occupied, most of the Wadi Suq settlements, in fact, were built near the coast, to have an easy access to maritime resources (Carter, 1997, 2003; Hellyer, 1998; Potts, 1997; Parker and Goudie, 2008). Archaeological investigations on the Wadi Suq sites such as Shimal and Tawi Sa'id suggest a less sedentary lifestyle (de Cardi et al., 1979; Potts, 1990; Vogt, 1998; Velde, 1991; Carter, 2003). It also appears that large-scale copper production, typical of the previous period, suffered a sharp drop. Probably the arid climate would have made access to the internal territories more difficult (Weeks, 1997; Carter, 2003).

Wadi Suq populations, therefore, would have led a more mobile lifestyle compared to the sedentary lifestyle of the Umm an-Nar period. This change also affected subsistence strategies and population diets. The Wadi Suq people consumed a diet heavily dependent on crustaceans and fish. Cereals only played a minor role in this type of diet. The supply of dates, staple food during the Umm an-Nar (Littleton and Frohlich, 1993; Blau, 1999, 2001a, 2007) was also reduced. As for pastoralism, this was not completely abandoned, on the contrary, archaeological investigations showed that sites with enough resources were able to maintain the subsistence practices developed in the early Bronze Age (Potts, 1990).

2.2.5 Late Bronze Age (1600-1300/1250 BC)

The archaeological data relating to the final phase of the Bronze Age are limited, making a precise reconstruction of settlement and subsistence models difficult. Few settlements from the Wadi Suq period continued to be occupied during this period (e.g., Kalba and Tell Abraq), while newly formed settlements are rare (e.g., Shimal: Velde, 2003). Archaeological data and, specifically, ceramics seem to reconstruct a less intensive production method than in the previous period. Contrary to ceramics, however, bronze production seems to be flourishing. Large quantities of bronze materials were found inside burials (e.g., Al-Wasit and Nizwa: Al-Shanfari and Weisgerber, 1989; Weisgerber, 2020a). A notable production of this period is that of weapons such as long swords, short swords, daggers and, above all, arrowheads (Velde, 2003). It is not clear, however, whether this is indicative of an increase in inter-tribal violence or whether it should be associated with an increase in hunting activity. The burials, which were such a common feature of archaeological documentation a few centuries earlier, become less archeologically visible. Only four sites are known: Nizwa, Qattara, al-Qusais and al-Wasit (Velde, 2003; Magee, 2014; Yule and Weisgerber, 2015a). Most sites with Late Bronze Age materials are sites of prolonged use. No site, therefore, is free from contamination of materials datable to other phases. This led to a difficulty in defining specific characteristics for this period. Although knowledge of the subsistence strategies of this period is extremely limited, archeozoological data from the Tell Abraq site suggest a preponderance of sheep and goats on cattle and hunting of a large variety of wild animals (Magee, 2014). Research conducted in Tell Abraq and Kalba also reconstructed an increase in occasional trade with southeastern Iran (Magee and Carter, 1999; Magee, 2014).

2.2.6 Iron Age (1300/1250-300 BC)

A more specific chronology for the Iron Age was proposed by Magee (1996) who divided the period into 3 phases: Iron Age I (1300-1100/1000 BC), Iron Age II (1100/1000-600 BC), Iron Age III (600-300 BC). If between the first two phases it was possible to detect substantial differences in settlement and production; a clear break was not highlighted between Iron Age II and Iron Age III. Although there is, during Iron Age III, a clear decrease in the number of inhabited areas, it seems that the same characteristics that occurred during the Iron Age II also took place in the final phase of the Iron Age.

As for the Late Bronze Age, sites with materials from Iron Age I show contamination from other periods. These two periods, Late Bronze Age and Iron Age I, are transition phases. The scarcity of material made the characterization difficult. No specific features have been outlined yet that allow these two periods to be distinguished. The first phase of the Iron Age, in fact, shows same characteristics of the Late Bronze Age (Magee, 2014).

The development of irrigation technologies and the domestication of the dromedary led, however, to the growth and expansion visible since Iron Age II. During this period, in fact, there is a significant settlement intensification. The expansion of the settlements is to be related to the introduction of the *aflaj* irrigation system (Magee, 2014).

Paleoclimatic data showed that around 1000 B.C. the Arabian Peninsula witnessed a sudden drop in rainfall (Parker et al., 2006). This would have affected the aquifers causing their decline. The *aflaj* irrigation system made it possible to overcome this problem. This system, in fact, involves tapping the aquifers by building long tunnels. The creation of these tunnels made it possible to transport underground water to the lower areas where cultivation is possible. Examples of ancient *aflaj* were found in Hili (Boucharlat and Lombard, 1985; Al-Tikriti, 2010), Bida Bint Saud, Jebeeb, Wadi al Ayaay (Al-Tikriti, 2010) and Salut (Avanzini and Phillips, 2010).

During the Iron Age II several mountain settlements were found (Potts et al., 1996; ElMahi e Ibrahim, 2003; Magee, 2014). Usually they are small settlements, often strategically positioned with respect to the wadis. Common feature of the inhabited areas is the presence of curtains perimeter and the shape of the houses, side by side to each other and made of stone. Safeguard structures, located near access to the oases, are an integral part of the defense system (Condoluci, 2009). Some settlements testify the existence of a functional diversification of the spaces within the settlements (Condoluci, 2009).

The livelihood strategy was probably based on small-scale agriculture and sheep and goat herding.

During Iron Age II the presence of domestic dromedaries allowed communications between coastal sites and internal sites, making possible an economic alignment between these two areas. These ratios demonstrated by malacofauna and archeozoological finds, however, do not find an equal response to coastal settlements. The scarcity of coastal sites found can be explained in part with the advancement of the coastline and, therefore, with the need to search for sites further inland. In part the scarcity can also be explained with the difficulty in identifying these sites, probably consisting of villages scattered with hut houses (Condoluci, 2009). The few coastal sites with stone structures are Bronze Age sites that continued to be used even during the Iron Age (e.g., Ra's al Hadd, Tell Abraq, Kalba).

From a social point of view, in general, the settlements of the Iron Age do not present domestic architecture that can be related to social diversifications. At the Muweilah site (Sharjah, UAE), however, a collective representation building (pillar hall) was found (Magee, 2003; Condoluci, 2009). This would be manifestation of the emergence of an elite who, through these structures, legitimized and consolidated their power. Just the management of water and *aflaj* could have contributed to the formation of social differentiation (Condoluci, 2009). These settlements are linked to each other by reciprocal relationships manifested through the exchange of resources between diversified productions and connected to varied ecosystems.

The chronology proposed by Magee is based on research conducted in the north of the Oman Peninsula (Magee, 1996, 2014; Magee and Carter, 1999). Investigations conducted in several sites from Central Oman, on the other hand, have led to reconsidering this classification. This reconsideration is based on the absence of material datable to Iron Age I and the presence of material identified as Iron Age II as early as 1300 BC (Avanzini and Phillips, 2010).

Based on this, it is now preferred to distinguish the period into two phases: Early Iron Age (1300-600 BC, corresponding to Iron Age I-II) and Late Iron Age (600-300 BC, corresponding to Iron Age III). (Phillips, 2010; Magee et al., 2017).

2.2.7 Recent Pre-Islamic period (300 BC-300 AD)

Pré-Islamique Recént (PIR) is defined as the post-Iron Age period. It is a culture geographically located in the Emirates and in the northern part of the Sultanate of Oman (e.g., Ed-Dur and Mleiha), although some sites were also discovered in central Oman (e.g., al-Fuwaydah) (Yule, 2016). Furthermore, in central Oman, P. Yule identifies another culture called Samad (Yule, 1999a, 1999b, 2016; 2018). There are several elements common to these two cultures, especially in material production. However, some differences were also noted.

In general, it can be said that the period starting from 300 BC showed a cultural transition characterized by few elements of continuity with respect to the Iron Age. The Iron Age settlements and *aflaj* were abandoned. Already in Iron Age III there were a sharp decrease in the use of Iron Age II settlements. The water supply in this period took place through wells that draw on the aquifer (e.g., Mleiha) (Condoluci, 2009; Mouton and Schiettecatte, 2014). It is not easy to date the abandonment of the *aflaj* system. However, this abandonment is likely to be linked to climate change and greater aridity that made the technology developed in Iron Age II unusable. This cultural phase, difficult to interpret, can be traced back to the arrival of a nomadic population that slowly assumes sedentary habits. However, the coexistence of a new population with local Iron Age populations cannot be excluded.

Compared to the Iron Age, PIR culture is characterized by the intensification of iron working, by the adoption of new technologies such as turning of soft stones, and by an increase of external exchanges and long-distance trades. Additionally, data related to the use of writing and the adoption of coinage were found (e.g., Mleilha and Dibba. Haerinck, 2003; Jasim, 2006; Mouton and Schiettecatte, 2014). Regarding the architectural aspect, the PIR settlements are characterized by towers and defensive structures, temples, and representative buildings (Mouton and Schiettecatte, 2014).

Different appears the situation in central Oman. Samad settlements have characteristics that can be defined as "local". Both housing and funerary structures appear to be less refined and more "rustic". Moreover, compared to the PIR sites, the presence of imported materials and productions is lower. (Yule, 1999b, 2016, 2018).

As said before, however, there are many elements of material culture that connect PIR and Samad cultures. It is therefore not clear whether these are two different cultures or if the divergent characters can be related to the geographical position of the sites studied. It is plausible, in fact, that the PIR sites, given their favorable position for trade and contacts with other populations, had greater external influences. Even the use of better finished materials in domestic and funerary architecture could be simply related to the raw material available and, therefore, to an easier workability of mountain and beach stones compared to those of wadi.

2.3 Funerary practices

Funerary practices and types of deposition are closely related to developments in society. As seen, various social and economic changes took place in Oman from the Neolithic to the Iron Age. These changes influenced the funerary practices of local populations.

2.3.1 Neolithic period

Few human remains were recovered dating before the V millennium BC. For this reason, funerary practices before this date are almost unknown. From the V millennium BC, however, some funerary sites were excavated. Most are located on the coast, except for the cemeteries of Jebel al-Buhais - BHS18 (Kiesewetter, 2006; Kutterer, 2010) and Jebel Faya - FAY-NE15 (Kutterer and De Beauclair, 2008) in the United Arab Emirates. In addition to the scarcity of archaeological data, the studies of Neolithic funerary practices in Oman present a significant imbalance between the data coming from the coast and those from the interior. Several factors can be recognized at the origin of this discrepancy. Among these factors, methodological problems related to the survey strategy, mainly focused on coastal areas, and conducted through small surveys, but also natural factors that would have influenced the conservation of the sites can be highlighted. It is also possible to hypothesize a difference connected to the funerary practices themselves or to the nature of the Neolithic anthropic sites (type of subsistence, density of occupation, size, and degree of mobility of the group) (Munoz, 2013).

Among the funerary sites excavated in Oman and dated to this period are those of Ra’s al-Hamra RH (Salvatori, 2007; Marcucci et al, 2010, 2014), the funerary complex of Wadi Shab GAS-1 (Gaultier et al., 2005), those of Suwayh SWY-1 and Al-Khuwaymah KHU-2 in the South (Charpentier et al., 2003; Munoz, 2013) and Ra's al-Khabbah KHB-1 (Munoz et al., 2010). Other tombs were excavated at Ra's al-Wuddaya WD-58 (Munoz, 2013), Ra's al-Jinz (Monchablon et al., 2003) and Ra’s al-Hadd HD-5 (Borgi et al., 2012; Borgi and Maini, 2020). Archaeological data revealed that during the Neolithic the graveyards were associated with the settlements (e.g., RH5, RH6, GAS-1). Graveyards were structured with the purpose of grouping the dead in the same place within the dwelling area. Although the burials were systematically grouped in a specific area of the site, sometimes the housing structures and those related to daily activities could overlap the burials (e.g., RH5 Area 43). Most of the tombs represent primary burials where the dead were laid on one side with limbs flexed in various ways (Santini, 1987; Charpentier et al., 2003; Gaultier et al., 2005; Salvatori, 2007; Munoz et al., 2010). Rather standardized ornamental objects, natural artifacts, and wildlife deposits (fish, shells, and turtles), perhaps interpretable as offerings or remains of funerary banquets, were found inside the burials. The pits were closed with stones whose appearance becomes more elaborate and structured over time.

Archaeological investigations conducted at the site of Ra's al-Hamra 5 (RH5) allowed to document the presence of multiple burials, including up to five people buried simultaneously (Salvatori, 2007). In populations of few people, most individuals probably had connections during life, such as family or emotional bonds. It is therefore probable that in the event of simultaneous or close death of some of these, they were placed inside the same pit (Munoz, 2013). There may also have been a practical reason behind the multiple depositions, such as the desire to save time and resources in the face of several contemporary deaths (Munoz, 2013).

Furthermore, excavations at RH5 showed that sometimes selected bones were laid in secondary burials. A similar datum, which would testify an attention and care in the conservation of some skeletal elements was documented in the site of Jebel al-Buhais 18 (UAE) where a series of beads was recovered wrapped around a human clavicle (De Beauclair, 2008).

2.3.2 Hafit period

The greatest number of archaeological remains relating to this period do not concern the inhabited areas, but the deposition areas. This chronological period is characterized by a new type of deposition. Tens of thousands of new single-room tombs made of local stone were replaced at the pit depositions of the previous period. These graves, known throughout south-eastern Arabia (Giraud, 2009; Deadman, 2012) are 4-5 meters high on average. They have the form of truncated cone towers, formed by two or three concentric walls built around a central chamber. The chamber is usually elliptical, and its main axial orientation is determined by the entrance, which was normally sealed by erecting the outer ring wall, or perhaps closed with mobile stones (Bortolini and Tosi, 2011; Bortolini and Munoz, 2015). The Danish archaeologist Glob (1959) was the first to find this depositional typology on the site of Jebel Hafit (Abu Dhabi, UAE) and it is from this site that they are named (Bibby, 1969; Frifelt, 1975; Bortolini and Tosi, 2011). As this is the most tangible feature of this phase, the same chronological period is called "Hafit period". The Hafit tombs have a considerable variability in the type of entrances, in the aspect that is influenced by the choice of the manufacturer and by the raw material and their internal articulation. The grouping of the dead in the same burial was, as seen, already practiced during the Neolithic. It is during the Hafit period, however, that the burials become "collective". These tombs, in fact, were built with the aim of lasting over time and provided a funerary camera that allowed the reopening and subsequent deposition of other individuals

(Bortolini and Tosi, 2011; Munoz, 2013). The poor state of conservation of human remains prevent, in most cases, a complete anthropological investigation. The scarcity of anthropological data, however, and the time duration of use, which could be several centuries, lead to see, as suggested by Munoz (2013), their collective character more in the intention that presided over the construction than in the reality of the deposits.

Despite the scarcity of anthropological study and the poor preservation of the remains, it was possible to reconstruct the number of individuals deposited within the Hafit towers, variable from 1 to 5. In some sites 20-30 individuals were found (Gregoricka, 2011; Munoz, 2013). According to the archaeological-anthropological reconstructions the deposition of the bodies, positioned on one side and associated with a great variety of accompanying goods, would have taken place in subsequent events (Frifelt, 1975; Salvatori, 2001; Cleuziou et al., 2011). These towers stood on top of the mountain ridges, almost marking the territory, and signaling the use of resources (Bortolini and Tosi, 2011). It has increasingly been claimed that the quantity and location of graves indicate a shift towards an economic oasis. Cleuziou (2009) suggested that the burials of the Hafit cairn "*can now be considered as indicating small palm tree gardens usually not visible to archaeologists, tapering springs or wadi gravels at some distance, which would have played a major role in the overall subsistence economy*".

In addition to the Hafit-type tombs, several depositions called "beehives" were found during this period (Potts, 1990; Hellyer, 1998; Gregoricka, 2011). Beehive tombs, like the Hafit ones, have a circular plan with a single internal chamber covered by a false dome. These burials are made of small pieces of limestone, have a smaller internal diameter and are slightly taller than the Hafit tombs.

The uniformity and standardized structural characteristics of the tombs from Hafit period suggests a cohesive and homogeneous population, characterized by regular contacts (Gregoricka, 2011). Furthermore, the spatial distribution of the tombs within the various necropolises seems to reflect the aggregation of different units which are supposed to be family (Munoz, 2013).

2.3.3 Umm an-Nar period

The changes happened in the Umm an-Nar period also modified the funerary aspects of the populations. Compared to the previous period, circular-plan tombs made of limestone have continued to be used. Compared to the Hafit tombs, however, the tombs of the Umm an-Nar period have significantly larger dimensions, ranging from 4 to 14 m in diameter. They have the shape of a monumental tower, like that of the settlements of this period. Probably the tombs had two levels (Cleuziou and Vogt, 1983; Al-Tikriti and Méry, 2000; Méry, 2010; Bortolini and Tosi, 2011). The Umm an-Nar tombs have a more complex internal structural articulation, with internal divisions forming two or more chambers with variable dimensions and shapes (Blau, 2001b; Potts, 2001; Guy and Munoz, 2020). Some tombs have internal divisions that require two separate entrances (McSweeney et al., 2008). The internal walls are made of local stones, while the external walls are made of carefully structured limestone blocks (Al-Tikriti, 1989a; Bortolini and Tosi, 2011).

The location of the Umm an-Nar tombs differs from those of the Hafit type. Inside the peninsula they generally arise on the plain, near the inhabited areas. Along the coast, on the other hand, they rise high on terraces, near fishing areas and inhabited areas. In both cases, therefore, proximity to an inhabited area seems to be a decisive criterion (Bortolini and Tosi, 2011; Munoz, 2013).

The monumentality and structural complexity of these tombs provided for a higher energy expenditure. This would presuppose the use of a larger workforce, perhaps obtained through the establishment of a social structure based on kinship (Bortolini and Tosi, 2011; Munoz, 2013).

The Umm an-Nar tombs were used for generations (200-300 years). They contained a few dozen to several hundred individuals (Al-Tikriti and Méry, 2000; Blau, 2001a; McSweeney et al., 2008; Munoz and Cleuziou, 2008; Méry, 2010; Bortolini and Tosi, 2011; Munoz et al., 2012; Bortolini and Munoz, 2015; Guy and Munoz, 2020). There does not seem to be a selection underlying the choice of people to bury. Individuals of all ages and both sexes were buried there. However, it appears that children under the age of 5 are underrepresented. Archaeological data from the settlements suggest that sub-adults may have been buried in homes, as evidenced by the finds in Ra’s al Jinz 2 (Cleuziou and Tosi, 2000). Most of the human remains found in the Umm an-Nar tombs are highly fragmented and disjointed. This is to be related to the selective stacking associated with the reuse but also to the various looting to which these tombs were subjected (Cleuziou and Vogt, 1983; 1985; Blau, 2001b; Cleuziou et al., 2011). In some cases, small fires appear to have been lit inside the tomb to remove further human debris. In Hili the post-mortem cut marks found on the remains suggest a deliberate disarticulation (Al-Tikriti and Méry, 2000; McSweeney et al., 2008). To create space inside the tombs, cremation seems to have been used throughout the south-east of Arabia (Blau, 2007; McSweeney et al., 2008).

As for the Hafit period, also in the Umm an-Nar period there was a second type of tombs used. Beside the circular tombs, more widespread, there are also tombs with a rectangular or ovoid plan (Méry, 2010). These tombs, found in Hili N and Mowaihat (Tomb B), are completely underground and consist of a pit covered with stone slabs (Haerinck, 1991; Al-Tikriti and Méry, 2000; Bortolini and Munoz, 2015). Like the others, also these contained the fragmented and disjointed remains of hundreds of individuals and did not show a selectivity in the choice of deposed individuals.

The main difference between this period and the Hafit period is in the large number of artifacts found in the tombs (Méry, 1997). In addition to ceramic findings, rings, beads, stone vases, seals, weights, copper objects and shells were also found (Potts, 1997), both locally produced and imported objects (Cleuziou et al., 2011; Bortolini and Munoz, 2015; Cleuziou and Tosi, 2020).

2.3.4 Wadi Suq period

The tombs of the Wadi Suq period, compared with those of the previous periods, show greater structural variability, with either monumental or modest burials, collective or individual (Bortolini and Munoz, 2015). Unlike the inhabited areas, the cemetery areas are well represented. Several sites were identified, such as Dibba, Jebel al-Buhais, Nizwa, Shimal, Wadi Suq (Frifelt, 1975; Donaldson, 1984; 1985; Vogt and Franke-Vogt, 1987; de Cardi, 1988; Hellyer, 1998; Vogt, 1998; Velde, 2003; Cleuziou and Tosi, 2020). Contrary to what has been assumed based on housing evidence, such a vast mortuary distribution seems to indicate the existence of a considerable population (Gregoricka, 2011).

As mentioned, a remarkable structural variety characterizes the tombs of the Wadi Suq period. The tombs of this period are made with large unworked stones and have variable morphology. Six types were identified (Gregoricka, 2011).

The Shimal-type tombs are built on earth and have a single oblong chamber (9-29 m long and 3.5 m wide) covered by huge stone slabs. The external walls are faced with unworked stones, while an internal layer is built with more massive stones. The accesses to the tomb are located on one of the long sides of the tomb (Hellyer, 1998; Potts, 1990; 2001). Examples of this typology were excavated in Dibba, Ghalilah and Shimal (Al-Tikriti, 1989b; Hellyer, 1998; Vogt, 1998; Riley and Petrie, 1999; Potts, 1990; 2001). Like the Shimal tombs are the Khatt tombs, which, however, are equipped with an external ring wall that surrounds the funerary chamber creating a passage (Hellyer, 1998; Potts, 2001). These tombs were only recognized in Bithna, Khatt and Shimal (Potts, 1990).

Another type of tombs is the Ghalilah-type ones. Ghalilah-type tombs have internal partitions which divided the chamber into several rooms (Potts, 1990). Like the previous ones, they were built on the surface. They could reach 11 meters in length and 6 meters in width (Potts, 1990; 1997). Examples were found in Ghalilah, Kalba and Shimal (Potts, 1990; Hellyer, 1998).
Other types are the Dhayah-type tombs, the horseshoe ones, and the circular ones. The former has a T-shape and are semi-underground (Potts, 2001). Examples of this typology are known from Bithna, Dhayah and Shimal (Kästner, 1991; Vogt, 1998; Gregoricka, 2011). Horseshoe tombs, on the other hand, were found along the east and west coasts of the United Arab Emirates, although in limited quantities (Hellyer, 1998; Potts, 2001). The circular plan typology, on the other hand, recalls the tombs of the previous period. Also, of this typology few tombs were found (in Ghalilah, Shimal, and Masirah Island: Potts, 1990; Vogt, 1998).
During the Wadi Suq period there was a significant increase in single depositions. Single depositions during this period are characterized by underground chambers covered in stone (Potts, 1990; 2001). Sometimes these lytic cysts are marked on the surface by stones or low mounds of earth. Examples of burials in lytic cysts were found throughout the Oman Peninsula (e.g., Shimal, al-Qusais, Wadi Suq: Potts, 1990; 1997; Vogt, 1998; Vogt and Franke-Vogt, 1987).
As for the Umm an-Nar period, a selection of the subjects placed inside the burials was not highlighted. In collective tombs, individuals were laid in an inflected position before being disturbed by subsequent burials. No traces of cremation were found (Vogt, 1998).

2.3.5 Late Bronze Age

In the Late Bronze Age, the archaeological documentation relating to funerary practices and depositional typologies is very limited. Few sites were dated specifically to this period: Nizwa, Qattara, al-Qusais al-Wasit and Daba LCG-1 (Velde, 2003; Genchi et al., 2012; Genchi, 2013a; 2013b; Magee, 2014; Yule and Weisgerber, 2015a). The dating was made based on the grave goods found inside the tombs. However, the distinction between the Late Bronze Age and Iron Age I tombs is not sure (Yule and Weisgerber, 2015a).
The tomb of Nizwa (N1985) is a warrior burial. The deposition arose between two large boulders and smaller stones that delimited the perimeter. The skeletal remains were not preserved and, therefore, it was not possible to reconstruct taphonomic and anthropological information.

The collective tomb W1 from al-Wasit site was largely destroyed and sacked at the time of the discovery (Yule and Weisgerber, 2015a). The shape of tomb W1 was conditioned by the surrounding topography. In general, the structure is like the Ghalilah-type tomb of the Wadi Suq period, but shorter. The analysis of skeletal remains revealed the presence of only 18 individuals buried. This would suggest a brief burial period (Yule and Weisgerber, 2015a).

The tomb LCG-1 from Daba funerary complex is another example of Late Bronze Age burial. It is a tomb with a completely underground rectangular chamber and entrances from the head of the perimeter wall. Contrary to the previous tomb, the LCG-1 contained the remains of several individuals (at least 188), thus testifying a prolonged use over time.

The scarcity of archaeological records and the morphological variety highlighted by the known sites makes difficult to clearly reconstruct funerary practices and deposition typology used during this transition phase.

2.3.6 Iron Age

In the Wadi Suq period, inventiveness and technical skills were manifested in new and vary funerary architectures. In the Iron Age, however, funerary architecture was characterized by the absence of innovation. During the first period of the Iron Age, two types of deposition were used. Hut tombs were used in central Oman, while individual or collective underground tombs were used in northern Oman (Jasim 2012; Yule, 2016).

From Iron Age II local communities often reused previous tombs or created simple single cairns (Fritz, 2010; Jasim, 2012; Pellegrino et al., 2019). Single burial cairns were found individually or in small groups. This type of deposition generally consists of shallow pit covered by irregular stones (Fritz, 2010; Düring et al., 2017). Iron Age tombs were found in very different environments, from wadi terraces to coastal sabkhas. This variety of locations is reflected in the diversity of their sizes and shapes.

During the Iron Age, the use of natural rock shelters, sometimes delimited by stone walls erected in front of the refuge, was also attested as a place of deposition (a very attested practice in Jebel al-Buhais: Jasim, 2012). The scarce typological funerary innovation, however, is not indicative of scarce manufacturing and production capacities. The burials, in fact, are characterized by rich and high-quality grave goods (Magee, 2014).

As for the Wadi Suq period, the use of both individual burials and collective depositions is attested. The excavations carried out on the Jebel al-Buhais site highlighted how it seems to be common practice to place the dead in a flexed position; males often on the right side while females on the left side (Jasim, 2012). Few data were documented concerning the treatment of the bodies in collective burials during Iron Age period. The continuous re-opening of the tombs caused the bones to be disturbed. In general, the quantity and quality of human skeletal remains from Iron Age tombs is poor, due to the post-depositional disturbances and the action of grave robbers.

2.3.7 Recent Pre-Islamic period

The communities of this period often reused previous tomb structures and depositional typologies (Mouton and Schiettecatte, 2014; Yule and Weisgerber, 2015b; Genchi, 2019, 2020). Sometimes the reuse of previous tombs carried out interventions on older tomb structures with the aim of creating new funerary chambers (e.g., Daba LCG-2. Genchi, 2019, 2020).

Different depositional types were detected in the excavated PIR sites. Some burials appear as underground cysts of different sizes (Haerinck, 2001; Mouton and Schiettecatte, 2014). However, the depositional typology which appears characteristic of the PIR deposition areas is the chamber tomb. The Mleiha site testifies the presence of depositional areas characterized by groups of tombs that would reflect the social organization of the living community. These groups, in fact, have some larger tombs in the center, with an underground chamber and surmounted by a tower or a monument in mud bricks. A series of simpler and smaller tombs are arranged around these monuments (Mouton and Schiettecatte, 2014). In older phases those monumental tombs housed the remains of a single individual. From the beginning of the first century AD, however, the tombs contained the remains of multiple individuals, testifying a passage from individual burials to collective burials (Mouton and Schiettecatte, 2014). While in Mleiha, however, the arrangement of the burials seems to indicate a spatial distinction between housing area and funerary sector, in Ed-Dur graves occur all over the site (Haerinck, 2001; Mouton and Schiettecatte, 2014). Furthermore, only sector N was identified as a clear concentration of tombs around a funerary monument (Haerinck, 2001).

In Samad culture, too, is attested the continuation of use of small underground cysts. These tombs, varying in length between 2 and 5 m, contained the remains of one or more skeletons. The coverage of these deposits consisted of stones placed just below the walking surface or deeper (Yule and Weisgerber 1988; Yule, 2018). Another typology is the plan one with rings formed by cantilevered stones that surround the funerary chamber (Yule and Weisgerber 1988). Characteristics of the Samad tombs is the presence of a heavy roof and a small retaining bar wall on the top of the entrance.

According to what reported by P. Yule (1999b, 2016, 2018) although similar in many respects, there are characteristics that allow to distinguish the PIR cysts tombs from the Samad ones. The Samad tombs are characterized by a more rustic appearance and are made of broken wadi stones, unlike the PIR ones where the materials are smooth. However, this could simply be due to the workability characteristics of the raw material itself.

As regards the taphonomic and anthropological aspects, little information is available regarding the PIR culture. While sporadic skeletal remains were found in Mleiah (Kutterer and Jasim, 2013; Kutterer et al., 2014), the discovery of skeletal remains in different burials at the Ed-Dur site made it possible to determine the absence of differentiations and specific rules related to sex or age. The individuals were placed on one side in a contracted position (Haerinck, 2001). In Samad culture, instead, men seem to be buried in richer clothes than women (Yule and Weisgerber 1988). Among the objects provided, the attributes relating to the sex of the deposed individual have always been documented. From a taphonomic point of view, the skeletons found showed that it was common practice to place male individuals in a contracted position on the right side, with the head facing east. Often the hands were brought in front of the face. As for female depositions, however, the clothes were less rich but always endowed with attributes related to sex. Sometimes the remains of a young goat and/or sheep were laid together with the individual. The females were also placed in a contracted position, usually on the left side and with their heads facing south or northeast. The hands were often brought before the eyes (Yule and Weisgerber 1988; Yule, 2018).

As explained, the origin of “collective” burials is closely related to the social developments of the populations (Fritz, 2010; Gregoricka, 2011; Munoz, 2013; Magee, 2014; Bortolini and Munoz, 2015; Cleuziou and Tosi, 2020). To understand the funerary practices that led to the formation of burial deposits containing the remains of several individuals, different sites were analyzed. A funerary context not clearly interpreted, and two collective tombs were considered in this study. These sites cover a very wide time span ranging from the Neolithic to the Iron Age. Specifically, the Neolithic cemetery of Ra’s al-Hamra 5 and the funerary complex of Daba al Bayah, dating from the Late Bronze Age to the PIR (*Pré-Islamique Récente*) period were analyzed. The data from these sites consist of both artifacts and biological human remains. How these data were collected and analyzed; plus, an assessment of this data and discussion of the interpretation of the data are presented in the following chapters.

Chapter 3. The sites

The research presented in this dissertation involves the study of two Omani sites. Before describing the methodologies used and the results of the analyzes of the data collected and assessed, an accurate introduction of the geography of the sites is presented, the history of the excavations and the funerary contexts of the graveyards are described.

3.1 Ra's al-Hamra 5

The first archaeological site described is Ra's al-Hamra 5, near Muscat (Oman). Specifically, the graveyard from this Neolithic fishing community is described.

3.1.1 Geography and ecology of the Ra's al-Hamra promontory

Ra's al-Hamra is the name of a tertiary calcareous promontory land formation located by the Oman gulf in the Arabian sea near the Omani capital city Muscat, in the suburb of Qurum[1]. The Surveys and excavations of this area led to the identification of fourteen archaeological sites located on the promontory (Marcucci, 2014; Cleuziou and Tosi, 2020). Two of these sites, which were extensively excavated since the 1980s, are the Neolithic sites of Ra's al-Hamra 5 (RH5) and Ra's al-Hamra 6 (RH6) (Biagi and Travers, 1985; Biagi and Salvatori, 1986; Biagi and Nisbet, 1992, 1999; Franceschini, 2006; Salvatori, 2007; Munoz, 2013; Marcucci, 2014; Marcucci et al., 2011, 2014; Cleuziou and Tosi, 2020). These archaeological sites are located near the estuary of the Wadi Aday, marking the most western point of the limestone formation of the Ra's al-Hamra landscape. This area is one of the more diverse and productive ecologically zones of the region. It connects the Arabian Sea shore with the lands of the interior portion of the promontory landscape. The *wadi* estuary and the mangrove that rises above it, in fact, represent a boundary between the flat sandy coast of Batinah and the rocky one of the Hajar Mountains. Several ecological niches (sandy beaches, mangrove swamps, rocky cliffs, tamarisk groves and acacia) coexist creating various ecosystems that made the promontory an ideal place for the development of the prehistoric population (Biagi et al.,1984, 1985; Salvatori, 2007; Marcucci, 2014). The fishing areas that opened on the other side of the promontory are

[1]Qurum is the arabic word for "mangrove".

an abundant source of food. Opposite the promontory, about two miles away, is the Fahal Island which marks the end of a narrow point on the continental shelf where phytoplankton, sardines, and other fish pass. The archeozoological data and the location of the RH6 site on the mangroves suggest that the main source of animal protein for this community was the collection of gastropods (Biagi and Nisbet, 1992, 1999; Munoz, 2013). The archeozoological remains from the RH5 site, on the other hand, suggest that fishing and harvesting of bivalve mollusks were the primary source of animal protein for these people (Biagi and Nisbet, 1992; Salvatori, 2007; Munoz, 2013). The remains of small herrings and sardines as well as larger fish, such as tuna and mackerel, were recovered from the site. In addition to fish, another food that the sea provided to the local population was sea turtles. The remains of sea turtles were found in abundance among the burials of RH5 and are considered grave offerings (Coppa et al., 1985; Salvatori, 2007; Munoz, 2013, 2020; Delfino and Frazier, 2020). The archaeological evidence for collecting marine resources includes shellfish deposits that came from local mangroves swamps and tools used for fishing; including shell-hooks, bone-hooks, gorges, and nets (Biagi and Travers, 1985; Biagi and Nisbet, 1992, 1999, 2006; Marcucci et al., 2011; Marcucci, 2014). The remains of goats and sheep were also found. The scarcity of faunal remains of goats and sheep leads to hypothesize that they were kept for dairy products and not for meat consumption (Salvatori, 2007; Cleuziou and Tosi, 2020).

3.1.2 History of the RH5 site excavations

The large shell-midden of RH5 (Figs. 3.1-3.2) is a critical feature of the site and it is an indication of the importance of marine resources for these people. It was also the focus of archaeological studies of the site by researchers attempting to better understand the life of these people. It was first excavated during the 1981 to 1985 field seasons by the Italian Archaeological Mission in Oman and Baluchistan of the Oriental Institute of the University of Naples. The direction of the excavation was entrusted to Tosi, professor of Palethnology at the University of Bologna, assisted by Salvatori and Biagi, who were helped by an important team of experts of various natural sciences (Biagi et al., 1984; Biagi and Nisbet, 1984, 1989; Biagi and Travers, 1985; Biagi and Salvatori, 1986; Marcucci, 2014). A second period of field work was undertaken from 2004 to 2005 and these field season excavations were conducted by the Italian Archaeological Mission which employed two research teams. The first team was led by Gasparini, Marcucci, Scaruffi and the second by Franceschini (Gasparini et al., 2005; Franceschini, 2006; Munoz, 2013; Marcucci, 2014). In 2008-2010, the Italian Archaeological

Expedition to Oman, under the direction of Tosi, assisted by Marcucci and Munoz, continued the research in the settlement and in the graveyard (Marcucci and Genchi, 2008; Marcucci et al., 2009, 2010, 2011; Munoz, 2013; Marcucci, 2014). The new field campaigns showed that the graveyard extended towards the northern part of the site.

The excavations of the RH5 settlement revealed at least 7 phases of habitation of the area, related to the community of fishermen-gatherers who inhabited the area between the end of the 5th and the 4th millennium BC (Biagi and Nisbet, 1984; Biagi and Salvatori, 1986; Biagi, 1994; Salvatori, 1996, 2007; Santini, 2002; Franceschini, 2006; Marcucci et al., 2010, 2011). The settlement was formed by circular huts built with light branches and other plant material supported by a framework of wooden poles using of mangrove, juniper and acacia trees arranged in a C-shaped pattern. The absence of post holes at the center of the structure suggest that the roof consists of a light covering of twigs, leaves and small branches that formed a low dome (Marcucci et al., 2011; Marcucci, 2014; Cleuziou and Tosi, 2020). The number of huts found at each phase suggests that no more than 25-30 individuals lived at the site at any one time (Biagi and Salvatori, 1986; Cleuziou and Tosi, 2020).

Figure 3.1. The coast of Oman and the location of the Qurum promontory (Google Earth Pro, 2020a).

Figure 3.2. The Qurum promontory with the specific location of the Neolithic fishing site of Ra's al-Hamra 5 (RH5) (Google Earth Pro, 2020b).

3.1.3 The RH5 graveyard excavations

The graveyard, located in the north-eastern part of the site, covers an area of about 200 square meters (Marcucci et al., 2011). The most eastern part of the graveyard is eroded, along an N-S axis, by one of the runoff lines of surface waters. Chronological assessment of the graveyard indicated that the burials date between 3800 and 3300 BC., corresponding to Phases III-VII of the inhabited area (Biagi and Salvatori, 1986; Biagi, 1994; Salvatori, 2007; Marcucci et al., 2011). The graves have been divided stratigraphically into three different levels. The observation of the topographic data related to settlement and graveyard allow to detect a gradual northward shift of the settlement area during the last phase of the graveyard, transporting a section of the graveyard towards North. The shift does not seem to have reached such proportions as would have distinguished it from normal spatial oscillations of settlement areas through time (Salvatori, 2007).

During the excavations, 143 tombs were discovered, with at least 259 individuals (Salvatori, 1996, 2007; Franceschini, 2006; Marcucci et al., 2011; Munoz, 2013). Burials usually had an oval or sub-oval pit and a shallow basin. It appears that there were four burial types distinguished based on covering: simple pit graves, pit graves with tumulus stone coverings, pit graves with flat stone coverings and cist graves with flat stone coverings (Munoz, 2013). The human remains always lay in contracted positions, usually oriented NE-SW, and on their right side. The grave goods were few, mainly objects of personal adornment. Often individuals were associated with different faunal remains. Remains of sea turtles might demonstrate the ideological importance of this animal for these peoples.

In many cases the burial pits held multiple individuals, often adult females were deposited with sub-adults. The graveyard also yielded secondary deposition burials, both single and multiple set of remains. The interpretation of these burials might be connected to factors such as type of death, place of death, status of individuals (Coppa et al., 1985; Biagi and Salvatori, 1986; Salvatori, 2007).

In general, the excavation of the graveyard of Ra’s al-Hamra 5 provides important data for understanding the beliefs and lifestyle of the Neolithic fishing community. This is supported by the archaeological artifacts recovered, the characteristics of the grave pits and other critical features of the site (Salvatori, 2007).

3.1.4 The Area 43

In the southwestern portion of the graveyard, across the line of overlapping of the graveyard with the settlement, just below the deflation pavement, was excavated a large concentration of human bones. The area was labeled "Area 43". During the first stages of excavation of the graveyard, the first concentrations of human bones were labeled as individual graves (G. 18, 19 and 20). Later, after archaeological and anthropological assessment, it became clear that they belonged to a more generalized distribution of skeletal remains. At the time of its discovery back in 1981, Area 43 was referred to as "tomb 43", but the complexity of the entire excavation and the difficulty of understanding its limits, forced Salvatori to change the qualification for this "dispersion" (Salvatori, 2007; Munoz, 2013). Area 43, therefore, was determined to be a vast area of partially burned, highly fragmented and commingled osteological remains. These remains were interspersed with limestone and peridotite blocks, with a few artifacts and faunal remains (turtle, fish, mammal, and shells). These were buried without any apparent coherence or pattern (Fig. 3.3). Studies done on the human skeletal remains from RH5 include in the Area 43 also the single Graves 19 and 20 and the multiple Graves 42, 68 superior, 68 inferior and 69 (Biagi and Salvatori, 1986; Santini, 2002; Salvatori, 2007). These tombs were from the same topographical area of the graveyard and were attributed to Area 43.

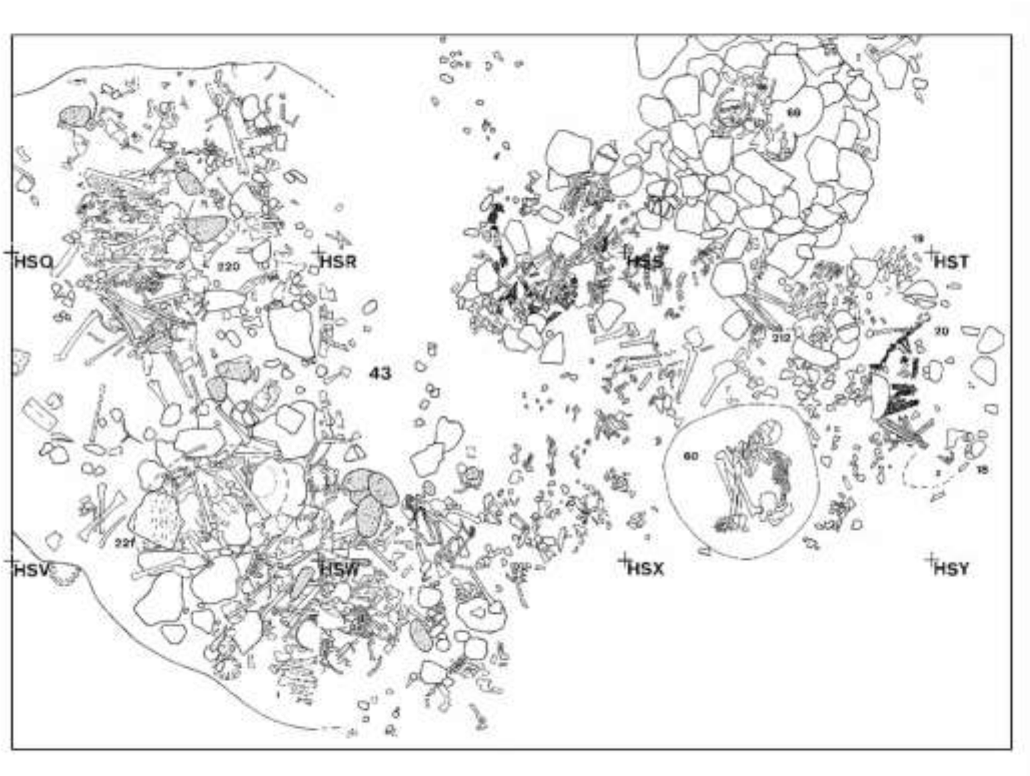


Figure 3.3. A modified map of Area 43 with recovered burials as it was excavated at the end of the 1984 campaign (Salvatori, 2007).

The excavation of Area 43 was conducted by subdividing the area (56 square meters) into 2 meters quadrants labeled as HSL, HSM, HSN, HSQ, HSR, HSS, HSV, HSW and HSX. Some of the skeletal remains recovered from Area 43 were labeled using quadrants' names. Other remains were labeled "Rif.0". According to the RH5 field notes from 1984-1985 excavation, "Rif.0" seems to be referred to commingled skeletal remains removed from the HSL quadrant. Based on this information all the human skeletal remains labeled as "Rif.0" analyzed in this dissertation were attributed to the HSL quadrant. All the quadrants were excavated during the years 1981-1982, except for the HSL, HSQ and HSV quadrants that were brought to light during the 1985 excavation campaign. This last excavation allowed the attribution of the area to stratigraphic levels 3a and 3b of the inhabited area (Biagi and Nisbet, 1989).
Santini (2002) proposed an interpretation of this area based on excavation documents. She suggested that Area 43 was formed by six different human burial clusters, labeled 43.1-43.6 (Fig. 3.4). The stratigraphic relationship between clusters was confused by subsequent disturbances. The analysis of stratigraphic and archaeological data had provided Santini with data to suggest that they might represent a critical change in funerary rituals for this Neolithic fishing community. This change would take place at the end of the graveyard and settlement sequences, in a period in which "*the population had undergone a process of collectivization of resources*" (Santini, 2002).

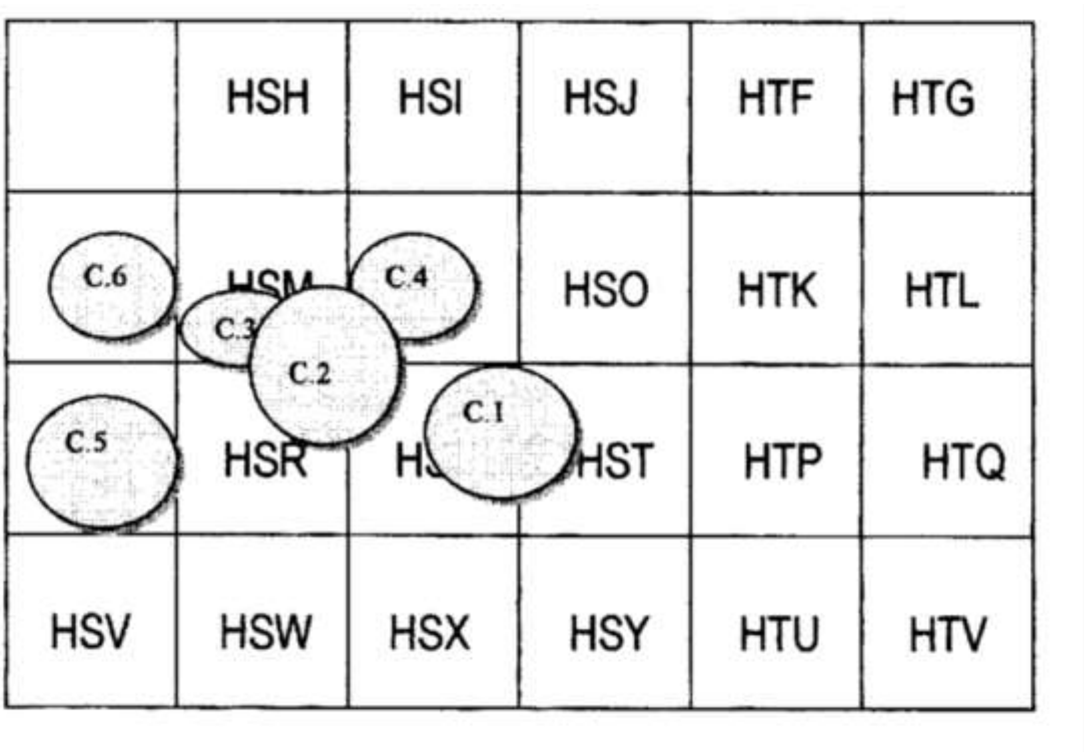


Figure 3.4. A schematic reconstruction of the position of the six clusters of human remains from Area 43 (Santini, 2002).

A few years later, Salvatori (2007) characterized the Area 43 as "multiple secondary burials". In doing so he speculated a number of scenarios that might possibly explained this change in burial ritual as seen in Area 43. Several of these possible explanations that Salvatori (2007) suggested is catastrophic in nature or the change in burial ritual represents the arrival of a new cultural group in the area. In the end, Salvatori (2007) acknowledged that Area 43 remains difficult to interpret due to the numerous post-depositional disturbances, the action of fire and the dispersion of exposed rocks, and that significant erosion in this part of the site had considerably altered the initial deposit (Salvatori, 2007).

The skeletal remains and archaeological data from Area 43 been reanalyzed. The aim of this study is to understand the causes that may have led to the formation of this area of the graveyard. Several hypotheses were developed (or formulated) and they are the focus for this portion of the dissertation:

1) Hypothesis 1 - catastrophic event (H1): the formation of Area 43 could be related to a catastrophic event that would have caused the death of a large number of people in a short period of time. Two scenarios were analyzed: the onset of an epidemic event, the development of a conflict between groups.
    a. H1a. An acute epidemic event killed the humans placed in Area 43. This would be supported by a lack of skeletal lesions seen among the remains.
    b. H1b. An acute violent event (warfare) is responsible for the deaths seen in Area 43. This would be supported by defects in the skeletal remains associated with trauma.
2) Hypothesis 2 - coexistence of different groups or differences within the same population (H2): the presence of grave goods not found in similar percentages in other areas of the graveyard allowed to suggest another theory. The temporary presence of opposing groups, with different funerary practices, was hypothesized. The differences in archaeological remains, however, could also be the manifestation of differences within the same population. Both hypotheses were considered.
    a. H2a. The site of RH5 was occupied by two different groups of Neolithic fishing communities. Evidence to support this hypothesis would come from the archaeological record.
    b. H2b. Burial practices of the fishing people of RH5 changed over time. Supporting evidence for this hypothesis would come from archaeology

and chronology of the burials.

3) Hypothesis 3 - removal and stacking of the remains (H3): the observation of the excavation plants highlighted the presence of anthropological remains arranged in an apparently orderly disposition. This led to also consider another hypothesis. Area 43 could be the result of interventions for the removal and reorganization of funerary spaces. The burial remains were found as they are due to different burial practices by a single community who lived in the area for an extend period of time, carrying out various interventions of reorganization of the area. Evidence to support this hypothesis may come from the remains themselves and from the archaeological interpretation of their placement within Area 43.

3.2 Daba al Bayah

The second site studied for the purpose of conducting funerary and health related issues in writing this dissertation comes from the funerary complex of Daba al Bayah, located on the Musandam Peninsula of Oman (Figs. 3.5-3.6). The complex includes graves dating from the Late Bronze Age to the PIR (*Pré-Islamique Récent*) period (Genchi et al., 2012, 2018, 2021; Genchi, 2013a, 2013b, 2015, 2019, 2020).

3.2.1 Geography of the site

Musandam is the smallest and most northern region of Oman, covering an area of around 3000 square km. It is separated from the rest of Oman by the United Arab Emirates. The gateway to Musandam is the Wilayat of Dibba, 112 km from Khasab. It occupies the southeastern tip of the Musandam Peninsula, bordering the United Arab Emirates in the south and the Gulf of Oman in the east (Genchi, 2013b). The geographical position of the Musandam, into the Strait of Hormuz and only 50 km away from Iran, gives the area a strategic dominance on one of the busiest shipping routes in the world (Genchi, 2013b, 2020; Genchi et al., 2018). The geomorphology of Musandam is characterized by drowned wadi systems along the north and east coasts. These drowned wadies create fjords with sea-cliffs hundreds of meters high (Searle, 2019). This characteristic aspect of the coastal line led the area to obtain the name 'fjords of Arabia' (Magee, 2014). Several marine fish species inhabit the waters adjacent to the Musandam Peninsula. The coasts of the Peninsula are famous for hosting sharks, manta rays, sailfish, guitarfish, sawfish, dolphin, and many other small fish species (Searle, 2019). The internal territory of the peninsula is substantially mountainous, and the al-Hajjar mountain range dominates the landscape (Genchi, 2013b). The highest peaks of the Musandam, including Jabal Yibir, are just over 2000 m above sea-level and lie only 4–6 km from the east coast (Searle, 2019). Among the species inhabiting the Musandam mountains, Arabian gazelles, caracals, and wolves are found today (Searle, 2019). The morphology of the area has always made fishing one of the main sources of livelihood for the local population. It is probable that the populations of the past also exploited the wadi. Local oases could have been used in the growing of agricultural products. However, specific studies have not yet been carried out for examining these issues from Musandam archaeological sites.

Figure 3.5. The coast of Oman and the location of the Daba al Bayah funerary complex (Google Earth Pro, 2020c).

Figure 3.6. The specific location of the Daba al Bayah funerary complex in Musandam Peninsula (Google Earth Pro, 2020d).

3.2.2 History of site excavations

The Daba al Bayah funerary complex, placed near the border between the Oman Musandam region and United Arab Emirates, was accidentally discovered in the summer of 2012 during a construction project to add an extension to a local sports center. The archaeological site is composed of two large collective graves that contains hundreds of individuals accompanied by thousands of valuable artifacts (Genchi et al., 2018, 2021; Genchi, 2020; Frenez et al., 2021. Fig. 3.7). The area was initially excavated, in September-November 2012, by Omani archaeologists of the Ministry of Heritage and Culture. After this brief period of excavation, the investigations were conducted by an Italian team that continued the excavation of the first collective tomb (labeled LCG-1). The archaeological work was done by the Italian team in April of 2013. The team also investigated, via trenches, the area surrounding the LCG-1 tomb and found several ritual pits containing many valuable objects and the remains of a second grave structure. Successive campaigns by the Italian team completed the excavation of the LCG-1 and started to investigate the second tomb structure (labeled LCG-2). Excavations in the LCG-2 tomb are still in progress. Anthropological and archaeological data from these excavations are used to support the research specific to this dissertation.

Figure 3.7. General plant of the Daba al Bayah funerary complex (by F. Genchi).

3.2.3 The Large Collective Grave 1 (LCG-1)

The tomb has rectangular shape with a length of 14.75 m and a width of 3.50 m for a total area of 49 sqm (Genchi, 2020. Fig. 3.8). The foundation and the lower part of the walls are made with large natural blocks, with rounded sides and with the internal face almost flat, disposed on at least 6-7 rows. The lowest stone block rows are very large in size, while the uppermost blocks of stone are smaller and more irregular. Above the walls a false vault covered the tomb with large slabs arranged partially overlapping toward the center line. A later phase of use of the tomb is marked by large stone slabs arranged in flat position to create a floor. These slabs cover a first layer of human bones and are significantly used as a floor of the second phase. The tomb is characterized by two entrances, accurately made of limestone rectangular blocks, one flat stone is used as threshold and others vertical slightly inclined toward the center at the top. The external walls in the western part are made of limestone blocks with flat and accurate faces.

The excavation conducted by archaeologists of the Omani Ministry of Heritage and Culture in the period between September and November 2012 was concentrated mainly in the exploration of the tomb, through the recovery of thousands of metal objects originally associated with the deposition of individuals. During this excavation little attention was given to the stratigraphic excavation techniques and to the methods of documentation and recovery of osteological remains. This led to the complete loss of taphonomic information. During 2013-2014, an Italian team continued the excavations applying a careful excavation methodology (Genchi, 2013a, 2013b, 2020). At the bottom of the grave, eight niches, labeled from A to H, were identified along the long sides of LCG-1. The niches have different dimensions and characteristics and host the remains, formerly skulls, of several individuals. Niches A and D, on the short sides of LCG-1, are made by big blocks placed horizontally and linked to the wall of the tomb. The absence of slabs to support these large stones allow hypothesize that niches A and D were planned when LCG-1 was built (Fattore, 2013). On the other hand, niches B, C, E, F, G and H are characterized by large, elongated slabs placed horizontally and supported by two large boulders placed at the edge and resting on the base of the tomb. The interior space on niches was occupied by the depositions of human bones, most likely not in primary position but moved in the niches later. This practice is necessary to create space for other individuals buried in the great tomb. The archaeological deposits preserved below the niches showed the presence of some skulls and other bones scattered. The materials found during the excavation of the tomb allowed it to be dated between the Late Bronze Age (1500-1300 BC) and the Early Iron Age (1350-1100/1000 BC) (Genchi et al., 2012; Genchi, 2013a, 2013b, 2020).

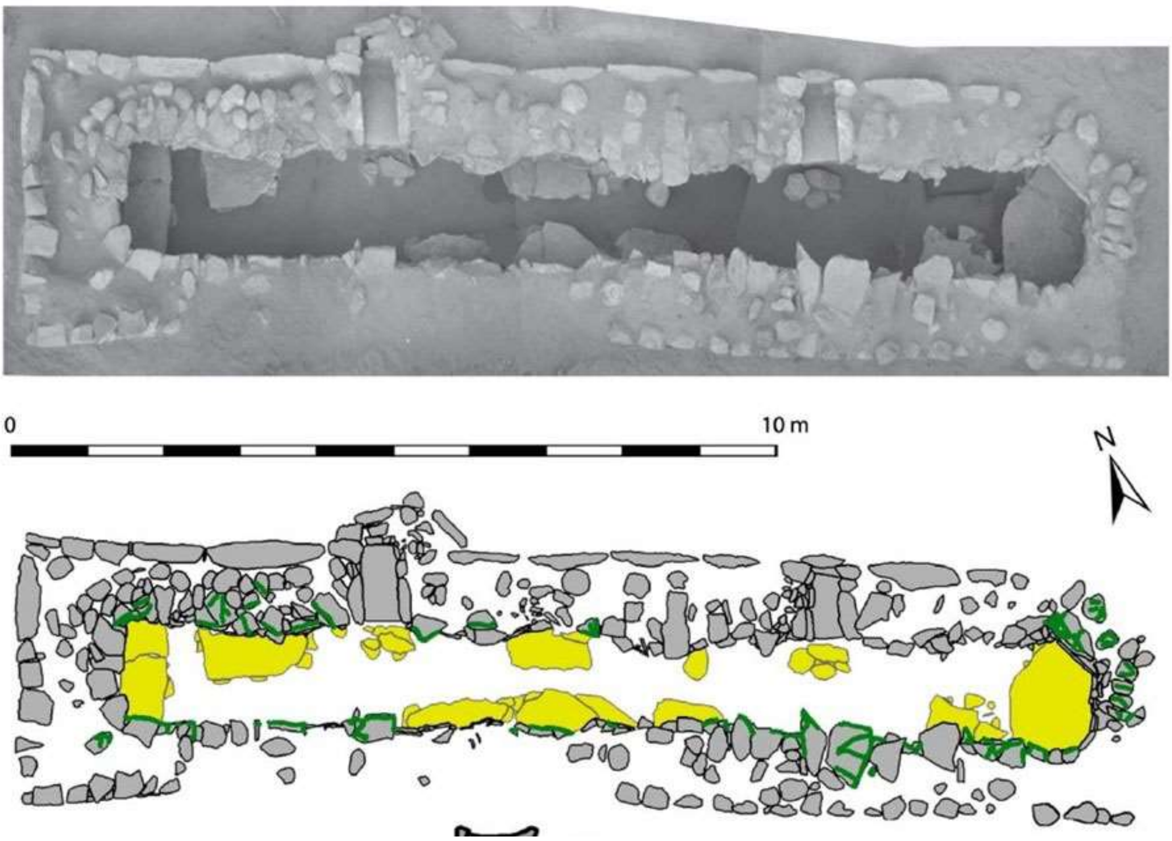


Figure 3.8. Photogrammetry and final plant of the Daba LCG-1 tomb (by F. Genchi).

3.2.4 The Large Collective Grave 2 (LCG-2)

LCG-2 is a collective rectangular-shaped structure, which developed partially on the surface (Fig. 3.9). The grave is dated from the Early Iron Age (1350-1100/1000 BC) to the PIR (*Pré-Islamique Récente*) period (300 BC-300 AC) (Genchi, 2020).

While LCG-1 tomb is subterranean, LCG-2 is a semi subterranean tomb. The continuous visibility of this tomb and the easier access to the structure led to several interventions over the centuries. LCG-2 tomb shows an intense and prolonged use characterized by changes in human burial deposition modalities (Genchi, 2015, 2019, 2020; Nava et al., 2015; Fattore et al., 2015, 2018; Genchi et al., 2018, 2021; De Cataldo, 2019; De Cataldo et al., 2020a). The excavation, conducted in a systematic and methodological way, allowed to document the use of the funerary space of LCG-2 tomb extended over time.

The upper layers of excavation were characterized by scattered and fragmented bones. These features cannot be interpreted as intentional depositions. This might be related to a period of abandonment of the site. The underlying layers yielded groups of human bones, deposited as voluntary secondary deposition actions. These archaeological features are referred to as Bone

Clusters (BC). In the bottom layers of the grave primary burial depositions were excavated. Recent archaeological assessment of the site indicates that those primary depositions are more recent than human remains from Bone Clusters. The mixing of remains and artifacts at the site are most likely linked to the action of making room for new burials (labeled as Chambers A, B, C, D, E, F, G, H, I, J, K).

Figure 3.9. Photogrammetry of the Daba LCG-2 tomb at the end of field season 2017 (by F. Genchi).

- *Bone Clusters*

The Bone Clusters are groups of human bones, deposited at the site as voluntary secondary deposition actions (Genchi, 2015; Nava et al., 2015; Fattore et al., 2015, 2018). Three types of Bone Clusters (BC) were detected during field campaigns: spot, wide and tridimensional. The spot clusters (BC 01, 02, 11, 12, 13, 16, 17, 18, 19, 21, 27, 32, 36, 41, 55, 56, 57, 60 and 61) are isolated skulls or assemblages of few bones placed in a well-defined space (purposely used feature). The term wide clusters (BC 08, 26, 29, 31, 37 and 48) refers to assemblages of human bones not delimited spatially and with vague borders. The tridimensional clusters (BC 09, 23, 24, 33, 38, 40, 51, 59, 62) are accumulations of bones characterized by a precise spatial organization in the three dimensions. In addition to these three types, sporadic bone accumulations were found, probably related to the practice of moving and accumulating osteological remains (BC 03=25, 04, 05, 06, 07, 14, 20, 22, 28, 29_under, 34, 35, 39, 42, 43, 44, 45, 46, 47, 49, 50, 52, 53, 54, 58).

- *Primary burials*

Several primary burials were excavated (Fattore, 2013; Fattore et al., 2015, 2018; De Cataldo, 2019; De Cataldo et al., 2020a). From the archaeological record, the primary burials are dated between the Early Iron Age and the Pre-Islamic Period (Genchi, 2019, 2020; Genchi personal communication Sept 4th 2020; Tab. 3.1). Fifty-eight primary burials were recovered. Fifty-two burials contained the skeletal remains of a single individual. Three burials contained two individuals each. All the three double burials contained skeletal remains of two sub-adult individuals (6A-B, 18A-B, 20A-B). In three burials (Burial 14, Burial 52, and Burial 58) laid the remains of several individuals. One of these burials (Burial 52) is still under excavation and is not considered in the demographic and paleopathological analysis of this dissertation.
Thirty-six burials were found inside the main chamber or near the LCG-2 tomb. The remaining twenty-two burials were excavated inside chambers built on the original walls of the tomb. Inside Chamber A were excavated six depositions (Burials 27, 31, 39, 44, 45 and 46). One double burial (Burial 20) and one multiple burial (Burial 58) were excavated inside Chamber E. Three burials (Burials 21, 28 and 30) were found inside Chamber F, one inside Chamber D (Burial 15) and two inside Chamber G (Burials 23 and 25). From Chamber H came a single primary deposition (Burial 26). In Chamber I the remains of two individuals were excavated (Burial 36 and 38) and two individuals were found in Chamber J (Burial 29 and 32). Three burials were excavated inside Chamber K (Burials 47, 54 and 57).
Two burials were found related with Bone Cluster. Burials 24 laid under the BC 51. Burial 11 was inside the BC 40, over the skeletal human remains of the bone assemblage.

Table 3.1. Localization and chronology of primary burials from Daba LCG-2.

Location	EIA	LIA	PIR	Total
Inside LCG-2 tomb	15	8	0	23
Inside Chambers	7	10	6	23
Near LCG-2 tomb	4	8	0	12
Total	26	26	6	58

EIA: Early Iron Age; LIA: Late Iron Age; PIR: *Pré-Islamique Récent*.

- *Orientation and position of burials*

Great variability was documented regarding the orientation of the primary burials from the Daba LCG-2 tomb (Fattore, 2013; Fattore et al., 2015; De Cataldo, 2019). Burial orientation is defined by the direction of location of the head versus the location of the feet. Thirteen individuals were orientated N-S, fifteen individuals E-W, nineteen individuals were orientated S-N and nine individuals W-E. Three individuals were orientated in a NE-SW position, three individuals were orientated in a SE-NW position, three in a SW-NE position and five in a NW-SE position (Tab. 3.2). It was possible to define the direction of the face for forty-four individuals only. Fourteen individuals had the skull facing west, twelve individuals were buried facing east. Six individuals laid with the skull facing north and seven individuals laid with the skull facing south. Of the remaining five individuals, three were buried facing south-east, one facing southwest and one facing east/south-east.

There is also a considerable variability in the positioning of the human remains (Tab. 3.2). Typical positioning includes prone, supine, lateral left, and lateral right. Thirty-nine individuals laid in lateral position, specifically thirteen on the left side and twenty-six on the right side. Three individuals laid in prone position, twelve in supine position, five individuals presented the upper body in prone position and the lower limbs flexed to one side. The remaining eleven individuals had the upper body in supine position with the lower limbs flexed to one side. Almost all the individuals had flexed or hyper-flexed lower limbs.

Regarding the position of the limbs, individuals buried in the Daba LCG-2 tomb had usually flexed upper limbs. Some individuals had upper limbs flexed bringing one or both hands near the skull. Other individuals had upper limbs crossed under or over the chest. Some other individuals had upper limbs extended along the body.

Table 3.2. Orientation and body position of human skeletal remains from the Daba LCG-2 primary depositions.

	Supine	Prone	Lateral L	Lateral R	Supine/lateral	Prone/lateral	TOT
N-S	3	--	3	4	2	1	13
NE-SW	1	--	--	1	1	--	3
E-W	1	1	6	5	2	--	15
SE-NW	1	--	--	1	--	1	3
S-N	3	1	2	7	4	2	19
SW-NE	--	--	1	1	1	--	3
W-E	2	1	1	3	1	1	9
NW-SE	1	--	--	4	--	--	5
TOT	12	3	13	26	11	5	70

- *Chamber A*

Chamber A was excavated during the 2017-2019 field campaigns. Chamber A is a big rectangular chamber built on the west wall of LCG-2 (Genchi, 2019). During the excavations, several human skeletal remains were recovered. The highest level of the chamber was characterized by scattered bones and five skulls, arranged without apparent spatial organization. Continuing the excavation, the remains of a primary deposition intruded upon was found (Burial 27).

In the lower layers of the Chamber scattered and commingled human skeletal remains, primary burials and several grave goods were recovered. During the excavation, the commingled remains were divided into two large groupings. The remains positioned on the highest level were better preserved and mixed with a huge number of archaeological artifacts (swords, beads, daggers, ceramics, and bronze vessels). The grouping below, on the other hand, was characterized by bones in a poor state of conservation and by a smaller quantity of grave goods. These two large groupings were in the northern part of the chamber. Two primary depositions (Burials 31 and 39) were highlighted in correspondence with these two groupings but in the southern part of the chamber. After the removal of the commingled bones and the two primary depositions, in the lower level of Chamber A, three primary intruded depositions were found (Burials 44, 45, 46).

- *Chamber B*

Chamber B was excavated during the 2014-2019 field campaigns (Fattore et al., 2015; De Cataldo, 2019). Chamber B is a chamber built on the east wall of the LCG-2 tomb. The chamber is subcircular. During the first field excavation the diameter of the chamber was 1.23 m. The diameter increased during following field excavations. At the end of the excavation the chamber reached a depth of 1.64 m. Inside Chamber B was found a deposition with at least 17 individuals. Twelve individuals were in complete or partial anatomical position (Burial 14, individuals A-B-C-G-H-I-J-L-N-O-R-S). Seven scattered skulls (labeled as 14D, 14E, 14F, 14K, 14M, 14P, 14T) and other commingled bones of adults and sub-adults individuals were excavated. During the excavation different layers of depositions separated by few millimeters of soil were recorded. The almost complete absence of archaeological grave goods from Chamber B does not provide a chronological division of the primary depositions (De Cataldo, 2019).

Chapter 4. Material and methods

This research involves the study of human remains from the two Omani sites of Ra’s al-Hamra 5 and Daba al Bayah.
From the graveyard of Ra’s al-Hamra 5, human remains from Area 43 were analyzed.

From the funerary complex of Daba al Bayah a preliminary study of the human remains from both the LCG-1 and LCG-2 tombs was assessed. Mandibles, maxillary bones, and teeth from LCG-1 were analyzed to reconstruct a minimum number count for these skeletal remains. Additionally, paleopathological studies of dental and oral pathologies were conducted.
The study of the human remains from the LCG-2 tomb consisted in the analysis of individuals from primary burials (73). Additionally, a preliminary analysis of the human remains from Chamber A and Chamber B of the Daba LCG-2 tomb was assessed to reconstruct a minimum number count for the two chambers.

Different methodologies were applied in the analysis of skeletal remains from Area 43 of Ra’s al-Hamra 5 and from the LCG-1 and LCG-2 tombs of Daba al Bayah.

4.1 Determination of the Minimum Number of Individuals (MNI)

Commingled and scattered human remains were studied to determine the minimum number of individuals (MNI) buried. The MNI was determined by counting the most represented osteological element (Lambacher et al., 2016). Since adult and sub-adult bones can be identified and separated, specific counts for each were obtained. The results were then combined to provide a complete MNI count. Stage of skeletal development, dental eruption and burial position were also considered, hence providing a more accurate total MNI result.
The MNI for the human remains from the Daba LCG-1 tomb was determined based on alveolar sockets count for adult individuals. For sub-adults skeletal remains the MNI provided was determined based on skeletal element count and dental eruption.

4.2 Age and sex assessment

Human remains were analyzed to determine the sex and age at death for the individuals buried. Long bone fusion rates and dental eruption patterns set the criteria by which sub-adult bones were determined (Ubelaker, 1989; Scheuer and Black, 2000; Schaefer et al., 2009). For adult age determination different methods were used to provide a more accurate age at death. Observation of dental wear, analysis of the obliteration of cranial sutures, analysis of pubic symphysis, of auricular surface and of humerus and femur spongiosa are used for adult individual (Todd, 1920; Brothwell, 1981; Lovejoy, 1985; Meindl and Lovejoy, 1985; Brooks and Suchey, 1990). In some cases, the morphological and dimensional characteristics of the skeletal elements were also considered to distinguish between adult and sub-adult individuals. For adult individuals, the sex was determined. The determination of sex was performed by analyzing the morphological differences of skull and pelvis according to the Acsádi and Nemeskéri method (1970).

4.3 Demographic assessment

Once the age at death for each burial was determined, it was possible to reconstruct a life table. To avoid overestimating or underestimating certain age groups, individuals whose age covered different age groups were proportionally distributed within the groupings. The life table was created following the standard methodologies reported by Ubelaker (1974) and Chamberlain (2006) and assuming a stationary population model (R=0). Age groupings were created: 0-4, 5-9 10-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60+. The number of people alive in each group was calculated as ax. The ax variable was created subtracting the number of individuals attributed to each age group (Dx). Once the ax variable was created, it was used for determining the number of survivors for each age interval (lx). The lx variable was created dividing each ax for the total number of individuals used for life table assessment. The percentage of total deaths occurring in each age interval (dx) was determined subtracting each lx from the lx of the previous age group. The dx and lx variables were used to determine the probability of dying at each age interval (qx). It was created dividing each dx with the corresponding lx. The total number of years lived (Lx) between one age interval and the following one was determined using the formula 5(lx+lo)/2 for each age group (Ubelaker, 1974). Each Lx was summed with the following ones to define the total number of years lived after a lifetime of all individuals who reach the age interval (Tx). Life expectancy (ex) was determined dividing Tx by the corresponding lx.

Additionally, formulas proposed by Bocquet and Masset (1977) for stationary populations were used to void the problem of under-representation of younger individuals. These formulas allow to calculate the life expectancy at birth (e_0) and the mortality rates in the first year of life (${}_1q_0$) and in the first 5 years of life (${}_5q_0$). These formulas are based on the Juvenility Index (JI), the ratio between the number of individuals who died between 5 and 14 years and the number of individuals aged 20 years and above ($X = \frac{D_{5-14}}{D_{20-x}}$). The formula used to reconstruct the life expectancy at birth is $e_0 = [(78.721 \times \log_{10} \sqrt{1/X}) - 3.384] \pm 1.503$. The formula used to reconstruct the mortality rate in the first year of life is $1q_0 = [(0.568\sqrt{\log_{10} 200X}) - 0.438] \pm 0.016$; while the formula used for the mortality rate in the first 5 years of life is $5q_0 = [(1.154\sqrt{\log_{10} 200X}) - 1.014] \pm 0.041$.

4.4 Paleopathological analysis

The osteological human remains were analyzed for paleopathological lesions. Lesion types include pitting, lipping, bone growth, bone loss and bone eburnation. The bone fragments were organized into recognizable skeletal elements. Once the skeletal elements were organized, specific lesions were identified using standard methods (Ortner and Aufderheide, 1991; Campillo, 1993; Aufderheide and Rodriguez-Martin, 1998; Ortner, 2003; Brinkley and Ives, 2008; Waldron, 2009; Grauer, 2012).

Occipital, parietal, frontal, maxilla, sphenoid, and mandible were analyzed for cranial pitting. From this assessment dietary deficiency and infections like scurvy and anemia were assessed (Angel, 1967; Goodman and Martin, 2002). For oral pathologies such as periapical lytic lesions (abscesses, cysts, granulomas) and antemortem tooth loss, mandible and maxillary bones were examined. Bone loss along the alveolar surface, bone resorption along the tooth sockets and dental related lytic lesions were considered (Lukacs, 1989; Hillson, 1996; Valletta et al., 1997; Waldron, 2009). Teeth were assessed for caries. Caries is the most common lesion. It affects the calcified teeth tissues and is related to high sugar and carbohydrates diet. If caries is not treated correctly the bacterial infection can affect the alveolar bone manifesting as abscesses or causing tooth loss and consequent alveolar reabsorption (Lukacs, 1989; Hillson, 1996; Aufderheide and Rodriguez-Martin, 1998).

Bone growth and bone loss as indicators of osteoarthritis, Schmörl’s nodes and spina bifida were looked in vertebral bones (Hilton et al., 1976; Jurmain, 1977; Mann and Murphy, 1990; Roberts and Manchester, 2007; Kumar and Tubbs, 2011; Singh, 2013).

Pitting, lipping, osteophytes, and eburnation on joint surfaces were examined for degenerative joint disease (DJD). It is caused by the loss of joint cartilage and the consequent lesion caused by direct interosseous contact. Degenerative joint disease is usually connected to age but could be related also to trauma or infection (Jurmain, 1980; Mann and Murphy, 1990; Ortner, 2003; Waldron, 2009).

The cross-sectional area of long bones was also assessed to determine the existence of extreme bone loss leading to osteoporosis. Osteoporosis is a metabolic disease in which bones become fragile due to bone tissue loss. Risk factor for osteoporosis, apart from sex and age, could be dietary deficiency (Aufderheide and Rodriguez-Martin, 1998; Waldron, 2009). Bone defects associated with infections were assessed by the presence of bone loss in the form of abscesses and regions of pitting (Rogers and Waldron, 1989; Brinkley and Ives, 2008; Weston, 2012).

The presence of bone growth on the periosteum surface of long bone shafts was examined for periostitis. Periostitis is a disease caused by inflammation of the periosteum of lower limbs' long bones. This condition is usually chronic and connected to excessive physical activity. Where acute it could be related to infection (Goodman et al., 1988; Mann and Murphy, 1990; Aufderheide and Rodriguez-Martin, 1998; Grauer, 2012). Enthesitis and exostosis, as example of ligament and tendon irritation, were assessed by the presence of bone growth on the muscle attachment surfaces. The term enthesitis indicates an inflammation of the tendons and ligaments insertions and in physical anthropology is manifested as an irritation of the periosteum surface. Entheseal changes usually occur in older individuals but could be related also to some disease such as ankylosing spondylitis and calcific tendinitis. An exostosis is a new bone growth on the surface of bones, and they can cause chronic pain. On the calcaneus are usually shaped like spurs (Weiss, 2015).

All skeletal elements were assessed for signs of healed fractures. The fracture is the interruption of the partial or total integrity of a bone. Fractures can be traumatic or pathological and, depending on the location on the bone, can be epiphyseal, metaphyseal or diaphyseal (Merbs, 1989; Mann and Murphy, 1990; Lovell, 1997; Aufderheide and Rodriguez-Martin, 1998; Waldron, 2009; Grauer, 2012).

For the RH5 Area 43 human remains the skeletal lesion frequency was determined using a minimal skeletal element count (Paine et al., 2007). Cranial pitting was determined by the presence of pitting on the frontal, parietal, occipital bones and on the orbits. Most of the cranial remains are fragmentary and unassociated. The minimum number count for skulls was determined by burial unit and associated skull fragments. Unassociated fragments were not considered in making this count.

Degenerative joint disease (DJD) is a pathological condition characterized by lipping, eburnation, and bone loss on joint surfaces. A count of all the elements of the various non-vertebral joints was done to obtain the minimal number for each joint. Commingled skeletal remains were counted separately from burials and individuals that were identified during excavations. First, the commingled skeletal elements were counted. Next, the count of the joints from the burials and individuals identified during excavation was done. The same skeletal elements used for the commingled bone count were considered for these burials. Where it was not possible to count the same skeletal element because it was damaged or missing, the joint was counted considering the presence of at least one of the other skeletal elements involved. In counting the joints, the presence of at least 75% of the articular surface was considered.

For the primary burials of Daba LCG-2, skeletal lesion frequencies were determined based on individuals. Given the different state of preservation of the burials the frequencies of skeletal lesions were based on the number of individuals with analyzable skeletal elements.

The frequency of oral pathologies for all the sites analyzed was determined for caries on the number of teeth available for assessment and for periapical lytic lesions and antemortem tooth loss on the number of alveolar sockets analyzed.

4.5 Statistical assessment

Since the data sets are small, statistical evaluation was done using the Fisher's exact test, two–tailed (Guo and Thompson, 1992). A 2 X 2 data matrix for testing hypotheses was created to determine if there are site-specific patterns of lesion frequency among the human remains, older and younger age, male and female individual groupings, intra-site and inter-site data. Additionally, numbers of individuals in age groupings between Area 43 and non-Area 43 of the RH5 graveyard were compared using a Chi-square test. The statistical findings are reported at 0.05 (significant), 0.01 (very significant) and 0.001 (extremely significant).

4.6 Diagenetic factors and traces of combustion

As previously explained, Area 43 was a large area of dispersion of partially burned and commingled human bones. Due to the state of preservation of the findings, poor and highly damaged, a macroscopic analysis of the material was conducted with the aim of detecting data related to diagenesis and combustion. These data were collected with the aim of reconstruct taphonomic processes.

4.6.1 Combustion

A factor that influences the preservation of the remains and that can provide important information on the taphonomy and funerary practices of a population is the action of fire. The changes that occur on the bones, following exposure to the action of fire, depend on several factors. Some of these factors are the power of heat, the proximity to the heat source, the duration of exposure and the presence/absence of oxygen. Fire action on skeletal remains is manifested with alterations in color, shape (warping, shrinking, and twisting) and texture (cracks and fractures) (Shipman et al., 1984; Ubelaker, 1989; Stiner and Kuhn, 1995; Correia, 1997; Symes et al., 2008; Petiti, 2009). Combustion can be divided into two categories, not always easily recognizable from the observation of osteological findings. The first category is the combustion that occurred when the bone was still covered with tissues. The second category is related to combustion occurred when the bone was already completely skeletonized. Binford (1963) found morphological patterns that allow to distinguish between dry burnt bone and fresh burnt bones. Warping curved and transverse cracking ("U effect") are characteristic of fleshed bones, while superficial checking, fine longitudinal striae, deep longitudinal fractures, and longitudinal splintering are typical of dry burnt bones.

In 1989 Buikstra and Swegle made an experiment on human, bovid, and canine bones that highlight the presence of warping in both fleshed and dry bones, contrasting Binford previous conclusions. Thurman and Willmore (1980) tried to classify morphological alteration in flesh and de-fleshed burnt bones. Their results seem to suggest that serrated, transverse fractures totally through cremated bone, along with diagonal cracking accompanied by warping, is indicative of in-flesh cremation. Serrated fractures near epiphyses but otherwise parallel-sided fractures through bone (along checking lines), and less pronounced warping, is more characteristic of cremated green (recently de-fleshed) bone. Reverte Coma (1999), observing the alterations frequently found on the incinerated remains, distinguished some patterns associated with primary cremation. The first is the so-called "S effect" (sandwich) or two light-colored layers, tending to white, which reach a dark, black-colored layer. The formation of this feature is explained by the reducing effect created by the outer layers to the inner layer. The "U effect" is another pattern characterized by the formation of conchoid-shaped fractures. This pattern usually appears on the diaphysis of long bones. The "LD effect" (*laguna desecada*) or the formation of cracks on bony elements that have a distinctly concave or convex shape (articular surfaces) is another pattern related to the action of fire. Doro Garetto (1993) documented another feature called the "Q effect" (quadrilateral). This feature occurs on the bones as elongated and irregular quadrilaterals. The absence of these patterns or the exclusive

presence of the "Q effect” (the only pattern observable even on secondary cremations) indicates the possibility that it is a secondary cremation. Longitudinal splits seem to suggest that the bone at the time of combustion was without tissues (Reverte Coma, 1999).
Although research on the fracture patterns found in cremated bone tried to distinguish fleshed, de-fleshed, or dry bone, recent studies highlight considerable controversy over the characteristics of the fracture patterns (Correia, 1997; Gonçalves et al., 2011). Although the occurrence of a bone deformation is rare, it can be observed on dry bones subjected to heat. The study conducted by Gonçalves and colleagues (2011) revealed that heat-induced deformation is not exclusively linked to the burning of fleshed and green (de-fleshed) bones as previously suggested by other researchers (Buikstra and Swegle, 1989; Spennemann and Colley, 1989; Whyte, 2001). The explanation of the presumed exclusive presence of heat-induced deformations on fleshy and green bones in contrast to dry bones has been linked to the contraction of muscle fibers (Binford, 1963). Alternatively, Spennemann and Colley (1989) link distortion to the presence of excessive heat trapped in the bone marrow cavity, thus being able to occur in both fleshy and dry bones. Thompson (2005) argues that both statements are problematic because the opposing muscles would hardly be able to bend the bones and the very porous nature of the bone would not allow the trapping of air in the medullary cavity. Alternatively, Thompson (2005) argues that periosteal or anisotropic contractions in the distribution of collagen within the bone cortex are better candidates for shoulder responsibility. However, Thompson (2005) notes that there are no quantitative data to support any theory.

The chromatic variations that occur on the surfaces of the bone fragments correspond to different temperatures of combustion. Several studies were conducted in this regard to try to reconstruct the temperature through the macroscopic observation of the findings (Shipman et al., 1984; Etxeberria, 1994; Mays, 1998; Castillo et al., 2013). In 1984 Shipman and colleagues tried to determine the correlation between color and temperature. They created a chromatic scale from yellowish (< 300°C) to white with sometimes few shades of gray and red (> 900°C). According to this chromatic scale between 300-450°C the coloring would have been yellow tending to brown or dark red, between 500-600°C the predominant color would be black, while from 650°C to 900°C the coloring would tend towards shades of gray that become clearer as the temperature increases. On the basis of the study conducted by Mays (1998) the color varies from red-orange (<300°C) to yellowish-white (650>900°C) passing through different shades such as dark brown-black (300°C), black (350-400°C), grey-dark brown (450-500°C) and light gray-brown (550-600°C). Even more than for morphological alterations, the study of color changes is subject to two main methodological limitations, the subjectivity of the chromatic scale used and the actual link between temperature and color (Petiti, 2009; Ellingham et al., 2015). The coloration of burnt bones is influenced by three variables: temperature, duration of the combustion and availability of oxygen. Walker and colleagues (2008) showed that by adjusting the amount of oxygen it is possible to vary the color of the bone while maintaining a constant temperature.

Commingled skeletal remains and individuals from burial units from Area 43 of RH5 were analyzed with the aim of detecting morphological alterations (deformations and fractures) and coloration related to temperature. For these analyzes each fragment was taken into consideration. The percentage, therefore, was not performed based on the same number of skeletal elements used for paleopathological analyzes. Separate counts were done for commingled remains and burial units.

The commingled skeletal elements were divided between burnt and unburnt remains. The burnt remains were identified based on color alterations and based on the presence of fractures and alterations related to the action of fire. The analyzes were conducted both for skeletal elements and for excavation quadrants, with the aim of detecting the presence of any relevant anthropological and topographical distinctions. The skeletal remains with unknown original location in excavation area are labeled as "NON ID". The same analysis was also carried out on the remains belonging to the individuals identified in the excavation phase. The remains of each single individual were considered as a unit.

A classification of the burnt remains for each sector was also made based on coloration using Mays scale (1998). Five groups were created: Group 1 with dark brown-black remains (300°C), Group 2 with black remains (350-400°C). Group 3 and Group 4 contain remains dark grey-brown (450-500°C) and light gray-brown (550-600°C). The Group 5 contains the skeletal remains with yellowish-white coloration (> 650°C). Coloration was used to identify temperature peaks. The peaks may be indicative of presence of any points in Area 43 where fires may have been lit. With the help of detailed plants from different sectors of the area, an attempt was made to identify the presence of concentrations of bones burnt at higher temperatures.

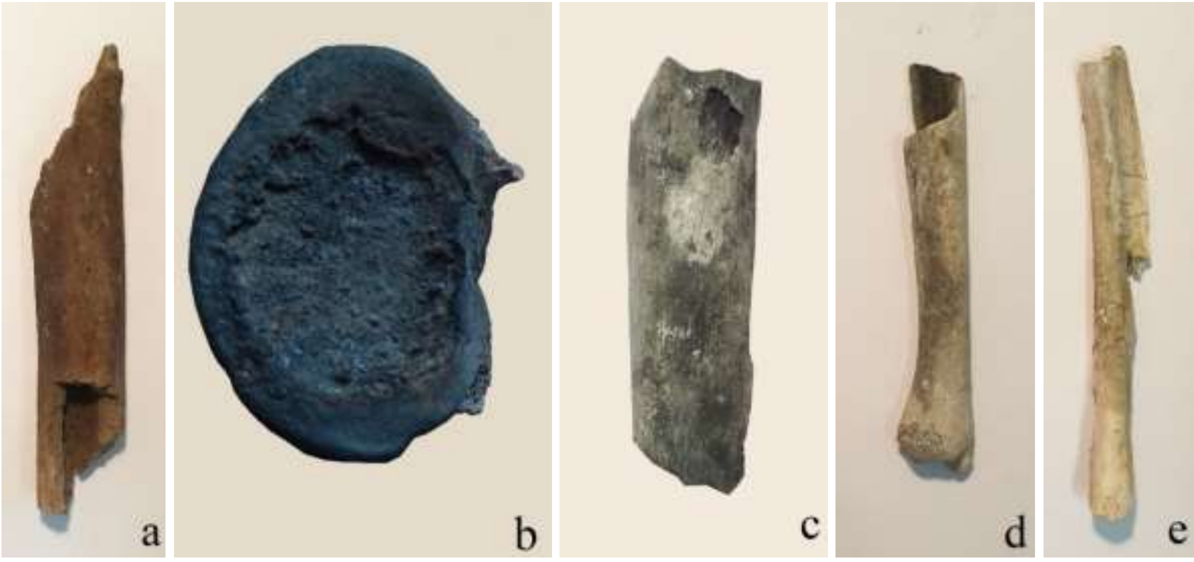


Figure 4.1 Examples of burnt skeletal remains from Area 43 of RH5 graveyard classified as Group 1 (a), Group 2 (b), Group 3 (c), Group 4 (d), Group 5 (e).

4.6.2 Histological analysis: bioerosion

Several factors contribute to the decomposition of soft tissues. One of these factors is the action of microorganisms. Microbiological alteration of the bone can occur due to fungi or bacteria (Marchiafava et al., 1974; Hackett, 1981; Jackes et al., 2001). Both fungi and bacteria are microorganisms that proliferate and grow in oxygen-rich environments. These micro-mechanisms remove collagen, alter the inorganic part of the bone, and erode the bone structure through tunnels (Kendall et al., 2018; Lemmers et al., 2020).

Studies conducted by Lemmers and colleagues (2020) showed how histological analysis allows to detect traces of bioerosion even in burnt remains suggesting that decomposition occurred for a period before burial. Its presence on burnt remains, therefore, can be used as an indicator of probable pre-combustion putrefaction. The disappearance or reduction of the organic component following combustion, in fact, slows down and leads to the interruption of the action of microorganisms.

Histological analysis was performed with the aim of detecting traces of bioerosion as a means for assessing the cultural process of burying the dead for this Neolithic fishing community.

To obtain bioerosion data, it was decided to perform histological analyzes on 24 samples. The selected skeletal element was the rib. It was decided to use the ribs because they are well represented among the fragments, they are identifiable, and they provide complete cross sections for evaluation. Secondly, the anthropological and medical literature provides considerable background specific to human rib histology (Frost, 1985; Sedlin et al., 1963; Sedlin 1964; Stout 1978, 1992; Stout and Paine 1992; Pfeiffer 1998; Brenton and Paine 2007; Garcia-Donas et al., 2016; Pfeiffer et al., 2016).

Once the samples were selected, the thin sections were created using standard histological slide preparation methods (Caropreso et al., 2000). The creation of the thin sections and a first microscopic analysis were carried out in the Anthropology Laboratory of the Museo delle Civiltà - Museo Preistorico Etnografico "Luigi Pigorini", with the help and collaboration of Prof. Luca Bondioli, Prof. Alessia Nava, Prof. Robert R. Paine and dott. Beatrice Peripoli.

Once the skeletal materials were selected, samples of about 1 cm in size were cut. In order to incorporate the samples into the resin, the fragments of ribs were therefore inserted inside special rubber molds. Each mold, containing a single sample, was filled with a special epoxy resin for cold incorporation (EpoThin 2) and hardener for cold epoxy resin. The molds were left to dry and solidify for two days. Once the resin solidified, the samples were taking care to be perfectly perpendicular to the rib external surface. The cut was performed using a low speed ISOMET (Buehler Inc) saw with 300 micrometer thick diamond blade. Once the first cut was made, the exposed surface of the block was polished with 2500 grit water resistant sandpaper to eliminate the saw marks. The block was then laid perfectly flat and glued to a glass microscope slide with the same resin and let dry for 24 hours. Once the block was firmly fixed to the glass slide a second cut was run at ca 300 micrometers from the slide surface, thus obtaining a ca 300 micrometers thick slice of the rib. The thin slice was than reduced in thickness with water resistant abrasive paper at different grits (400, 1200, 2500) till the final thickness of ca 100 micrometers. This step was carried out using the microscope to find the right thickness for histological analyzes. The section was then covered with a coverslip fixed with Eukitt mounting medium (Sigma Aldrich) to allow a clear reading under the microscope (Caropreso et. al., 2000).

The thin sections thus created were then analyzed using an Olympus microscope BX60 coupled with a microscope digital camera (Nikon FI3) and with a 10x objective. The images of 2880x2048 pixels and with a calibration factor of 1 pixel = 0.3846 micrometers were pasted together using the Microsoft Image Composite Editor Program. The photos were then processed using the free image processing program (ImageJ, ver. 1.53i National Institute of Health, USA). The cortical area (Ct.Ar.) of the individual samples and all the other morphometric traits were measured through the ImageJ software. Once the traces of bioerosion present on the samples were identified, the area showing these alterations was measured (Ct.BAD). The same patterns reported by Kendall and colleagues (2018) and Lemmers and colleagues (2020) were considered as traces of bioerosion.

1. Ct.Ar. is defined as the area of rib cross-section specific to cortical bone. It was measure using a standard program for measuring area found in Image J. The scale used for measurement was set by multiplying the magnification of the microscope objective with the lens magnification of a digital camera attached to the Olympus BX60 microscope. The total magnification for each photo was taken at 50x.
2. Ct.BAD is defined and measured using the same method for determining the entire cross-sectional area. In this case only the cortical bone regions that exhibit features specific to bioerosion were measured.

The two variables analyzed were used to create a ratio (Ct.BAD/Ct.Ar.) that represented the percentage of bone cross section affected by diagenesis. Based on this ratio 3 groups were created. Group 0 represents samples with no diagenetic patterns. Group 1 consists of samples that show diagenesis features in cortical bone in percentage less than 49%. Group 2 represents samples with higher percentage of diagenesis features (50% or more).

There have been several attempts to define cross sectional area for diagenesis as seen in long bones, specifically the Oxford Histological Index (Millard, 2001) and the General Histological Index (Hollund et al., 2011, 2015). While the results obtained from the materials of RH5 Area 43 are based on a quantitative assessment, the previous indices are determined by qualitative assessments. Another critical difference between the index used in this dissertation and the previously established indices is based on bones sampled. In contrast to previous studies that used femoral long bone samples, the study of the RH5 Area 43 materials was performed on rib thin sections. The rib cortical bone is less dense than femoral cortical bone suggesting that ribs should be more sensitive to diagenetic changes than the femur. Hence, the degree of bioerosion specific to time in the ground would differ from our results. But more important it appears that only a small region of the cortical femur was examined in previous studies, approximately 2x1 cm of cortical bone (Hollund et al., 2011, 2015). This highlights an issue of sampling within the larger cross-sectional bone while looking for diagenesis. The small area may not represent diagenesis for these femoral samples. The method used in this dissertation avoids sampling error while reading the rib cross sectional area by reading the entire rib section. Unfortunately, the methodological differences might complicate comparisons between the RH5 quantitative data and the qualitative indices. Despite this issue, a comparison was made between the different methods.

4.6.3 Diagenesis

When a corpse is exposed to the elements, alterations related to putrefaction, mummification, saponification, or autolysis are produced. When there are no more soft tissues preserved, the bones kept in the open air undergo a series of alterations whose severity depends on several exogenous factors (weather, temperature, sunlight, duration of exposure, action of other organisms, type of soil on which they are located) and endogenous (skeletal element, age and health conditions of the subject to which they belong) and that which can lead to the complete destruction of the remains (Marchiafava et al., 1974; Von Endt and Ortner, 1984; Piepenbrick, 1986; Grupe, 1988; Grupe and Piepenbrink, 1988; Pate and Hutton, 1988; Ubelaker, 1989; Maat, 1993; Botella et al., 1999; Haglund and Sorg, 2002; White and Folkens, 2005). Clearer signs can be detected on diaphyseal surfaces. The inner structure of the diaphysis, in fact, preserves less humidity than the epiphyses, allowing an easier assessment of diagenetic patterns. After a first phase of dehydration, bones become whitening due to sunlight. Desquamation and fragmentation after complete dehydration are other manifestations. Once the skeletal element has completely lost the organic matter, it appears dusty and chalky (Botella et al., 1999; Waterhouse, 2013).

The analysis was carried out on the bone portions where the alterations occur with greater clarity. Specifically, on the diaphysis, on the shoulders, on the hip bones and on the skull fragments as they are the portions where the bones are covered by a much thinner layer of tissues. Separate counts were done for commingled remains and burial units, following the same procedure used for combustion analysis.

4.7 Traces of manipulation

Another element that was analyzed in the RH5 materials is the presence of traces of manipulation. The various osteological fragments were observed with the aim of searching for traces such as flaying, disarticulation, flesh removal, scraping and alteration of the medullary canal (Turner and Morris, 1970; Turner, 1983; Villa, 1992; White, 1992; Botella et al., 1999; White and Folkens, 2005).

Flaying is the practice of removing the skin. This practice leaves visible marks on the bone only in the points where the skin is very close to the skeleton. For this reason, only the signs found on the skull are considered as flaying traces. The signs appear as straight lines, usually longitudinal to the skull.

Disarticulation is the cutting of soft tissues with the purpose of dividing the different body segments. Signs of disarticulation are found only in the periarticular areas, often on the epiphyses of the long bones or in the point corresponding to the muscular insertions. They appear as V-section incisions, parallel to the articular surface and perpendicular to the axis of the bone. They can be single or multiple and the depth depends on the strength and instrumentation used to perform the action.

Other traces are related to the practice of removing muscle mass and flesh from the bones. The traces of defleshing have a V-section and can be found on any bone, in any position. The size and depth vary according to the material used.

The term scraping indicates the numerous and irregular striae (shallow and with V-section) produced following the removal of the periosteum. They are caused by cleaning actions of areas with muscular/ligamentous insertion or bone preparation to make instruments.

The alteration of the medullary canal is one of the clearest signs of manipulation. It is the consequence of the marrow extraction process. The bone has the scraped bone trabecula with consequent smoothing of the inner surface of the bone.

On the bones there may be other traces associated with the manipulation of corpses such as fractures and strokes, difficult to detect in highly fragmented material, or cuts and bites (Botella et al., 1999). All skeletal remains from Area 43 were analyzed for manipulation features.

Chapter 5. Results

Data results from a multidisciplinary analysis of human skeletal remains from the archaeological sites of RH5 Area 43 and Daba al Bayah are presented here in chapter. The chapter is organized by site and by methodology specific for obtaining data from burial samples from each site. When the dissertation was originally planned, more demographic and paleopathological data from the site of Daba al Bayah were anticipated. Unfortunately, current world health issues and travel restrictions has limited the data collected from this site.

5.1 Ra's al-Hamra 5 – Area 43

A data archive was created. The skeletal remains from RH5 Area 43 were divided by districts. Side identification of skeletal elements, a brief description of the elements, and taphonomic state of bones (combustion and diagenetic) were documented. Archaeological data and excavation sector were documented.

5.1.1 Minimum number count

The condition of skeletal remains from Area 43 is poor, fragmented, and damaged by fire. Still, conducting an inventory of the remains is possible, specifically the commingled remains were sorted, and identifiable elements were counted both from the right and left side of the body. Since elements were also counted by skeletal region, it was possible to determine the count for these as well by general age grouping (Tab. 5.1). Based on the skeletal elements a MNI of 44 individuals is provided: 2 fetal individuals (right ulna), 16 sub-adults (skull) and 26 adults (mandible). Burial position, stage of skeletal development and dental eruption were considered in order to add other individuals to the minimum number count. The combined MNI count for Area 43 is a total of 77 individuals.

Table 5.1. Counts specific to skeletal elements from RH5 Area 43.

	Fetal			Sub-adults			Adults		
Skeletal elements									
Skull	--			16			22		
Maxillary	--			4			14		
Mandible	--			10			26		
Cervical vertebrae	--			1			60		
Thoracic vertebrae	--			13			72		
Lumbar vertebrae	--			10			58		
Sternum	--			1			4		
Hand phalanges	--			46			212		
Foot phalanges	--			26			126		
	Ln	Rn	N.D.	Ln	Rn	N.D.	Ln	Rn	N.D.
Clavicle	--	--	1	2	4	--	8	7	--
Scapula	--	--	--	5	5	--	4	10	5
Humerus	--	--	1	7	7	3	13	9	4
Radius	--	--	--	5	5	--	10	8	--
Ulna	--	2	--	9	10	--	13	16	1
Carpals	--	--	--	6	7	--	43	37	3
Metacarpals	--	--	--	4	6	4	28	33	3
Pelvic bone	--	--	--	7	4	1	14	13	--
Femur	1	--	1	5	5	--	11	8	8
Patella	--	--	--	1	1	--	14	8	--
Tibia	1	1	1	8	2	3	8	10	--
Fibula	--	--	--	3	4	4	9	8	1
Talus	--	--	--	2	4	--	12	11	1
Calcaneus	--	--	--	2	1	--	11	10	1
Tarsals*	--	--	--	4	4	--	34	45	--
Metatarsals	--	--	--	6	7	--	42	47	6

* except for tali and calcanei.

5.1.2 Age and sex assessment

Despite the extreme fragmentary nature of the sample, it was also possible to determine the age and sex of most of the skeletal remains. In separating the burials into general age groupings, two individuals are fetuses/perinatal, 30 individuals are sub-adults (aged 0 to 19) while 45 individuals are adult and over the age of 20. The 30 sub-adults are further subdivided into specific groupings (Bogin, 1997): six are infants (0-3 years of age), eleven are children (4-8 years of age), four are juvenile (9-12 years of age) and nine sub-adults are adolescent (13-19 years of age). Of the 45 adults, 19 are males or probable males, 20 are females or likely females, while the remaining 6 individuals could not be identified for sex (Tab. 5.2). The lack of sex identification for these burials is due to their poor state of preservation.

Table 5.2. Age and sex determination of individuals from RH5, Area 43.

Age	n (77)	%
Fetus/perinatal	2	2.6
Infant	6	7.8
Childhood	11	14.3
Juvenile	4	5.2
Adolescent	9	11.7
Adult	45	58.4

Adult sex	n (45)	%
M	14	31.1
Prob. M	5	11.1
F	13	28.9
Prob. F	7	15.6
N.D.	6	13.3

5.1.3 Life table

A life table was created for the human remains from RH5 Area 43 (Tab. 5.3). Using 5-years non-overlapping age groupings, the life expectancy (ex) at birth of RH5 Area 43 sample is approximately 25 years. At 20 years of age life expectancy increases to approximately 36 years of age. Other important data presented in the life table is the mortality rates (qx). From birth to 9 years of age the probability of dying is higher compared to the other sub-adult age groups. The qx decreases from 10 to 14 years and then it starts increase again.

Table 5.3. Life table of individuals from RH5 Area 43

Age classes	ax	Dx	dx	lx	qx	Lx	Tx	ex
0-4	75.00	9.85	13.13	100.00	131.30	467.18	2517.20	25.17
5-9	65.15	8.35	11.14	86.87	128.24	406.50	2050.03	23.60
10-14	56.80	5.26	7.01	75.73	92.57	361.13	1643.53	21.70
15-19	51.54	6.53	8.71	68.72	126.75	321.83	1282.40	18.66
20-24	45.01	8.67	11.56	60.01	192.63	271.15	960.58	16.01
25-29	36.34	8.24	10.98	48.45	22663	214.80	689.43	14.23
30-34	28.10	7.78	10.38	37.47	277.02	161.40	474.63	12.67
35-39	20.32	6.57	8.76	27.09	323.37	113.55	313.23	11.56
40-44	13.75	4.28	5.70	18.33	310.97	77.40	199.68	10.89
45-49	9.47	2.67	3.56	12.63	281.87	54.25	122.28	9.68
50-54	6.80	2.32	3.10	9.07	341.79	37.60	68.03	7.50
55-59	4.48	2.15	2.87	5.97	480.74	22.68	30.43	5.10
60+	2.33	2.33	3.10	3.10	1000.00	7.75	7.75	2.50
		75.00	100.00			2517.20		

ax = n of people alive at each group; Dx = total n of deaths occurring in each age group; dx = percentage of total deaths occurring in each age group; lx = n of survivors for each age interval; qx = probability of dying at each age interval; Lx = total n of years lived between one age interval and the following one; Tx = total n of years lived after a lifetime of all individuals who reach the age group; ex = life expectancy.

5.1.4 Paleopathological analysis

An assessment of the health status for skeletal remains of Area 43 was determined based on the frequency of dental and skeletal lesions observed. Skeletal lesions such as pitting, lipping, bone growth, bone loss and bone eburnation as well as, dental/oral defects such as periapical lytic lesions, caries and resorbed sockets were looked for among the commingled and primary burials. Dietary specific lesions, dental defects and vertebral lesions were recorded and described.

Several skeletal and dental lesions were documented in the Area 43 osteological remains: dietary lesions, infections, periostitis, vertebral lesions (osteoarthritis, Schmörl's nodes and spina bifida), degenerative joint disease, oral defects (caries, antemortem tooth loss and periapical lytic lesions). A few traces of osteoporosis, inflammations, enthesitis, exostosis and fractures were also found.

- *Non-specific stress indicators*

Cranial vault fragments were analyzed for lesions associated with dietary or infection-based metabolic problems. Of the cranial vaults (frontal, parietal, and occipital bone) observed, 3 adult skulls show traces of healed cranial pitting, while one sub-adult skull exhibited this lesion (Tab. 5.4; Figs. 5.1-5.2).

Table 5.4. Frequency of pitting observed on remains from the site of RH5 (Area 43).

	Adults		Sub-adults		
Bones	n	%	n	%	P
Cranium	3/22	13.6	1/16	6.2	0.6245
Maxillary bone	1/14	7.1	1/4	25.0	0.4052
Mandible	0/26	0.0	1/10	10.0	0.2778

A comparison of lesions between adults and sub-adults is done using the Fisher's exact test.

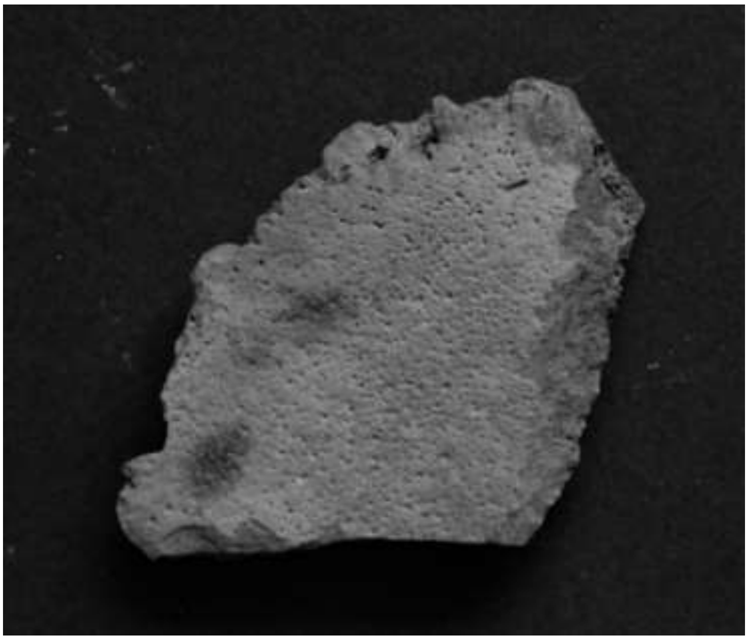


Figure 5.1. Fragment of cranial vault exhibiting well healed cranial pitting (porotic hyperostosis), RH5 Area 43.

Figure 5.2. A supraorbital margin exhibiting cribra orbitalia (from RH5, Area 43).

Long bone shafts (femur and tibia) were analyzed to detect the presence of periostitis. Among the adults, two fragments of femur shaft and 6 tibia fragments show bone growth on the periosteal surface (Tab. 5.6; Fig. 5.3). The percentage of periostitis in adult tibia fragments is 40.0%, while the percentage of femoral periostitic lesions in adults is 6.2%. The analysis of sub-adult bones detected only one tibia shaft with periostitis (Tab. 5.6). Given these frequencies, adults show a higher frequency of periostitis than the sub-adults (P = 0.0373).

Table 5.5. Frequency of periostitic lesions in skeletal elements from the site of Ra's al-Hamra 5, Area 43.

	Sub-adults		Adults		
Bones	n	%	n	%	P
Femoral shaft	0/13	0.0	2/32	6.2	1.0000
Tibia shaft	1/16	6.2	6/15	40.0	0.0373^

A comparison of lesions between adults and sub-adults is done using the Fisher’s exact test.
^ Indicated statistically significant results at p = 0.05.

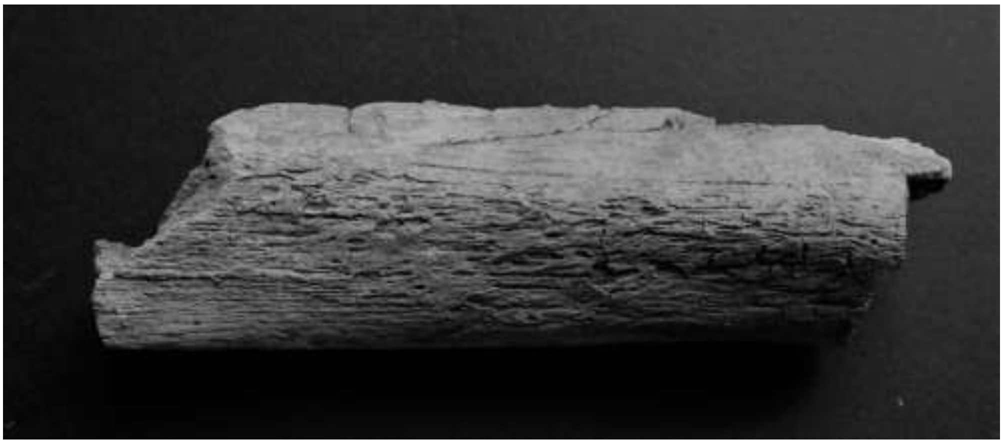


Figure 5.3. Fragment of tibia shaft with periostitic lesion (from RH5, Area 43).

- *Infections*

The presence of abscesses and lytic lesions was analyzed to assess lesions specific to infection. Lytic lesions were detected, for adult remains, on the distal epiphyses of two fibulae, on the posterior surface of a sternum, on the acromial portion of two clavicles and on the acromion process of a scapula. Additionally, lytic lesions were found on three vertebral bones, one phalanx and one metatarsal. For the sub-adult lesions, one was observed on the femoral neck and on the proximal epiphysis of a tibia. The frequencies for these lesions are presented (Tab. 5.5). For the adult skeletal elements, the highest frequency was found on the adult sternum, 20%; for sub-adults is on long bones (10.0%). There is no statistical difference in infection-based lesions between sub-adults and adults from Area 43 of the RH5 graveyard (Tab. 5.5).

Table 5.6. Frequency of lytic lesions in skeletal elements from the site of Ra's al-Hamra 5, Area 43.

	Sub-adults		Adults		
Bones	n	%	n	%	P
Vertebral bones	--	--	3/190	1.6	--
Sternum	--	--	1/ 5	20.0	--
Clavicle	0/6	0.0	2/15	13.3	1.0000
Scapula	0/10	0.0	1/14	7.1	1.0000
Hand phalanges	--	--	1/212	0.5	--
Femur	1/10	10.0	0/19	0.0	0.3448
Tibia	1/10	10.0	0/18	0.0	0.3571
Fibula	0/7	0.0	2/17	11.8	1.0000
Metatarsal	--	--	1/95	1.0	--

A comparison of lesions between adults and sub-adults is done using the Fisher's exact test.

- *Vertebral defects*

An inventory of the vertebral bones was divided by region. There are 60 cervical vertebrae, 72 thoracic vertebrae, and 58 lumbar vertebrae available for assessment. The vertebrae were observed for the presence of bone growth and bone loss lesions associated with OA and Schmörl's nodes.

Of the 60 clearly identified cervical vertebrae, 11 exhibits osteoarthritic lipping. Of the 72 thoracic vertebrae, 18 show bone growth typical of arthritis while only 2 have Schmörl's nodes characterized by depression of the vertebral body. Of the 58 lumbar vertebrae, 8 have osteoarthritic lipping and 4 show Schmörl's node defects (Fig. 5.4). For the frequencies, only the intact vertebrae were calculated or whose degree of conservation was such as to determine with certainty the attribution to one of the three typologies. Traces of osteoarthritis, therefore, are present on 18.3% of the cervical vertebrae, on 25% of the thoracic vertebrae and on 13.8% of the lumbar vertebrae. Schmörl's nodes, on the other hand, were found on 2.8% of the thoracic vertebrae and 6.9% of the lumbar vertebrae (Tab. 5.7).

Three individuals (A, C, D, E) from Grave 68 superior were affected by a lack of spinal processes with an open neural arch which strongly suggest a spina bifida related disorder. Grave 68sup A, a male estimated to be approximately 25-31 years of age, exhibits an unfused S1 and S2 and with S2-S5 arc defect. Grave 68sup C, also a male aged approximately 26-35 years old, exhibits neural arch defects in S1-S3. Grave 68sup D, aged 16-19 years old, has spina bifida in S2 and S4, probable also in S3 and S5 (S1 has no defect). Grave 68sup E is a female aged, 19-25 years old. She shows a complete open neural arch for the entire sacral bone (S1-S5). Grave 69 superior, a male aged to be approximately 32-41 years old, shows a complete open neural arch of the sacral bone (S1 to S5).

Table 5.7. Frequency of vertebral lesions in skeletal elements from the site of Ra's al-Hamra 5, Area 43.

Osteoarthritis	Type	n	%
	Cervical	11/60	18.3
	Thoracic	18/72	25.0
	Lumbar	8/58	13.8
Schmörl's nodes	Type	n	%
	Thoracic	2/72	2.8
	Lumbar	4/58	6.9

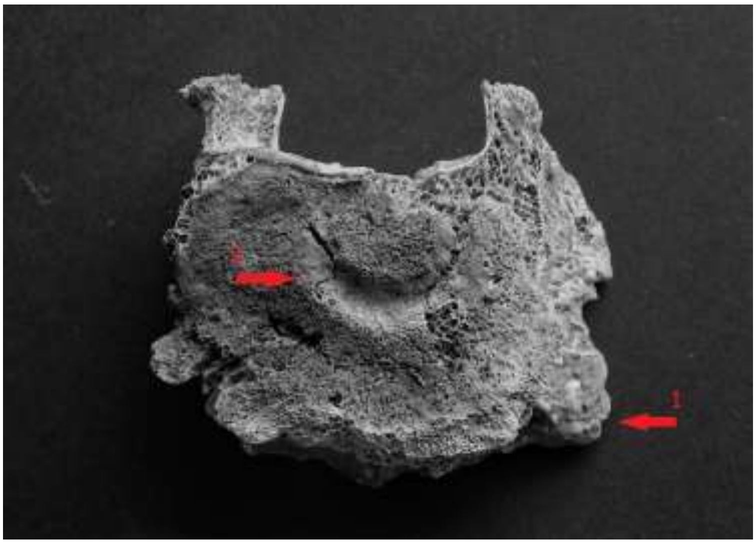


Figure 5.4. Lumbar with OA lipping (1) and Schmörl's node (2) from RH5, Area 43.

- *Degenerative joint disease*

Alteration of the joint surface specific to the bone elements related to DJD were detected. As a result, the left elbow (15.43%) joints exhibit the greatest DJD defect frequencies for the burials found in Area 43 (Tab. 5.8).

Table 5.8. Frequency of DJD in skeletal elements from the site of Ra's al-Hamra 5, Area 43.

Joint	Ln	%	Rn	%
Mandibular	0/7	0.0	0/12	0.0
Shoulder	1/7	14.3	1/11	9.1
Elbow	2/ 13	15.4	0/16	0.0
Wrist	0/ 10	0.0	1/12	8.3
Hip	0/7	0.0	0/8	0.0
Knee	1/16	6.2	1/12	8.3
Ankle	0/12	0.0	1/10	10.0
Metacarpal*	0/64		0.0	
Hand phalanges*	1/212		0.5	
Metatarsal*	2/95		2.1	
Foot phalanges*	15/126		11.9	

Ln equals the number of left sided joints and Rn equals the number of right sided joints.
* Left and right-side elements combined.

- *Oral defects*

Oral defects are defined as lesions that afflict the teeth and maxillary/mandible bones. No caries was found on any of the teeth with a crown (n = 170) (Tab. 5.9). For determining the frequency of caries only the teeth with crowns analyzable were counted. Several other oral lesions emerged by examining the mandibles and maxillary fragments. The antemortem tooth loss seen as reabsorbed tooth sockets is 1.6% and the frequency of periapical large lytic lesions associated with an open tooth socket is 0.3%.

Table 5.9. Dental and oral pathologies frequencies in RH5 Area 43.

	n	%
Caries	0/170	0.0
Periapical lytic lesions	1/287	0.3
Antemortem tooth loss	5/311	1.6

- *Other skeletal lesions*

The cross-sectional area of long bones was assessed to determine the existence of extreme bone loss leading to osteoporosis. Only one adult femur fragment shows signs of osteoporosis. The fragment HSR 39 is characterized, in section, by spongy bone that affects part of the compact bone.

Three adult skeletal remains have signs of exostosis (2 calcaneus and a metacarpal). In the metacarpal the lesion is located along the diaphysis and is characterized by new bone growth, in the two calcanei the exostosis manifests itself in the form of bone spurs.

One femur and two fibulae, all related to adult individuals, have irritation of the tendons and ligaments insertions. On the femur is characterized by irregular surface of one side of the rough line with bone growth that affects the periosteum, on the fibulae is characterized by small pits with smooth edges.

Skeletal elements were also analyzed for fractures. Only two fractures were detected. Both are located on ulna. The right ulna labeled HSR 41 presents a fracture in the olecranon process in an early phase of healing. An evident line fracture can be seen in both sides of the process. A left ulna from sector HSL lacks the olecranon process. The observation of the fracture margin allowed for the understanding that the absence was not caused by taphonomic damages. The margins, in fact, are smooth and the fracture is nearly healed completely.

A sub-adult skull fragment shows an irregular endocranial surface with intense bone growth and lamellar alteration (Fig. 5.5). Unfortunately, the state of preservation of the remains from Area 43 (commingled and highly fragmented) does not allow to analyze the relative post-cranial remains. Although not sure in the etiology, it is possible to speculate a meningitis as cause of this skeletal lesion (Aufderheide and Rodriguez-Martin, 1998; Ortner, 2003; Lewis, 2004). The extent of bone growth suggests a bacterial origin rather than viral meningitis. The latter one, in fact, result in a quicker death. The extent of bone growth in the RH5 Area 43 sample, on the other hand, is such as to assume longer timing.

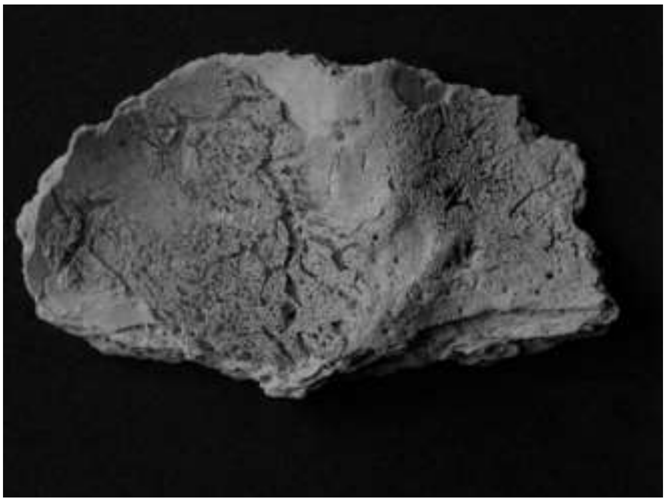


Figure 5.5. Fragment of cranial vault with intense bone growth on endocranial surface (from RH5, Area 43).

5.1.5 Fire action and diagenesis

Diagenetic and combustion patterns were assessed among skeletal remains from RH5 Area 43. First an assessment of the state of burning of bone fragments was done. Secondly, information about bone diagenesis related to the degree of burning emerged from a histological examination of rib thin sections.

- *Combustion*

The commingled skeletal remains from Area 43 were initially analyzed distinguishing between burnt and unburnt remains (Tabs. 5.10-5.12). Of the total analyzed, 53.5% of the skeletal remains show alterations related to the action of fire, in varying percentages, while the 46.5% show no signs of combustion. The percentages of burned skull fragments appear higher in comparison with other skeletal elements but might be related to the fragmentary condition of the remains. Observing the percentages divided by sectors and excluding the samples from not defined sector (NON ID), the largest number of burnt skeletal remains was found in the HSR sector (24.5%). The observation of commingled burnt remains allowed to detect the presence of LD effect, deformation and fractures related to fire action, on 21.1% of the finds. As already explained, however, there is still a debate about the interpretation of these bone alterations. It is not yet clear whether these alterations can be related to the burning of skeletal remains with the presence of soft tissues.

Table 5.10. Distinction between burnt and unburnt commingled remains from Area 43 based on skeletal elements.

Skeletal element	Burnt		Unburnt	
	n	%	n	%
Skull fragments	535	40.1	166	14.3
Mandible	12	0.9	18	1.5
Vertebra	196	14.6	248	21.4
Rib fragments	216	16.1	115	9.9
Scapula	20	1.5	15	1.2
Clavicle	7	0.5	13	1.1
Sternum	1	0.0	4	0.3
Humerus	24	1.8	50	4.3
Radius	19	1.4	30	2.5
Ulna	16	1.2	33	2.8
Carpal	9	0.7	35	3.0
Metacarpal	27	2.0	28	2.4
Hand phalanx	53	3.9	68	5.8
Hip Bone	26	1.9	40	3.4
Femur	34	2.5	41	3.5
Patella	8	0.6	12	1.0
Tibia	15	1.1	31	2.6
Fibula	18	1.3	30	2.5
Talus	4	0.3	17	1.4
Calcaneus	7	0.5	18	1.5
Tarsal	16	1.2	51	4.4
Metatarsal	49	3.6	46	3.9
Foot phalanx	22	1.6	49	4.2
TOTAL	1334	53.5	1158	46.5

Table 5.11. Distinction between burnt and unburnt commingled remains from Area 43 based on excavation sectors.

Sector	Burnt		Unburnt	
	n	%	n	%
HSI	27	2.0	0	0.0
HSL	109	8.1	523	45.1
HSM	159	11.9	31	2.6
HSN	12	0.9	5	0.4
HSQ	0	0.0	2	0.1
HSR	328	24.5	234	20.2
HSS	143	10.7	12	1.0
HSW	9	0.6	209	18.0
NON ID	547	41.0	142	12.2
TOTAL	1334	53.5	1158	46.5

A classification of the burnt remains for each sector was also made based on coloration using the Mays scale (1998) (Tab.5.12). The 23.2% of the burnt remains show coloration between dark-brown and black (Group 1). The 8.6% of the samples are black (Group 2). Coloration between dark gray-brown and light gray were found on 20.2% and 20.7% of the remains (Groups 3-4). Yellowish-white color was found on the 27.3% of the remains (Group 5).

Table 5.12. Commingled burnt skeletal remains from Area 43 divided in group and sectors based on color classification.

	Group 1		Group 2		Group 3		Group 4		Group 5	
	n	%	n	%	n	%	n	%	n	%
HSI	1	0.3	0	0.0	26	9.6	0	0.0	0	0.0
HSL	33	10.6	2	1.7	33	12.2	16	5.7	25	6.8
HSM	53	17.0	32	27.8	25	9.2	27	9.7	22	6.0
HSN	2	0.6	2	1.7	2	0.7	3	1.0	3	0.8
HSR	101	32.5	30	26.0	45	16.7	61	22.1	91	25.0
HSS	36	11.6	24	20.8	23	8.5	46	16.6	14	3.8
HSW	9	2.9	0	0.0	0	0.0	0	0.0	0	0.0
NON ID	75	24.1	25	21.7	115	42.7	123	44.5	209	57.4
TOTAL	310	23.2	115	8.6	269	20.2	276	20.7	364	27.3

The remains belonging to individuals identified from field documentation and to individuals from single and multiple burials were also analyzed. Nineteen individuals show traces of combustion. Ten of them have remains with light gray-white and yellowish-white coloration; the individuals from Graves 19 and 42B and all individuals from Grave 68 sup. The same individuals also present remains with alterations related to the action of fire (deformations, fractures, and LD effect).

- *Histological analysis: Bioerosion*

Histological analysis of bioerosion patterns in the rib thin sections from Area 43 was performed (Tab. 5.13; Figs. 5.6-5.9). One sample does not show signs on diagenetic alteration (Group 0). Twelve samples show less than 50% of diagenetic alteration in cortical bone (Group 1). The remaining eleven samples have higher percentages of cortical bone affected by diagenesis (Group 2).

The samples belonging to Group 1 have percentages ranging from 7.0% to 47.7%. If the group is further divided into two subgroups (less than 25% and higher than 25%but less than 49%), six samples show alterations in a percentage lower than 25% while the remaining six in a percentage higher than 25%. For Group 2 the percentages range from 52.2% to 100%. Eight of these samples, show more than 75% of cortical bone undergoing diagenesis.

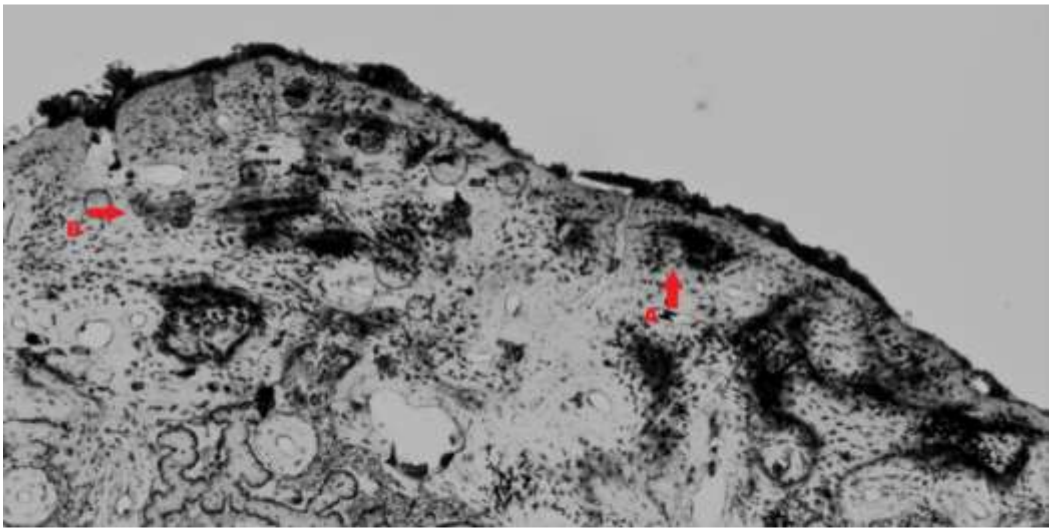


Figure 5.6. Example of diagenesis (A. enlarged canaliculi/Wedl type 2; B. lamellate micro-foci of destruction based on Lemmers et al., 2020) of the cortical cross section from sample HSR 38.1.

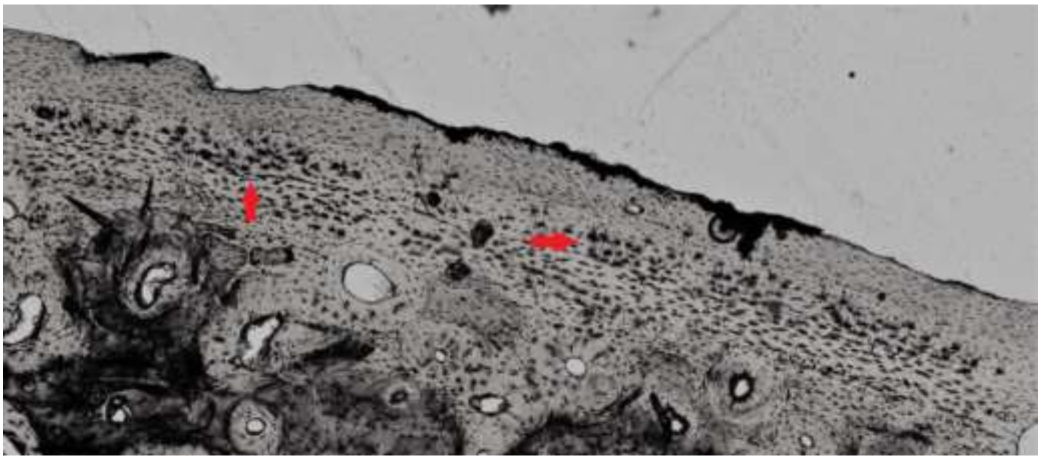


Figure 5.7. Example of diagenesis (enlarged canaliculi/Wedl type 2 based on Lemmers et al., 2020 assessment). Taken from sample NONID.19.

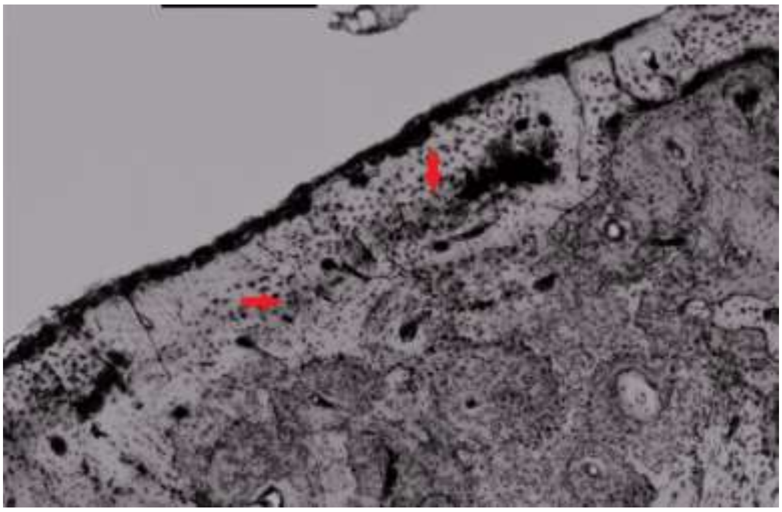


Figure 5.8. Example of diagenesis (enlarged canaliculi/Wedl type 2 based on Lemmers et al., 2020) of the cortical cross section from sample IND 1.2.

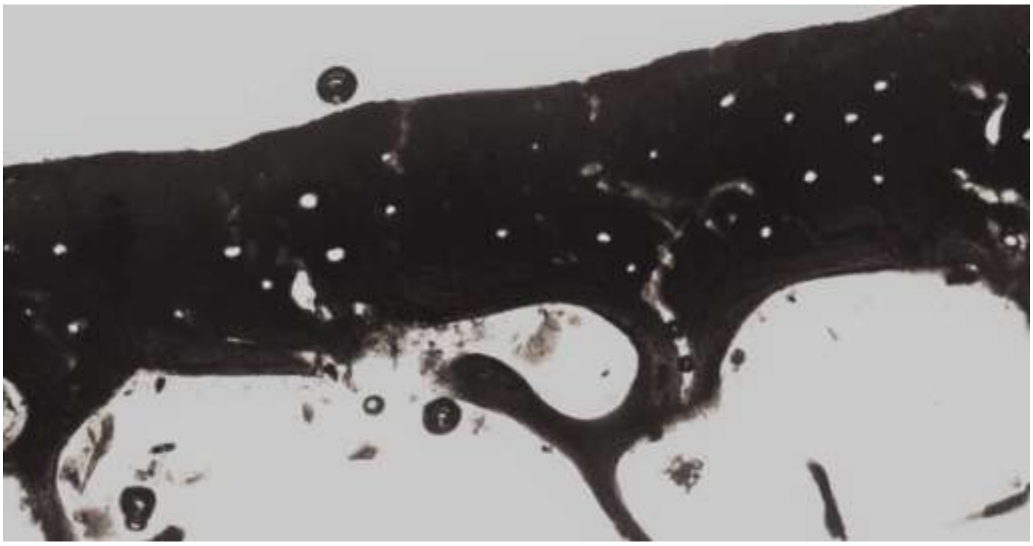


Figure 5.9. A complete lack of micro-anatomical features from sample HSR 7.2

Table 5.13. Cortical area (Ct.Ar.) and area of cortical bone affected by diagenesis (Ct.BAD) from Area 43 thin sections.

	SAMPLE	Ct.Ar.	Ct.BAD	%	Group	OHI/GHI*
BURNT	NON ID. 2	18.205	0.000	0.0	0	5
	NON ID. 9	40.358	2.859	7.0	1	4
	NON ID. 5	11.961	1.396	11.6	1	4
	HSR 19. 2	19.165	3.979	20.7	1	3
	T. 68 SUP. 4	15.969	3.834	24.0	1	3
	HSR 7. 1	10.013	3.077	30.7	1	3
	IND 1. 1	29.52	9.59	32.4	1	3
	IND 1. 2	28.65	9.896	34.5	1	3
	IND 1. 3	30.55	13.154	43.0	1	3
	HSR 38. 1	20.765	9.907	47.7	1	3
	NON ID. 8	21.422	11.84	55.2	2	2
	NON ID. 19	21.731	12.599	57.9	2	2
	HSR 15. 1	14.793	12.689	85.7	2	1
	HSR 7. 2	15.172	13.592	89.5	2	1
	NON ID. 6	13.443	12.047	89.6	2	1
	HSM	11.854	11.149	94.0	2	1
	NON ID. 15	24.426	23.343	95.5	2	0
	HSN/HSM. 1	6.758	6.464	95.6	2	0
	T. 68 SUP. 3	10.674	10.674	100	2	0
UNBURNT	HSW 19. 2	32.166	2.841	8.8	1	4
	HSW 24. 2	31.789	5.339	16.7	1	3
	HSW 24. 4	31.321	11.604	37.0	1	3
	HSW 24. 1	33.342	20.105	60.2	2	2
	HSW 19. 1	32.125	32.125	100	2	0

* Oxford Histological Index (Millard, 2001) and General Histological Index (Hollund et al., 2011, 2015).

- *Diagenesis*

The skeletal remains were analyzed to detect useful data for a taphonomic reconstruction of the events. Once the soft tissues are decomposed, if skeletal elements are left in the open air, they undergo a series of alterations. These alterations can occur on the surface of the bone in the form of streaks, flaking and fragmentation. The observation of the remains from Area 43 of Ra’s al-Hamra 5 revealed the presence of different bone elements whose state of conservation allows to reconstruct a more or less long period of exposure in the open air (Figs. 5.10-5.13).

Of the total bone portions analyzed (917), 20.5% show evident signs of surface alterations related to the exposure of fresh bones in the open air (Tab. 5.14). The analysis showed that the sectors in which bones show most this alteration are HSR (6.8%) and HSL (6.2%) (Tab. 5.15).

Table 5.14. Diagenetic alteration from Area 43 based on skeletal elements.

Skeletal element	Diagenesis	
	n	%
Skull	53/537	9.8
Mandible	12/30	40.0
Scapula	7/34	20.5
Humerus	20/50	40.0
Radius	17/42	40.4
Ulna	15/47	31.9
Hip Bone	26/58	44.8
Femur	15/37	40.5
Tibia	10/42	23.8
Fibula	13/40	32.5
TOTAL	188/917	20.5

Table 5.15. Diagenetic alteration of bones from Area 43 based on excavation sectors.

Sector	Diagenesis	
	n (917)	%
HSL	57	6.2
HSM	5	0.5
HSN	1	0.1
HSQ	2	0.2
HSR	63	6.8
HSS	1	0.1
HSW	15	1.6
NON ID	44	4.7
TOTAL	188	20.5

Individuals identified from field documentation and from single and multiple burials were also analyzed. Six individuals show alteration of the cranial vault surface related to exposure to open air.

Additionally, signs related to the action of animals were documented. Few finds show these traces. Some remains have circular holes to be connected to the action of termites. Two diaphysis, one of humerus and one of ulna, show signs of rodent teeth. A fragment of hip bone, on the other hand, shows signs of the bite of a carnivore. The signs of rodent and carnivorous teeth can be important for a study of post-depositional processes.

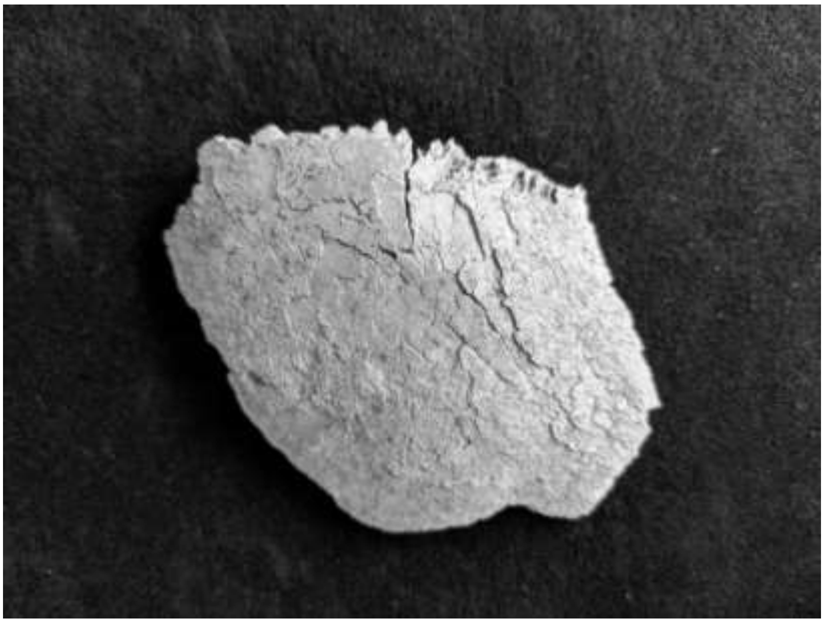


Figure 5.10. Cranial vault fragment from Area 43 showing diagenetic alteration of the surface.

Figure 5.11. Fragment of ulna with surface altered due to the exposure of fresh bone in the open air (Area 43, Rif. 0).

Figure 5.12. Fragment of femoral diaphysis with surface altered due to the exposure of fresh bone in the open air (Area 43, Rif. 0).

Figure 5.13. Hip fragment with diagenetic alteration of the surface (Area 43, HSR)

5.1.6 Manipulation traces

The state of preservation of the findings, whose surface is significantly altered by combustion and diagenetic factors, made difficult to detect traces associated with manipulation practices.

Few osteological fragments on the total highlighted the presence of manipulation signs (Figs. 5.14-5.16). One fragment of cranial vault presents scratch marks, one clavicle has small cut marks on the superior surface, one fragment of radius' diaphysis presents one small cut mark. Data are too scarce to allow the reconstruction of specific cultural or ritual practices.

Figure 5.14. Scratch marks on a cranial vault fragment from Area 43.

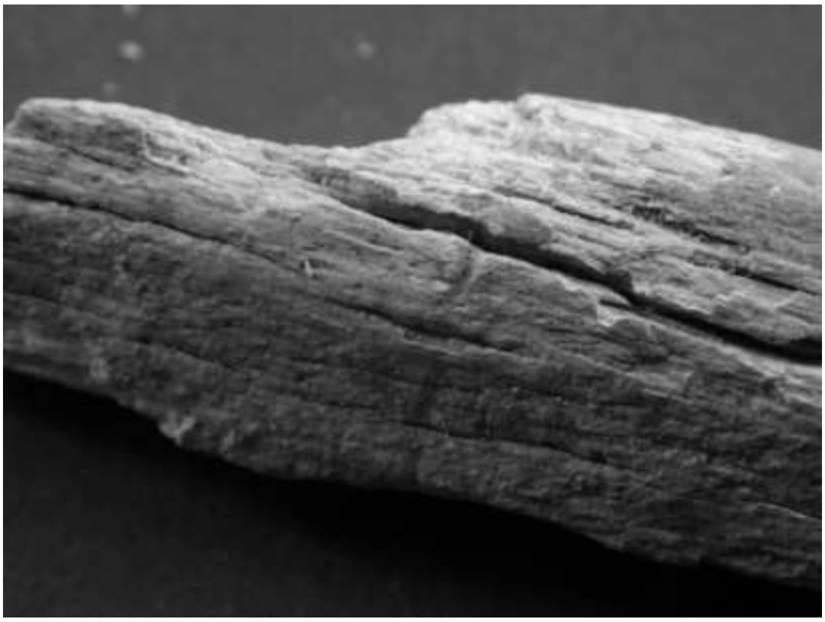


Figure 5.15. Cut mark on a fragment of radius' diaphysis (Area 43, Rif. 0).

Figure 5.16. Cut marks on the superior surface of the clavicle HSM 9-10 from Area 43, RH5.

5.1.7 Within the site comparison

Demographic and paleopathological data emerged from the present study were compared, if possible, with the data from other RH5 depositions (Grilletto, 1982; Macchiarelli,1984, 1989; Coppa et al., 1985, 1990; Salvatori, 2007; Munoz, 2013).

First, the demographics were compared. In Area 43 the presence of 77 individuals, 2 fetuses/perinatal, 30 sub-adults and 45 adults was documented. In the rest of the RH5 graveyard the remains of 6 fetus/perinatal, 60 sub-adults and 115 adult individuals were found. As far as adult individuals are concerned, in Area 43 twenty individuals are female or probably females and 19 males or probably males. The rest of the RH5 graveyard, however, contained the remains of 34 females and 63 males. A statistical comparison was made by age grouping and by sex. No demographic difference was detected in a general comparison between Area 43 and the rest of the graveyard, either by sex or by adult and sub-adult numbers (Tab. 5.16).

Table 5.16. Demographic data between RH5 Area 43 and other RH5 depositions examined by Chi-square test (1) and a Fisher's exact test (2).

	non-Area 43[1]		Area 43		
	n	%	n	%	P (1)
Fetus/perinatal	7	3.8	2	2.6	0.6066
Sub-adults	60	33.0	30	39.0	
Adults	115	63.2	45	58.4	
	non-Area 43		Area 43		
	n	%	n	%	P (2)
Females	34	35.0	20	51.3	0.0858
Males	63	65.0	19	48.7	

[1] Salvatori, 2007; Munoz, 2013.

Fetuses and sub-adults were analyzed more specifically by distinguishing five groups (Bogin, 1997): fetus/perinatal, infant (0-3 years), childhood (4-8 years), juvenile (9-12 years) and adolescent (13-19 years) (Tab. 5.17).

Table 5.17. Number of sub-adult individuals from the RH5 graveyard non-Area 43 and Area 43 examined by Fisher's exact test (1) and Chi-square test (2)

	RH5 non-Area 43		RH5 Area 43			
	n (67)	%	n (32)	%	P(1)	P (2)
Fetus/perinatal	7	10.4	2	6.2	0.7141	0.4863
Infant	20	29.8	6	18.8	0.3300	
Childhood	13	19.4	11	34.4	0.1336	
Juvenile	8	11.9	4	12.5	1.0000	
Adolescent	19	28.3	9	28.1	1.0000	

While in Area 43 the percentage of sub-adult individuals between 4-8 years is higher (34.4%) than that of sub-adults from other groups, in the rest of the RH5 graveyard the infants (0-3 years) are represented by a higher percentage (29.8%). The difference does not appear statistically significant and might just be related to numerical variations.

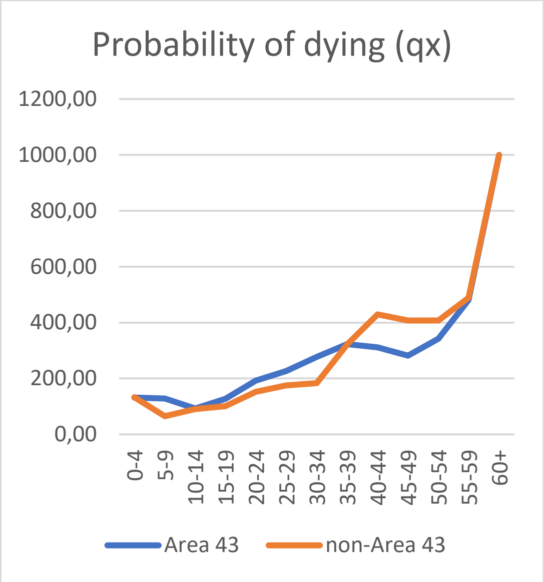
- *Life table comparison between Area 43 and non-Area 43*

A life table was created for the RH5 non-Area 43 human remains, following the same procedure applied to the Area 43 burials (Tab. 5.18). Life expectancy (ex) at birth of RH5 non-Area 43 is approximately 27 years. At 20 years of age life expectancy increases to approximately 37 years of age. Similar to Area 43, the non-Area 43 burials show higher probability of dying at birth compared to the other sub-adult age groups. The qx decreases and then it starts increase again. As shown in Figs. 5.17-5.18, RH5 Area 43 and RH5 non-Area 43 present similar trends for both probability of dying and life expectancy.

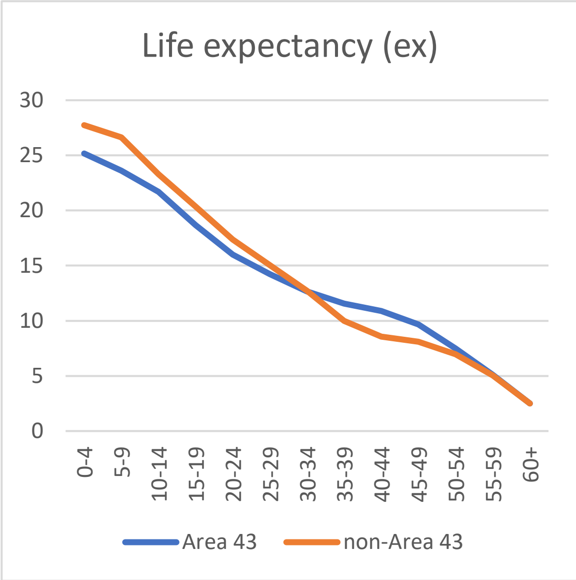
Table 5.18. Life table of individuals from RH5 non-Area 43

Age classes	ax	Dx	dx	Lx	qx	Lx	Tx	ex
0-4	175.00	23.29	13.31	100.00	133.09	466.73	2774.14	27.74
5-9	151.71	9.86	5.63	86.69	64.99	419.37	2307.41	26.62
10-14	141.85	12.89	7.37	81.06	90.87	386.87	1888.04	23.29
15-19	128.96	12.98	7.42	73.69	100.65	349.91	1501.17	20.37
20-24	115.98	17.72	10.13	66.27	152.78	306.06	1151.26	17.37
25-29	98.26	17.20	9.83	56.15	175.05	256.17	845.20	15.05
30-34	81.06	14.81	8.46	46.32	182.70	210.44	589.03	12.72
35-39	66.25	21.32	12.18	37.86	321.81	158.83	378.59	10.00
40-44	44.93	19.28	11.02	25.67	429.11	100.83	219.76	8.56
45-49	25.65	10.45	5.97	14.66	407.41	58.36	118.93	8.11
50-54	15.20	6.20	3.54	8.69	407.89	34.57	60.57	6.97
55-59	9.00	4.40	2.51	5.14	488.89	19.43	26.00	5.06
60+	4.60	4.60	2.63	2.63	1000.00	6.57	6.57	2.50
		175.00	100.00			2774.14		

ax = n of people alive at each group; Dx = total n of deaths occurring in each age group; dx = percentage of total deaths occurring in each age group; lx = n of survivors for each age interval; qx = probability of dying at each age interval; Lx = total n of years lived between one age interval and the following one; Tx = total n of years lived after a lifetime of all individuals who reach the age group; ex = life expectancy.



5.17. Comparison of mortality rates (qx) among RH5 Area 43 and RH5 non-Area 43 burials.



5.18. Comparison of life expectancy values (ex) among RH5 Area 43 and RH5 non-Area 43 burials

- *Paleopathological comparison between Area 43 and non-Area 43 burials*

Paleopathological data related to dietary lesions, dental defects and DJD from Area 43 were compared with data lesions from the other depositions in the RH5 graveyard. No statistically significant differences were found regarding the frequencies of the three lesion types between Area 43 and the other burials (Tabs. 5.19-21). Burial frequency of lesions provides no evidence of community change over time. This is neither in terms of difference in the peopling of the fishing village in the difference in activity patterns.

Table 5.19. Cranial dietary lesion frequencies from Area 43 and non-Area 43 of RH5 graveyard examined by a Fisher's exact test.

	non-Area 43[1]				Area 43				P	
	Sub-adults		Adults		Sub-adults		Adults			
Bones	n	%	n	%	n	%	n	%	Sub-adults	Adults
Cranium	9/28	32.1	13/64	20.3	1/16	6.2	3/22	13.6	0.0670	0.7515
Maxillary bone	0/19	0.0	1/47	2.1	1/4	25.0	1/14	7.1	0.1739	0.4093
Mandible	0/25	0.0	1/54	1.9	1/10	10.0	0/26	0.0	0.2857	1.0000

[1] Data come from raw data sheets housed in the Laboratory of Biology of Ancient Populations of Sapienza University of Rome.

Table 5.20. Dental and oral disease frequencies from RH5 Area 43 and RH5 non-Area 43.

	RH5 non-Area 43[1]		RH5 Area 43		
	n	%	n	%	P
Caries	0/1289	0.0%	0/170	0.0%	1.0000
Periapical lytic lesions	18/1613	1.1%	1/287	0.3%	0.3403
Antemortem tooth loss	60/1672	3.6%	5/311	1.6%	0.0818

[1] Data come from raw data sheets housed in the Laboratory of Biology of Ancient Populations of Sapienza University of Rome.
A comparison of lesions between adults is done using the Fisher's exact test.

Table 5.21. Degenerative joint disease frequencies among adults from RH5 Area 43 and RH5 non-Area 43.

	non-Area 43[1]				Area 43				P	
Joint	Ln	L %	Rn	R %	Ln	L %	Rn	R %	L	R
Shoulder	5/33	15.1	3/27	11.1	1/7	14.3	1/11	9.1	1.0000	1.0000
Elbow	7/56	12.5	9/59	15.2	2/13	15.4	0/16	0.0	0.6742	0.1907
Wrist	3/30	10.0	4/33	12.1	0/10	0.0	1/12	8.3	0.5597	1.0000
Hip	4/38	10.5	2/41	4.9	0/7	0.0	0/8	0.0	1.0000	1.0000
Knee	14/52	26.9	7/49	14.3	1/16	6.2	1/12	8.3	0.0978	1.0000
Ankle	3/49	6.1	2/45	4.4	0/12	0.0	1/10	10.0	1.0000	0.4591

L= left; R= right.
[1] DJD data comes from raw data sheets housed in the Laboratory of Biology of Ancient Populations of Sapienza University of Rome.
A comparison of lesions between adults and sub-adults is done using the Fisher's exact test.

Differences in health status between Area 43 and the rest of the graveyard were not found. All teeth analyzed from Area 43 and the RH5 depositions have no caries. The lack of caries reflects dietary habits that appear to exclude sugary foods (Littleton and Frohlich, 1993; Larsen, 1995; Ortner, 2003; Waldron, 2009). Archaeological and anthropological data, therefore, show they were primarily fishing and collecting wild plant foods as the key component of their diet. Despite the lack of statistically significant differences in DJD frequencies, the Area 43 skeletal remains show a slightly lower frequency of DJD for almost all joints than RH5 non-Area 43. This is most likely an issue of sampling. Both burial deposition groups show patterns of chronically formed skeletal lesions consistent with food gathering lifestyles that require habitual labor. The DJD and OA skeletal lesions are reflective of age and daily work efforts as these individuals gathered and fished for a living.

5.2 DABA AL BAYAH - LARGE COLLECTIVE GRAVE 1 (LCG-1)

5.2.1 Minimum number count

Due to the commingled and fragmented condition of skeletal remains, a minimum number count of adult individuals was performed based on sockets count (Tab. 5.22). Based on maxillary bones at least 54 individuals have been identified (left canine). According to mandibular sockets (left canine) a minimum number of 79 individuals is determined.

Table 5.22. Count of mandibular and maxillary alveolar sockets from the LCG-1 skeletal remains.

	Maxillary		Mandibular	
	Left	Right	Left	Right
I1	50	53	63	54
I2	53	52	70	58
C	54	50	79	75
P3	45	46	67	71
P4	29	31	65	71
M1	18	16	63	70
M2	7	3	59	62
M3	1	0	11	20
TOT	257	251	477	481

Additionally, several sub-adult maxillary and mandibles were found in the LCG-1 tomb. A minimum number count of at least 15 sub-adult individuals is determined. Based on dental eruption the age of 14 sub-adult individuals was assessed: one infant (from birth to 3 years), ten individuals are aged between 4-8 years (childhood), one individual is a juvenile (9-12 years), two individuals are adolescent (15-18 years).

5.2.2 Oral pathologies

From the analysis of maxillary and mandibles from the LCG-1 tomb, oral pathologies were assessed. From the total number of alveolar sockets analyzed, 489 sockets exhibit antemortem tooth loss (AMTL) and 155 show the formation of periapical lytic lesions (Tab. 5.23).

Table 5.23. Frequency of oral pathologies (AMTL and periapical lytic lesions) in maxillary and mandibular sockets from LCG-1.

Oral pathologies	n	%
AMTL	489/1466	33.3
Periapical lytic lesions	155/724	21.4

The alveolar sockets were analyzed distinguishing maxillary and mandibular bones (Tabs. 5.24-5.25). The analysis of maxillary bones revealed higher percentages of AMTL in premolar and molar sockets. As for the premolars, the highest percentages of antemortem tooth loss are documented on left alveolar sockets (specifically P3). The highest percentage of AMTL on molar sockets is recorded on right M1 sockets. The 66.6% frequency in right M2 cannot be considered significant due to the small sample analyzable (n = 3). The statistical comparison does not reveal any relevant difference in the comparison based on laterality.

Table 5.24. Frequency of AMTL in left and right maxillary sockets from LCG-1.

	Maxillary Left			Maxillary Right			P
	n	affected	%	n	affected	%	
I1	50	4	8.0	53	4	7.5	1.0000
I2	53	5	9.4	52	4	7.7	1.0000
C	54	3	5.5	50	2	4.0	1.0000
P3	45	11	24.4	46	7	15.2	0.3030
P4	29	5	17.2	31	3	9.6	0.4653
M1	18	9	50.0	16	11	68.7	0.3151
M2	7	1	14.3	3	2	66.6	0.1833
M3	1	0	0.0	0	0	0.0	1.0000
TOTAL	257	38	14.7	251	33	13.1	0.6111

A comparison of lesions between adults is done using the Fisher’s exact test.

Table 5.25. Frequency of AMTL in left and right mandibular sockets from LCG-1.

	Mandibular Left			Mandibular Right			P
	n	affected	%	n	affected	%	
I1	63	15	23.8	54	16	29.6	0.5320
I2	70	13	18.5	58	11	18.9	1.0000
C	79	13	16.4	75	9	12.0	0.4941
P3	67	27	40.3	71	33	46.4	0.4956
P4	65	33	50.7	71	39	54.9	0.7312
M1	63	54	85.7	70	64	91.4	0.4116
M2	59	40	67.8	62	47	75.8	0.4188
M3	11	0	0.0	20	4	20.0	0.2693
TOTAL	477	195	40.9	481	223	46.3	0.0906

A comparison of lesions between adults is done using the Fisher's exact test.

The analysis of maxillary and mandibular sockets revealed the presence of several periapical lytic lesions (Tabs. 5.26-5.27). In maxillary bones the percentage of these lesions appears higher in left first molar (57.1%) and in right first molar (80.0%) than in the other sockets analyzed. The difference might be related to sample size (n = 7 for left first molar, n = 5 for right first molar). A comparison between left and right sockets does not reveal any statistically relevant difference. The analysis of mandibular bones highlighted that the higher percentages of periapical lytic lesions appear in the left and right M1 and M2 sockets. A comparison between left and right sockets shows statistically relevant difference for canines. Higher frequencies of periapical lytic lesions are shown in left canine (27.5%) compared to right canines (9.5%).

Table 5.26. Frequency of periapical lytic lesions in left and right maxillary sockets from LCG-1 examined by a Fisher's exact test.

	Maxillary Left			Maxillary Right			P
	n	affected	%	n	affected	%	
I1	38	7	18.4	39	10	25.6	0.5843
I2	41	10	24.3	42	10	23.8	1.0000
C	38	6	15.7	37	6	16.2	1.0000
P3	25	8	32.0	26	7	26.9	0.7645
P4	19	3	15.7	11	4	36.3	0.3717
M1	7	4	57.1	5	4	80.0	0.5758
M2	3	1	33.3	1	0	0.0	1.0000
M3	1	0	0.0	0	0	0.0	1.0000
TOTAL	172	39	22.6	161	41	25.4	0.5151

Table 5.27. Frequency of periapical lytic lesions in left and right mandibular sockets from LCG-1.

	Mandibular Left			Mandibular Right			P
	n	affected	%	n	affected	%	
I1	28	6	21.4	31	6	19.3	1.0000
I2	42	6	14.3	37	6	16.2	1.0000
C	40	11	27.5	42	4	9.5	0.0467^
P3	28	5	17.8	29	1	3.4	0.1020
P4	25	3	12.0	26	3	11.5	1.0000
M1	8	6	75.0	5	3	60.0	1.0000
M2	14	6	42.8	17	7	41.1	1.0000
M3	8	1	12.5	11	1	9.1	1.0000
TOTAL	193	44	22.8	198	31	15.6	0.0945

A comparison of lesions between adults is done using the Fisher's exact test.
^ Indicated statistically significant results at P = 0.05.

A general comparison between mandibular and maxillary sockets shows statistically significantly higher percentages of AMTL on almost all the lower sockets (Tab. 5.28). As for periapical defects the difference is not statistically significant, except for P3. Upper P3 sockets show higher percentages of periapical lytic lesions (29.4%) compared to lower sockets (10.5%) (Tab. 5.29).

Table 5.28. Frequency of AMTL from LCG-1 compared between maxillary and mandibular sockets examined by a Fisher's exact test.

	Maxillary			Mandibular			P
	n	affected	%	n	affected	%	
I1	103	8	7.7	117	31	26.5	0.0003^{x}
I2	105	9	8.5	128	24	18.7	0.0367^
C	104	5	4.8	154	22	14.3	0.0210^
P3	91	18	19.7	138	60	43.4	0.0002^{x}
P4	60	8	13.3	136	72	52.9	0.0001^{x}
M1	34	20	58.8	133	118	88.7	0.0002^{x}
M2	10	3	30.0	121	87	71.9	0.0106*
M3	1	0	0.0	31	4	12.9	1.0000
TOTAL	508	71	13.9	958	418	43.6	0.0001^{x}

^ Indicated statistically significant results at P = 0.05.
* Indicated statistically significant results at P = 0.01.
^{x} Indicated statistically significant results at P = 0.001.

Table 5.29. Frequency of periapical lytic lesions from LCG-1 compared between maxillary and mandibular sockets.

	Maxillary			Mandibular			P
	n	affected	%	n	affected	%	
I1	77	17	22.0	59	12	20.3	0.8360
I2	83	20	24.1	79	12	15.1	0.1717
C	75	12	16.0	82	15	18.3	0.8329
P3	51	15	29.4	57	6	10.5	0.0158^
P4	30	7	23.3	51	6	11.7	0.2148
M1	12	8	66.6	13	9	69.2	1.0000
M2	4	1	25.0	31	13	41.9	0.6350
M3	1	0	0.0	19	2	1.5	1.0000
TOTAL	333	80	24.0	391	75	19.1	0.1226

A comparison of lesions between adults is done using the Fisher's exact test.
^ Indicated statistically significant results at P = 0.05.

Additionally, two sub-adult skulls show antemortem tooth loss and periapical lytic lesions. Both the individuals are aged 15-18 years. One individual shows antemortem tooth loss and periapical lytic lesions on upper sockets: left C, P3, P4, M1, M2 and right P4, M1. The other sub-adult individual shows antemortem tooth loss on lower left M1 and lower right P4, M1, M2.

Deciduous and permanent teeth were analyzed to assess the presence of dental caries (Tab. 5.30). Of the total number of permanent teeth analyzed (81), 12 show dental caries. Five deciduous teeth over the total number analyzed (18) show dental caries. No differences were found comparing the frequencies of caries in deciduous and permanent teeth. The permanent teeth were analyzed distinguishing upper and lower teeth (Tab. 5.31). No statistical difference was found comparing dental defect frequencies between upper and lower teeth.

Table 5.30. Frequency of caries from LCG-1 compared between deciduous and permanent teeth.

	Dental defects		P
	n	%	
Deciduous teeth	5/18	27.7	0.2966
Permanent teeth	12/81	14.8	

A comparison of lesions between adults is done using the Fisher's exact test.

Table 5.31. Frequency of dental defects from the LCG-1 permanent teeth compared between upper and lower teeth.

	Dental defects		P
	n	%	
Upper teeth	7/58	12.0	0.3067
Lower teeth	5/23	21.7	

A comparison of lesions between adults is done using the Fisher's exact test.

5.3 Daba al Bayah - Large Collective Grave 2 (LCG-2)

Several burial deposition typologies were excavated in LCG-2. Anthropological and taphonomic data from excavation reports and skeletal remains are presented as a preliminary assessment.

5.3.1 Minimum number count of skeletal remains inside Chamber A

Skeletal remains from Chamber A were counted to assess the MNI buried. The scattered bones, the bones from the accumulations located in the northern part of the Chamber and the bones from the primary depositions were counted (Tab. 5.32). Based on the bone count from Chamber A at least 15 individuals, fourteen adults (20-x years) and two sub-adults (0-19 years) were buried there over time. The count is based on the data reported during field excavations. It was not possible to count all the skeletal remains due to the poor state of preservation of many of them.

Table 5.32. Count of human skeletal remains from Chamber A of LCG-2.

	Sub-adult			Adult		
Bones	Ln	Rn	N.D.	Ln	Rn	N.D.
Skull	1			14		
Mandible	0			11		
Atlas	1			7		
Axis	1			7		
Sternum	0			2		
Scapula	1	1	0	10	6	0
Clavicle	0	0	0	7	10	2
Humerus	0	0	0	8	10	2
Radius	0	0	0	6	10	1
Ulna	0	0	0	9	7	1
Scaphoid	0	0	0	9	3	2
Lunate	0	0	0	5	5	1
Triquetral	0	0	0	1	2	1
Pisiform	0	0	0	0	2	0
Trapezium	0	0	0	2	3	0
Trapezoid	0	0	0	1	2	0
Capitate	0	0	0	8	5	1
Hamate	1	0	0	3	3	1
Metacarpals	0	0	0	7	9	31
Hand phalanges	0	0	0	16	19	79
Sacrum	1			10		
Hip	0	2	0	7	7	0
Femur	1	1	0	8	8	4
Patella	1	1	0	7	10	0
Tibia	1	1	0	6	6	3
Fibula	1	1	0	5	6	1
Talus	1	1	0	12	9	1
Calcaneus	1	0	0	8	8	1
Navicular	1	0	0	6	8	0
Cuboid	1	0	0	5	4	1
Cuneiforms	3	2	0	11	13	11
Metatarsals	5	0	0	14	12	45
Foot phalanges	1	0	2	23	5	53

5.3.2 Minimum number count of skeletal remains inside Chamber B

The excavations of Chamber B revealed the remains of a number of individuals. Some individuals (12) were in partial or complete anatomical position. Some of them, 2 adults and one sub-adult had no skull. In addition to these remains, several scattered post-cranial skeletal remains and seven skulls were found. A count of the skeletal remains from Chamber B, both in anatomical connection and scattered, was performed (Tab. 5.33). From the count of skeletal elements, it appears that there are at least 12 adult individuals (over 20 years of age) and 4 sub-adult individuals.

Table 5.33. Count of bones from LCG-2 Chamber B.

	Sub-adult			Adult		
Bone	Ln	Rn	N.D.	Ln	Rn	N.D.
Skull	4			12		
Mandible	0			8		
Atlas	0			10		
Axis	0			9		
Sternum	1			8		
Scapula	1	3	0	6	9	0
Clavicle	3	0	0	9	10	0
Humerus	4	3	2	9	10	0
Radius	1	2	0	8	10	0
Ulna	2	2	1	10	10	0
Sacrum	0			7		
Hip	1	1	2	6	11	1
Femur	4	4	2	8	11	2
Patella	0	0	0	8	8	0
Tibia	0	1	0	7	9	0
Fibula	0	1	0	7	8	1
Talus	2	0	1	10	9	0
Calcaneus	2	2	0	6	8	0

From the excavation data it seems that various interventions (reuse of the tomb over time) influenced the state of preservation, and the anatomical connection of the burial remains. The scattered bones do not seem to be the result of secondary depositions but seem to be the result of reductions or intrusions.

5.3.3 Primary deposition burials

Individuals from deposition burials were assessed for sex, age at death and skeletal lesions.

- *Age and sex assessment*

A demographic analysis was conducted on the 73 primary deposition burials, as a result 4 fetus/perinatal individuals, 35 sub-adults and 34 adults are identified (Tab. 5.34). From the 35 sub-adults, 26 are infants (0-3 years), 5 are children (4-8 years), 2 are juvenile (9-12 years) and there are two adolescents (13-19 years). Of the adults, twelve are male or probably male and 19 are female or probably female. It was not possible to determine the sex of three adult individuals. This was due to their poor state of preservation.

Table 5.34. Age and sex determination of individuals in primary deposition from Daba LCG-2.

Age	n (73)	%
Fetus/perinatal	4	5.5
Infant	26	36.1
Childhood	5	7.0
Juvenile	2	2.8
Adolescent	2	2.8
Adult	34	45.8

Sex	n (34)	%
M	7	20.6
Prob. M	5	14.7
F	14	41.2
Prob. F	5	14.7
N.D.	3	8.8

Given the large chronologic span for the use of the Daba LCG-2 tomb, age and sex determination of individuals from primary deposition were also analyzed distinguishing by chronological periods (Tabs. 5.35-5.36). Based on this distinction the mean age for adult individuals was determined. For EIA adult individuals, the mean age of male individuals is 38.12 years, while for female individuals is 40.28 years. The mean age of adult individuals from LIA period is 44.75 years for males and 32.94 for females.

Table 5.35. Age determination of individuals in primary deposition from Daba LCG-2, distinguished by chronological periods.

Age	EIA		LIA		PIR	
	n (29)	%	n (38)	%	n (6)	%
Fetus/perinatal	1	3.4	3	7.9	0	0.0
Infant	12	41.4	14	36.8	0	0.0
Childhood	3	10.3	2	5.3	0	0.0
Juvenile	0	0.0	2	5.3	0	0.0
Adolescent	0	0.0	0	0.0	2	33.3
Adult	13	44.8	17	44.7	4	66.7

EIA: Early Iron Age; LIA: Late Iron Age; PIR: *Pré-Islamique Récent*.

Table 5.36. Sex determination of adult individuals in primary deposition from Daba LCG-2, distinguished by chronological periods.

Sex	EIA		LIA		PIR	
	n (13)	%	n (17)	%	n (4)	%
M	3	23.1	4	23.5	0	0.0
Prob. M	1	7.7	2	11.8	2	50.0
F	7	53.8	7	41.1	0	0.0
Prob. F	2	15.4	2	11.8	1	25.0
ND	0	0.0	2	11.8	1	25.0

EIA: Early Iron Age; LIA: Late Iron Age; PIR: *Pré-Islamique Récent*.

- *Life table*

Based on the ages determined for human skeletal remains a life table was created (Tab. 5.37). According to the life table the life expectancy (ex) at birth of the Iron Age LCG-2 community is approximately 20 years. At 20 years of age the life expectancy increases to approximately 39 years. Compared to other sub-adult groups the 0-4 group present a higher mortality. After a high mortality rate at birth (qx = 436,51), the qx decreases up to 19 years and then increases again.

Table 5.37. Life table for individuals from Daba LCG-2 Iron Age primary burials

Age classes	ax	Dx	dx	Lx	qx	Lx	Tx	ex
0-4	63.00	27.50	43.65	100.00	436,51	390.87	2056.98	20.57
5-9	35.50	4.50	7.14	56.35	126,76	263.89	1666.11	29.57
10-14	31.00	1.00	1.59	49.21	32.26	242.06	1402.22	28.50
15-19	30.00	0.43	0.68	47.62	14.33	236.39	1160.16	24.36
20-24	29.57	4.03	6.40	46.94	136.29	218.69	923.77	19.68
25-29	25.54	2.98	4.73	40.54	116.68	190.87	705.08	17.39
30-34	22.56	2.90	4.60	35.81	128.55	167.54	514.21	14.36
35-39	19.66	4.89	7.76	31.21	248.73	136.63	346.67	11.11
40-44	14.77	5.44	8.63	23.44	368.31	95.63	210.04	8.96
45-49	9.33	3.91	6.21	14.81	419.08	58.53	114.40	7.73
50-54	5.42	2.54	4.03	8.60	468.63	32.94	55.87	6.49
55-59	2.88	1.72	2.73	4.57	597.22	16.03	22.94	5.02
60-64	1.16	0.87	1.38	1.84	750.00	5.75	6.90	3.75
65+	0.29	0.29	0.46	0.46	1000.00	1.15	1.15	2.50
		63.00	100.00			2056.98		

ax = n of people alive at each group; Dx = total n of deaths occurring in each age group; dx = percentage of total deaths occurring in each age group; lx = n of survivors for each age interval; qx = probability of dying at each age interval; Lx = total n of years lived between one age interval and the following one; Tx = total n of years lived after a lifetime of all individuals who reach the age group; ex = life expectancy.

- *Paleopathological analysis*

A paleopathological assessment was performed. Several skeletal and dental lesions were recorded in skeletal remains from the LCG-2 primary depositions: dietary lesions, infections, periostitis, vertebral lesions (osteoarthritis, Schmörl's nodes and spina bifida), degenerative joint disease, oral defects (caries, antemortem tooth loss and periapical lytic lesions) (Tabs. 5.38- 5-39). Few traces of fractures, traumas, inflammations were also found.

Table 5.38. Frequency of skeletal lesions in adult and sub-adult individuals from the LCG-2 primary burials, distinguished by Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA				P	LIA				P
	Sub-adults		Adults			Sub-adults		Adults		
Skeletal lesion	n	n	n	%		n	%	n	%	
Dietary lesions	0/12	0.0	2/12	16.6	0.4783	1/12	8.3	2/15	13.3	1.0000
Infections	0/15	0.0	4/12	33.3	0.0282^	2/15	13.3	2/17	11.7	1.0000
Periostitis	0/14	0.0	2/9	22.2	0.1423	1/13	7.7	3/15	20.0	0.6000

^ Indicated statistically significant results at P = 0.05.
A comparison of lesions between males and females is done using the Fisher's exact test.

Table 5.39. Comparison of skeletal lesion frequencies between adults and sub-adults of Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA sub-adults vs LIA sub-adults	EIA adults vs LIA adults
Skeletal lesion	P	P
Dietary lesions	1.0000	1.0000
Infections	0.4828	0.1981
Periostitis	0.4815	1.0000

Metabolic disorders were found in the form of cribra orbitalia and porotic hyperostosis in 4 adults (2 from EIA: Burials 16 and 24; 2 from LIA: Burials 23 and 36) and one sub-adult (Burials 34; Fig. 5.19). Two sub-adult individuals from LIA period (Burials 5 and 14L) show pitting related to infection both on left femur neck. Infections were found also on skeletal remains of 6 adult individuals (Burials 12, 15, 21, 24 from EIA period; Burials 14B and 14N from LIA period). One has a severe pitting on acromial part of right clavicle (B.24) and one shows pitting on the sternal part of the right clavicle (Burial 12). Pitting related to infections was found on femurs necks of Burial 14B (Fig. 5.20). Individual from Burial 14B also shows skeletal lesions related to infection on the posterior surface of the sternum and on the neck of both astragal (Fig.5.21). The same type of infection on the sternum was found on individual from Burial 14N (Fig. 5.22). Burial 21 has an infectious based lesion near the glenoid cavity of both scapulae. An alteration of the acetabular fossa related to infection was found on Burial 15. Periostitis is found on lower limbs of 5 individuals, 1 sub-adult (LIA Burial 5) and 4 adults (EIA Burials 26; LIA Burials 14R, 23, 57). Additionally, Burial 48 (EIA period) shows periostitic lesion on the sternal part of left clavicle.

The comparison of skeletal lesions between adult and sub-adult individuals from each period (Tab. 5.38) highlights significant higher percentages of infections in adult skeletal remains from EIA period.

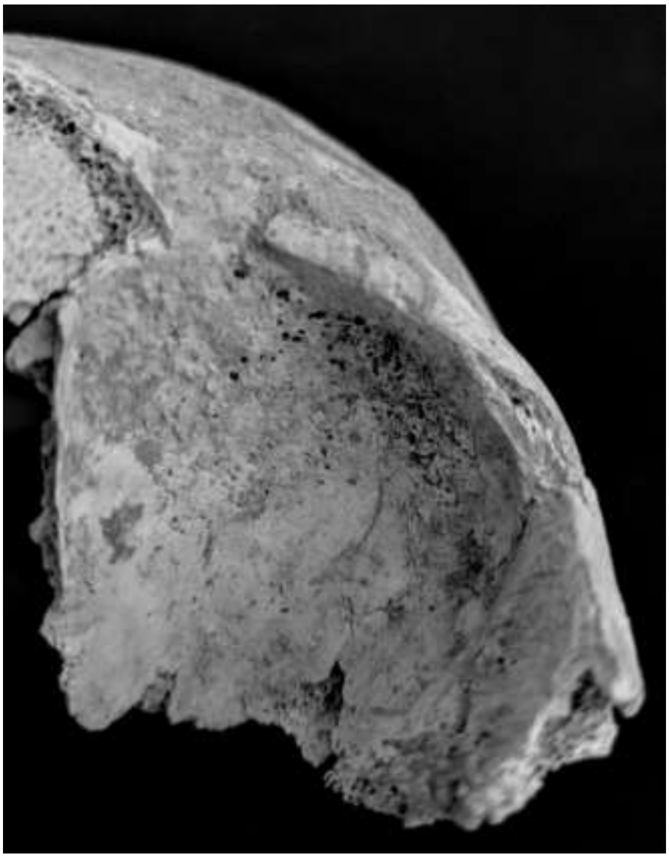


Figure 5.19. Left supraorbital margin exhibiting cribra orbitalia (from Burial 34).

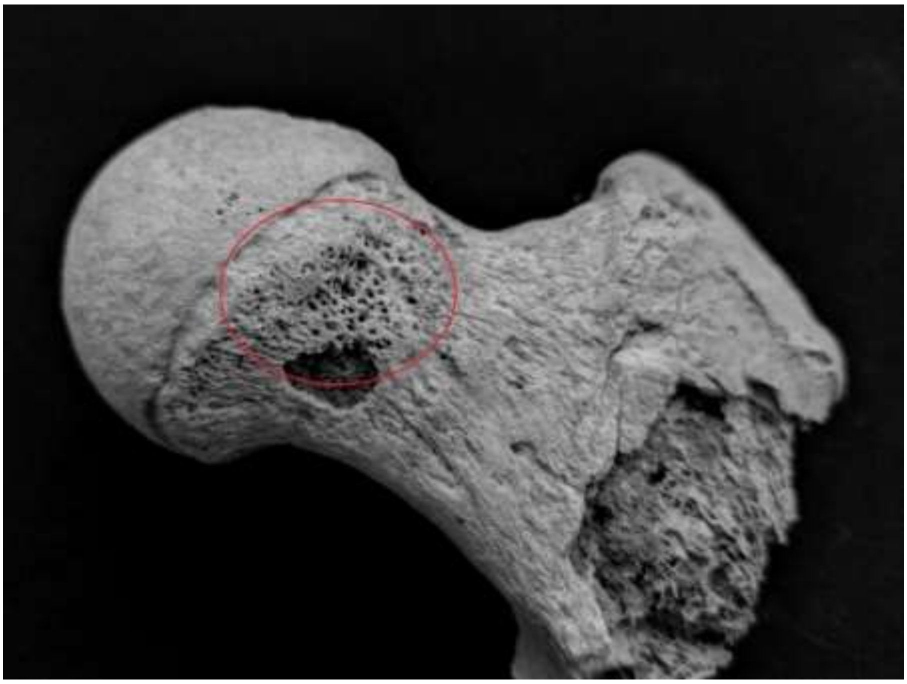


Figure 5.20. Pitting related to infection on the femur neck (from Burial 14B).

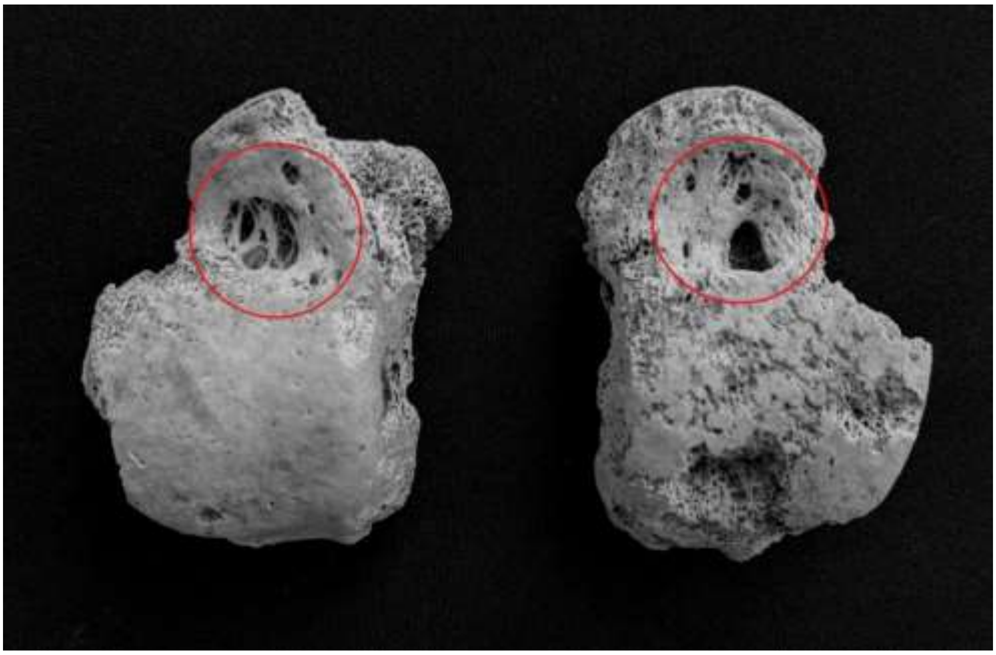


Figure 5.21. Infection-based lesion on the neck of both astragali (from Burial 14B).

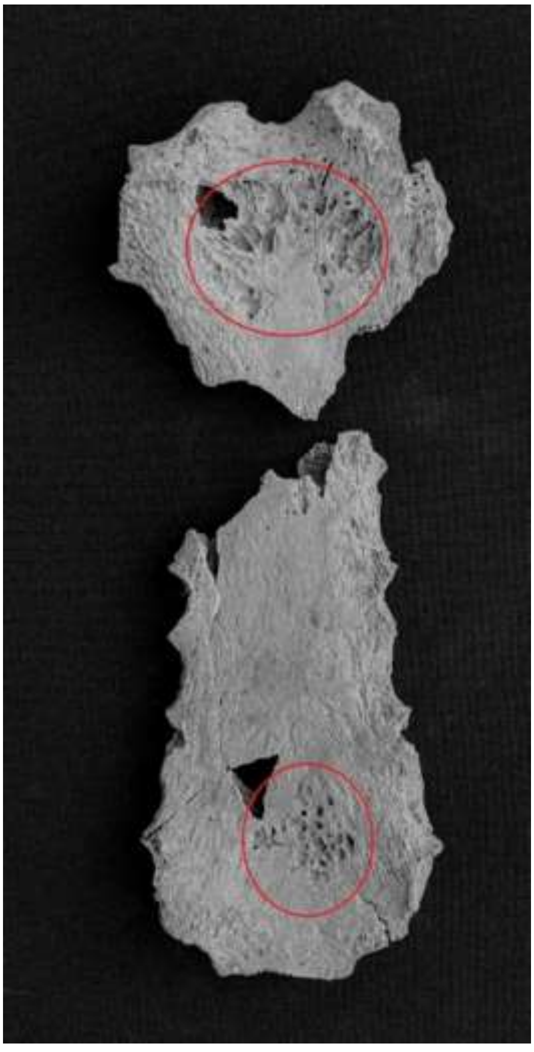


Figure 5.22. Infection-based lesions on the posterior surface of the sternum (from Burial 14N).

Age-related lesions were found on 25 adult individuals (Tab. 5.40). Two individuals from EIA period (Grave 2, Burials 26 and 58B) and six individuals from LIA period (Burials 14C, 14H, 14N, 14S, 36, 38) show skeletal lesions related to DJD. Almost all individuals have alterations in the form of lipping or bone growth affecting the joints of the upper limbs. Degenerative changes in the vertebrae, in the form of lipping, pitting and bone growth, are instead detected on 22 adult individuals (Burials 12, 15, 16, 21, 24, 26, 35, 48 from EIA period; Burials 14A, 14G, 14H, 14J, 14N, 14O, 14R, 14S, 23, 25, 32, 36, 38, 57 from LIA period) (Fig. 5.23). Schmörl's nodes on thoracic and lumbar vertebrae were found on 5 individuals (Burials 14G, 14H, 14J, 32 from LIA period and Burial 48 from EIA period). No significant difference was found comparing the frequency of DJD, osteoarthritis and Schmörl's nodes from the two periods.

Table 5.40. Frequency of vertebral defects and DJD on adult individuals from the LCG-2 primary depositions, distinguished by Iron Age periods.

	EIA		LIA		P
Skeletal lesion	n	%	n	%	
DJD	3/12	25.0	6/17	35.3	0.6942
Osteoarthritis	8/12	66.6	14/17	82.3	0.4029
Schmörl's nodes	1/12	8.3	4/17	23.5	0.3701

Figure 5.23. Fifth lumbar with collapsed vertebral body from Burial 14O.

Other skeletal lesions were highlighted on the skeletal remains from the LCG-2 primary depositions. Two individuals were affected by spina bifida occulta, one complete (LIA Burial 14B) and one partial (S1-S2, EIA Burial 15).

Burials 12, 13 and 24 from EIA period and Burial 14C from LIA period have healed fractures. Individual from Burial 12 have a fracture on left clavicle. A fracture on the left radius was found on the individual from Burial 24 (Fig. 5.24). The remaining two individuals have fractures on metacarpal bones.

Additionally, stress markers related to work activities were found on several individuals from the two periods. Stress markers were found on both lower and upper limbs.

a


b


Figure 5.24. Left radius with healed fracture (a) from Burial 24. Detail of the fracture on the proximal part of the diaphysis (b).

All skeletal lesions detected on adult skeletal remains were analyzed related to the sex of the individual (Tabs. 5.41-5.42). No relevant differences in skeletal lesion frequencies were found between males and female for each period. The comparison of skeletal lesions in male and female individuals between the two groups shows no relevant differences.

Table 5.41. Frequency of skeletal lesions compared between males and females from both Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA					LIA				
	Males		Females		P	Males		Females		P
Skeletal lesion	n	%	n	%		n	%	n	%	
Dietary lesions	1/4	25.0	1/8	12.5	1.0000	0/5	0.0	2/8	25.0	0.4872
DJD	0/4	0.0	2/8	25.0	0.5152	4/6	66.6	2/9	22.2	0.1357
Fractures	1/4	25.0	2/8	25.0	1.0000	1/6	16.6	0/9	0.0	0.4000
Infections	3/4	75.0	1/8	12.5	0.0667	2/6	33.3	0/9	0.0	0.1429
Periostitis	0/3	0.0	1/6	16.6	1.0000	1/6	16.6	2/7	28.5	1.0000
Osteoarthritis	4/4	100	5/8	62.5	0.4909	4/6	66.6	8/9	88.8	0.5253
Schmörl's nodes	0/4	0.0	1/8	12.5	1.0000	1/6	16.6	2/9	22.2	1.0000

A comparison of lesions between males and females is done using the Fisher's exact test.

Table 5.42. Comparison of skeletal lesion frequencies between males and females of the two Iron Age periods.

	EIA males vs LIA males	EIA females vs LIA females
Skeletal lesion	P	P
Dietary lesions	0.4444	1.0000
DJD	0.0762	1.0000
Fractures	1.0000	0.2059
Infections	0.5238	0.4706
Periostitis	1.0000	1.0000
Osteoarthritis	0.4667	0.2941
Schmörl's nodes	1.0000	1.0000

A comparison of lesions between males and females is done using the Fisher's exact test.

As far as dental pathologies are concerned, the percentage of caries was counted on the total number of crown teeth analyzed (n = 69 for EIA, n = 144 for LIA) in adult burials. For antemortem tooth loss (AMTL) and periapical lytic lesions the frequencies were determined on the number of alveolar sockets of adult individuals analyzed (EIA: n = 198 for AMTL and n = 115 for periapical lytic lesions: LIA: n = 178 for AMTL and n = 119 for periapical lytic lesions) (Fig. 5.25). Additionally, oral pathologies were analyzed distinguishing by tooth. Due to the small number of the sample the teeth were only distinguished by tooth type and not by individual tooth location (Tabs. 5.43-5.44)

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Table 5.43. Frequency of oral pathologies on adult individuals from the Daba LCG-2 primary burials, distinguished by Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA		LIA		P
Oral pathologies	n	%	n	%	
Antemortem tooth loss	76/198	38.4	58/178	32.5	0.2809
Periapical lytic lesions	12/115	10.4	13/119	10.9	1.0000
Caries	6/69	8.5	14/144	9.7	1.0000

Table 5.44. Frequency of oral defects from the Daba LCG-2 adult primary burials, distinguished by teeth and laterality.

		EIA						LIA					
		AMTL		Periapical lytic lesions		Caries		AMTL		Periapical lytic lesions		Caries	
		n	%	n	%	n	%	n	%	n	%	n	%
Maxillary left	Incisors	5/12	41.6	0/7	0.0	1/8	12.5	3/11	27.2	1/8	12,5	1/5	20.0
	Canines	1/7	14.2	1/6	16.6	0/3	0.0	1/5	20.0	0/4	0.0	0/6	0.0
	Premolars	4/11	36.3	1/7	14.2	0/3	0.0	3/10	30.0	0/7	0.0	2/11	18.1
	Molars	2/8	25.0	0/5	0.0	1/6	16.6	2/11	18.1	1/9	11.1	0/16	0.0
Maxillary right	Incisors	1/10	10.0	2/8	25.0	2/4	50.0	3/10	30.0	1/7	14.2	1/5	20.0
	Canines	0/5	0.0	1/5	20.0	0/1	0.0	1/5	20.0	1/4	25.0	0/4	0.0
	Premolars	1/8	12.5	1/7	14.2	0/9	0.0	1/8	12.5	0/7	0.0	1/12	8.3
	Molars	2/8	25.0	2/5	40.0	0/7	0.0	3/13	23.0	0/10	0.0	2/15	13.3
Mandibular left	Incisors	3/16	18.7	0/10	0.0	0/6	0.0	3/15	20.0	2/12	16.6	0/9	0.0
	Canines	2/9	22.2	0/7	0.0	0/4	0.0	2/7	28.6	1/5	20.0	0/4	0.0
	Premolars	11/21	52.3	2/10	20.0	0/2	0.0	9/17	52.9	0/8	0.0	2/6	33.3
	Molars	18/24	75.0	0/6	0.0	0/1	0.0	8/14	57.1	0/5	0.0	1/10	10.0
Mandibular right	Incisors	2/12	16.6	2/10	20.0	1/7	14.2	2/16	12.5	3/14	21.4	0/12	0.0
	Canines	2/8	25.0	0/6	0.0	0/4	0.0	1/8	12,5	2/7	28.5	0/4	0.0
	Premolars	7/17	41.1	0/10	0.0	1/3	33.3	7/13	53.8	1/6	16.6	1/11	9.0
	Molars	15/22	68.1	0/6	0.0	0/1	0.0	9/15	60.0	0/6	0.0	3/14	21.4

Figure 5.25. Edentulous mandible from Burial 38.

A comparison between maxillary and mandibular sockets and teeth was performed (Tab. 5.45). Significant differences appear in the percentages of antemortem tooth loss in mandibular and maxillary sockets from Early Iron Age and Late Iron Age periods. Mandibles have higher percentages of antemortem tooth loss compared to maxillary bones. Based on table 5.44 the most affected lower sockets are premolars (52.3% on left side and 41.1% on right side for EIA; 52.9% on left side and 53.8% on right side for LIA) and molars (75.0% on left side and 68.1% on right side for EIA; 57.1% on left side and 60.0% on right side).

Table 5.45. Frequency of oral defects compared between maxillary and mandibular, distinguished by Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA				P	LIA				P
	Maxillary		Mandibular			Maxillary		Mandibular		
	n	%	n	%		n	%	n	%	
Antemortem tooth loss	16/69	23.1	60/129	46.5	0.0013*	17/73	23.2	41/105	39.0	0.0344^
Periapical lytic lesions	8/50	16.0	4/65	6.1	0.1240	4/56	7.1	9/63	14.2	0.2509
Caries	4/41	9.7	2/28	7.1	1.0000	7/74	9.4	7/70	10.0	1.0000

* Indicated statistically significant results at P = 0.01.
^ Indicated statistically significant results at P = 0.05
A comparison of lesions between maxillary and mandibular is done using the Fisher's exact test.

A more detailed comparison was made distinguishing oral pathologies by sockets and teeth (Tabs. 5.46-5.48). The comparison of AMTL frequency between maxillary and mandibular sockets, instead, highlights in Early Iron Age skeletal remains statistically significant results for molars. In Late Iron Age sockets the comparison highlights statistically significant results for both premolars and molars. Statistically relevant difference was not highlighted comparing upper and lower sockets for periapical lytic lesions. The comparison between upper and lower teeth highlights higher percentages of caries in incisors and premolars. Although not statistically relevant, upper incisors present more caries (25.0% for EIA teeth; 20.0% for LIA teeth) than lower incisors. Lower premolars present more caries (16.6% for EIA teeth; 17.6% for LIA teeth) compared to upper premolars.

Table 5.46. Frequency of antemortem tooth loss from the LCG-2 adult burials compared between maxillary and mandibular sockets.

	EIA				P		LIA				P
	Maxillary		Mandibular				Maxillary		Mandibular		
	n	%	n	%			n	%	n	%	
Incisors	6/22	27.2	5/28	17.8	0.5025		6/21	28.5	5/31	16.1	0.3177
Canines	1/12	8.3	4/17	23.5	0.3701		2/10	20.0	3/15	20.0	1.0000
Premolars	5/19	26.3	18/38	47.3	0.1592		4/18	22.2	16/30	53.3	0.0409^
Molars	4/16	25.0	33/46	71.7	0.0023*		5/24	20.8	17/29	58.6	0.0109*
TOTAL	16/69	23.1	60/129	46.5	0.0013*		17/73	23.2	41/105	39.0	0.0344^

^ Indicated statistically significant results at P = 0.05.
* Indicated statistically significant results at P = 0.01.
A comparison of lesions between adults is done using the Fisher's exact test.

Table 5.47. Frequency of dental periapical lytic lesions from the LCG-2 adult burials compared between maxillary and mandibular sockets.

	EIA				P	LIA				P
	Maxillary		Mandibular			Maxillary		Mandibular		
	n	%	n	%		n	%	n	%	
Incisors	2/15	13.3	2/20	10.0	1.0000	2/15	13.3	5/26	19.2	1.0000
Canines	2/11	18.1	0/13	0.0	0.1993	1/8	12.5	3/12	25.0	0.6186
Premolars	2/14	14.2	2/20	10.0	1.0000	0/14	0.0	1/14	7.1	1.0000
Molars	2/10	20.0	0/12	0.0	0.1948	1/19	5.2	0/11	0.0	1.0000
TOTAL	8/50	16.0	4/65	6.1	0.1240	4/56	7.1	9/63	14.2	0.2509

A comparison of lesions between adults is done using the Fisher's exact test.

Table 5.48. Frequency of caries from the LCG-2 adult burials compared between maxillary and mandibular teeth.

	EIA				P	LIA				P
	Maxillary		Mandibular			Maxillary		Mandibular		
	n	%	n	%		n	%	n	%	
Incisors	3/12	25.0	1/13	7.6	0.3217	2/10	20.0	0/21	0.0	0.0968
Canines	0/4	0.0	0/8	0.0	1.0000	0/10	0.0	0/8	0.0	1.0000
Premolars	0/12	0.0	1/5	20.0	0.2941	3/23	13.0	3/17	17.6	1.0000
Molars	1/13	7.6	0/2	0.0	1.0000	2/31	6.4	4/24	16.6	0.3866
TOTAL	4/41	9.7	2/28	7.1	1.0000	7/74	9.4	7/70	10.0	1.0000

A comparison of lesions between adults is done using the Fisher's exact test.

Data related to dental defects were analyzed based on the sex of the individuals (Tab. 5.49). Of the 4 adult male individuals from EIA period analyzable for oral lesions, 100% show alveolar reabsorbing related to antemortem tooth loss and 50.0% (2) present periapical lytic lesions. Of adult female individuals from EIA period analyzed (8), 100% are affected by antemortem tooth loss and 50.0% show periapical lytic lesions (4). For LIA period, of the 4 adult male individuals analyzable for oral lesions, 100.0% show alveolar reabsorbing related to antemortem tooth loss and 50.0% (2) present periapical lytic lesions. Of adult female individuals from LIA period analyzed (7), 85.7% are affected by antemortem tooth loss (6) and 28.6% show periapical lytic lesions (2). The analysis of dental defects based on sockets count highlights a statistically higher percentage of antemortem tooth loss in female individuals from EIA period (51.5% for EIA) compared to male individuals (13.2% for EIA).

Of the 4 EIA male individuals with crown teeth analyzable, 50.0% (2) has caries. Of the 7 EIA female individuals with crown teeth analyzable, 42.8% (3) has caries. Of the 3 LIA male individuals analyzed for dental defects, 66.6% present caries (2). Of the 7 LIA female individuals 71.4% present caries (5).

The mean age of individuals studied for oral defects was calculated. For Early Iron Age period, male individuals have a mean age of 38.1 years, while females have a mean age of 39.6 years. For Late Iron Age period, male individuals have a mean age of 39.6 years, while females have a mean age of 32.7 years.

Table 5.49. Frequency of oral defects compared between males and females, distinguished by Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA				P	LIA				P
	Male		Female			Male		Female		
	n	%	n	%		n	%	n	%	
Antemortem tooth loss	9/68	13.2	67/130	51.5	0.0001[x]	22/58	37.9	36/115	31.3	0.3983
Periapical lytic lesions	4/55	7.6	8/60	13.3	0.3766	3/36	8.3	10/79	12.6	0.7519
Caries	3/43	6.9	3/26	11.5	0.6654	6/42	14.2	7/75	9.3	0.5411

[x] Indicated statistically significant results at P = 0.001.
A comparison of lesions between adults is done using the Fisher's exact test.

Given the difference highlighted for antemortem tooth loss (AMTL) and caries between males and females a more precise comparison was done. The comparison was performed distinguishing by tooth and socket (Tabs. 5.50-5.52). Almost all sockets from EIA female individuals show statistically higher frequencies of AMTL compared to male individuals. Statistically relevant difference was not highlighted comparing male and female individuals for periapical lytic lesions and caries.

Table 5.50. Frequency of antemortem tooth loss from the LCG-2 adult burials compared between males and females, distinguished by Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA				P	LIA				P
	Male		Female			Male		Female		
	n	%	n	%		n	%	n	%	
Incisors	0/15	0.0	11/35	31.4	0.0214^	5/20	25.0	6/32	18.7	0.7300
Canines	0/10	0.0	5/19	26.3	0.1336	3/9	33.3	2/15	13.3	0.3256
Premolars	2/18	11.1	21/39	53.8	0.0031*	6/12	50.0	14/34	41.1	0.7379
Molars	7/25	28.0	30/37	81.0	0.0001[x]	8/17	47.0	14/34	41.1	0.7687
TOTAL	9/68	13.8	67/130	51.5	0.0001[x]	22/58	37.9	36/115	31.3	0.3983

^ Indicated statistically significant results at P = 0.05.
* Indicated statistically significant results at P = 0.01.
[x] Indicated statistically significant results at P = 0.001.
A comparison of lesions between adults is done using the Fisher's exact test.

Table 5.51. Frequency of dental periapical lytic lesions from the LCG-2 adult burials compared between males and females, distinguished by Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA				P	LIA				P
	Male		Female			Male		Female		
	n	%	n	%		n	%	n	%	
Incisors	1/12	10.0	3/23	13.0	1.0000	2/15	13.3	5/26	19.2	1.0000
Canines	0/10	0.0	2/14	14.2	0.5020	0/6	0.0	4/13	30.7	0.2554
Premolars	1/16	6.2	3/18	16.6	0.6041	0/6	0.0	1/20	5.0	1.0000
Molars	2/17	11.7	0/5	0.0	1.0000	1/9	11.1	0/20	0.0	0.3103
TOTAL	4/55	7.6	8/60	13.3	0.3766	3/36	8.3	10/79	12.6	0.7519

A comparison of lesions between adults is done using the Fisher's exact test.

Table 5.52. Frequency of caries from the LCG-2 adult burials compared between males and females, distinguished by Early Iron Age (EIA) and Late Iron Age (LIA).

	EIA				P	LIA				P
	Male		Female			Male		Female		
	n	%	n	%		n	%	n	%	
Incisors	2/12	16.6	2/13	15.3	1.0000	2/8	25.0	0/18	0.0	0.0862
Canines	0/8	0.0	0/4	0.0	1.0000	0/7	0.0	0/9	0.0	1.0000
Premolars	1/11	9.0	0/6	0.0	1.0000	1/12	8.3	5/21	23.8	0.3792
Molars	0/12	0.0	1/3	33.3	0.2000	3/15	20.0	2/27	7.4	0.3295
TOTAL	3/43	6.9	3/26	11.5	0.6654	6/42	14.2	7/75	9.3	0.5411

A comparison of lesions between adults is done using the Fisher's exact test.

Teeth from sub-adult individuals aged between 3 and 18 years show several caries. Burial 18B (11-12 years; LIA period) has caries on upper left I1, I2 and M1 and on upper right I1 and I2 (buccal). The individual from Burial 19 (4-5 years; LIA period) presents caries on upper left c and m1, upper right m2 and on lower left m1. Sub-adult from Burial 53 (4-5 years; EIA period) has 5 caries: on upper right c and m1, upper left m1 and on lower right m2 and lower left m2. Individuals from Burial 34 (6-7 years; LIA period) and Burial 60 (2-4 years; EIA period) have only one caries. The first has caries on lower right m2, while the second on the lower left c.

In addition to the Iron Age burials, six burials (Burials 27, 31, 39, 44, 45, 46) from Pre-Islamic period were studied for paleopathological lesions. Skeletal lesions were found on three individuals (Burials 27, 31, 39). Individual from Burial 27 (adult, probably male) shows skeletal lesions related to osteoarthritis. Individual from Burial 31 (15-18 years) show pitting lesions related to dietary/metabolic problems on the skull. The individual also presents signs of a periostitic lesion of unknown origin on the acromion of both scapulae. The individual from Burial 39 (probably male, 40-60 years) presents defects related to osteoarthritis on cervical and thoracic vertebrae. Pitting lesions related to DJD were found on the right glenoid cavity and on the head of right radius. As far as dental defects concern, three individuals from PIR period show antemortem tooth loss. The individual from Burial 27 presents AMTL on lower left M1, Burial 31 presents antemortem tooth loss on both lower M1. Individual from Burial 39 shows antemortem tooth loss on lower left P3, P4, M1, M2 and on lower right P3, P4. Additionally, the individual Burial 31 has caries on all upper incisors and on upper left M1.

5.3.4 Comparison between the LCG-1 and LCG-2 tombs.

Oral and dental defect frequencies from the LCG-2 primary burials are compared with defect frequencies from the LCG-1 tomb remains. No statistically significant differences are found regarding the frequencies of antemortem tooth loss and caries between these two sets of burials (Tab. 5.53). Periapical lytic lesions are statistically higher in alveolar sockets among the LCG-1 burials compared to LCG-2 (Tab. 5.53). The difference in periapical lytic lesion frequencies might be related to diet, different food processing or genetic traits. Sample size of dental elements might also be a factor in these results. The sample size of sockets is considerably higher in LCG-1, while LCG-2 has twice the number of teeth available for assessment.

Table 5.53. Dental and oral defect frequencies from LCG-1 and LCG-2.

	LCG-1		LCG-2		P
	n	%	n	%	
Antemortem tooth loss	489/1466	33.3	134/376	35.6	0.4271
Periapical lytic lesions	155/724	21.4	25/234	10.6	0.0002^{x}
Caries	12/81	14.8	20/213	9.3	0.2091

^{x} Indicated statistically significant results at P = 0.001.
A comparison of lesions between LCG1 and LCG2 is done using the Fisher's exact test.

Chapter 6. Discussion

6.1 Ra's al-Hamra 5

Results from anthropological analyses of human skeletal remains from Area 43 specific to demography and health status of the RH5 fishing community are provided. They are the foundation for the following portion of the discussion.

6.1.1 Demographic assessment

No skeletal evidence was found to support the idea that these two burial samples represent different communities. Therefore, I have assumed that it is reasonable to combine the human skeletal material from Area 43 and non-Area 43 into one large sample that provides a fuller picture of the demographic profile of this fishing community. As shown in table 6.1, life expectancy (ex) at birth of the RH5 sample is approximately 27 years. At 20 years of age life expectancy increases to approximately 37 years of age. As far as mortality concern, the RH5 burials show higher probability of dying (qx) from birth to 4 years of age compared to the other sub-adult age groups. The qx decreases from 5 to 14 years and then it starts increase again.

Table 6.1. Life table for individuals from the RH5 graveyard (Area 43 + non-Area 43).

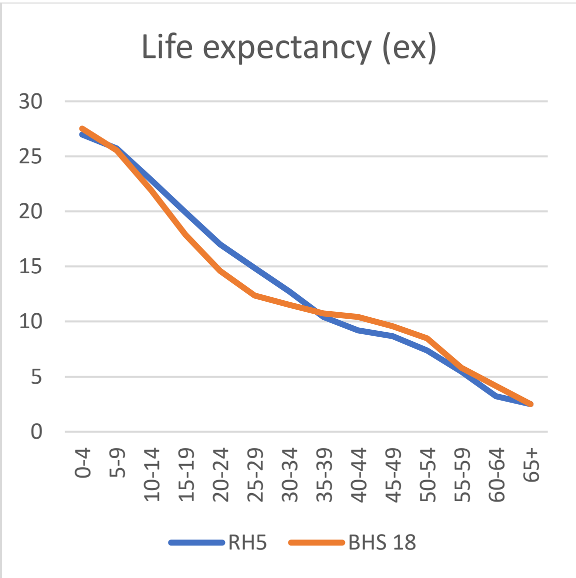
Age classes	ax	Dx	dx	lx	qx	Lx	Tx	Ex
0-4	250.00	33.14	13.25	100.00	132.55	466.86	2697.09	26.97
5-9	216.86	18.21	7.29	86.75	83.99	415.51	2230.22	25.71
10-14	198.65	18.15	7.26	79.46	91.38	379.15	1814.71	22.84
15-19	180.50	19.51	7.80	72.20	108.08	341.48	1435.56	19.88
20-24	160.99	26.38	10.55	64.40	163.89	295.59	1094.08	16.99
25-29	134.60	25.44	10.18	53.84	189.03	243.76	798.48	14.83
30-34	109.16	22.59	9.04	43.66	206.94	195.73	554.72	12.70
35-39	86.57	27.89	11.16	34.63	322.17	145.25	358.99	10.37
40-44	58.68	23.56	9.42	23.47	401.52	93.80	213.74	9.11
45-49	35.12	13.12	5.25	14.05	373.48	57.12	119.95	8.54
50-54	22.00	8.52	3.41	8.80	387.31	35.48	62.82	7.14
55-59	13.48	6.55	2.62	5.39	485.94	20.41	27.34	5.07
60+	6.93	6.93	2.77	2.77	1000.00	6.93	6.93	2.50
		250.00	100.00			2697.09		

ax = n of people alive at each group; Dx = total n of deaths occurring in each age group; dx = percentage of total deaths occurring in each age group; lx = n of survivors for each age interval; qx = probability of dying at each age interval; Lx = total n of years lived between one age interval and the following one; Tx = total n of years lived after a lifetime of all individuals who reach the age group; ex = life expectancy.

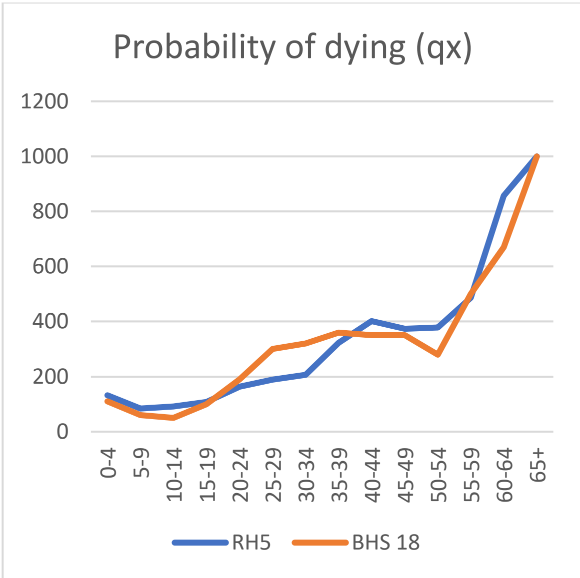
Before proceeding with the discussion of palaeodemographic data, it is appropriate to highlight how an accurate palaeodemographic reconstruction requires some important conditions including an accurate determination of sex and age at death, application of appropriate demographic methods, a uniform approach to excavation and its evaluation, clearly identified chronological sequence of burials (Acsádi and Nemeskéri, 1970). Furthermore, the sample examined should constitute the totality of the skeletal material of the cemetery. There are few skeletal collections that fit all the requisites necessary for an accurate paleodemographic analysis. In the RH5 graveyard, sub-adults under 5 years of age represent only the 13% of the sample. The loss of 0-4-year-old individuals could be related to a greater fragility of the bones which would therefore have been lost due to diagenetic and taphonomic factors. The fact that only few individuals under 2 years of age were found in single graves at the RH5 site (Salvatori, 2007), and that most were found associated with burials of adult individuals, also allow speculation that individuals aged 0-4 years were buried elsewhere. The underestimation of sub-adult individuals and the small number of samples available for paleodemographic analyses do not allow to perform a complete and reliable reconstruction of values such as fertility and growth rate. Based on this problem, then, it was decided to apply the formulas proposed by Bocquet and Masset (1977) for stationary populations (R = 0). A Juvenility Index (JI) of 0.2259 was calculated. The JI results in a realistic value according to the range 0.100-0.300 proposed by Bocquet (1979). Based on the JI the life expectancy at birth (e_0 = 22.05 ± 1.503), the mortality rates in the first year of life ($_1q_0$ = 0.293 ± 0.016) and in the first 5 years of life ($_5q_0$ = 0.470 ± 0.041) were calculated.

Paleodemographic data from the RH5 graveyard were then compared with data from the Neolithic site of Jebel al-Buhais 18 (BHS18) (Kiesewetter, 2006). According to Kiesewetter (2006) in the BHS18 site too there is a general underrepresentation of the sub-adults aged from 0 to 4 years (10.8% of the sample). If the formulas proposed by Bocquet and Masset (1997) were applied to the burials of Jebel al-Buhais 18 a life expectancy at birth of 32.17 (± 1.503) years was calculated. Additionally, the mortality rates in the first year of life ($_1q_0$ = 0.233 ± 0.016) and in the first 5 years of life ($_5q_0$ = 0.350 ± 0.041) were determined.
For both sites needs to be considered, however, that the death rate of the 5–9 years old sub-adults compared with the 10-14 years old sub-adults ($\frac{D_{5-9}}{D_{10-14}}$) results in a quotient that is low (1.00 for RH5; 1.23 for BHS18). This ratio usually ranges from 1.5 to 2.0 (Bocquet and Masset, 1977). Based on this data it seems that in both sites there is an underrepresentation not only of the 0-4 years group but also of the 5-9 years group.

Using the formulas proposed by Bocquet and Masset (1977) the 10-years difference found in life expectancy between the two sites can reflect an actual difference among the two communities, or it can only be the result of numerical variations. The underestimation of the sub-adults in both sites does not allow to say with certainty which of the two hypotheses is the most correct. Considering the results provided using the life table, in both sites the life expectancy at birth is approximately 27 years and the general trend of life expectancy appears similar among the two sites (Fig. 6.1).

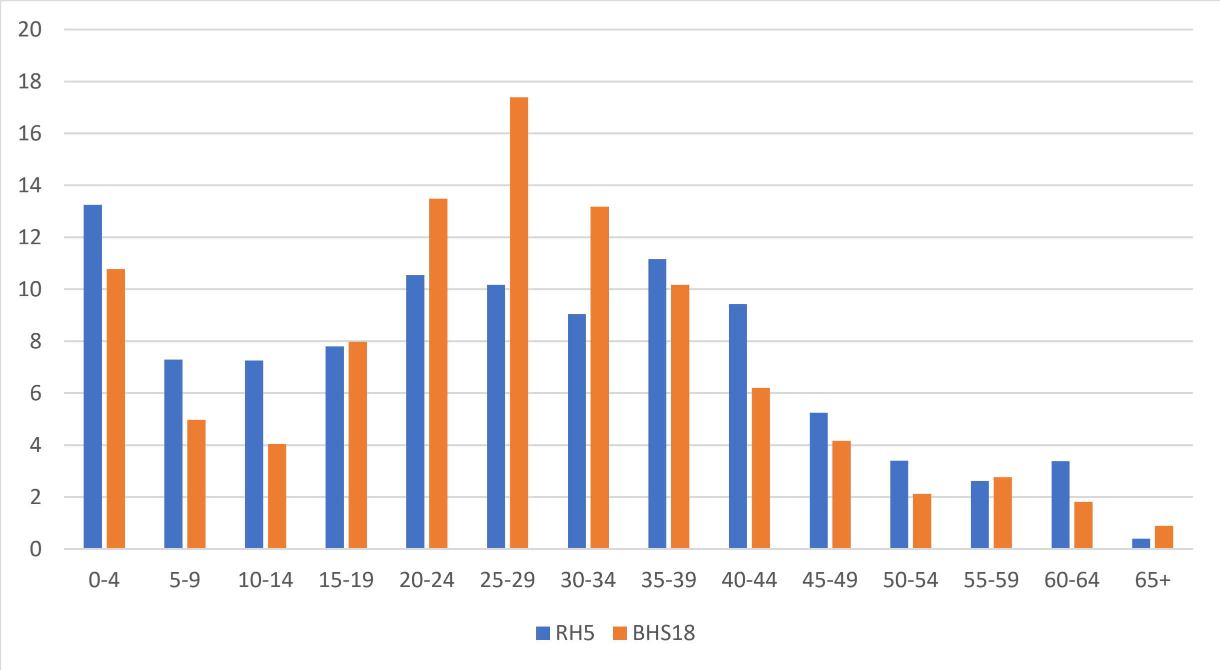


6.1. Comparison of life expectancy value (ex) between RH5 and BHS18 (Kiesewetter, 2006).



6.2. Comparison of mortality rates (qx) between RH5 and BHS18 (Kiesewetter, 2006).

Interestingly, there is a difference in percentages of deaths among the two communities. As shown in figures 6.2-6.3, in the site of Jebel al-Buhais 18 (BHS18) the frequency of adult deaths between 20 and 34 years of age is higher than RH5. On the contrary, the number of sub-adult deaths between 5 and 14 years of age appears higher in the RH5 graveyard than in the BHS18 site. Given the underrepresentation of sub-adults among both sites, it is possible that this difference only reflects numerical variations. However, it is also possible that the high number of sub-adults between 5 and 14 years of age found in the RH5 graveyard might be related to the high frequency of spina bifida found in the site and which would have caused an increase in mortality in those age groups (Coppa et al., 1985; Coppa and Cucina, 2007; De Angelis, 2019).



6.3. Comparison of the percentage of deaths by age group between RH5 and BHS18 (Kiesewetter, 2006).

6.1.2 Paleopathological assessment

The results provided by paleopathological analyzes allowed to better assess the general health trends for the Neolithic fishing community of Ra's al-Hamra 5.

In Area 43 sub-adult skeletal elements lack indicators of chronic stressors. This is considerably different than what is exhibited by adult remains. Ninety-three percent of the sub-adults show no skeletal lesions, whereas 60% of the adults from Area 43 show no signs of lesions. This difference is a perplexing observation to assess. It is possible that acute ailments burden this community and contributed to the high death rate among its sub-adults (Wood et al., 1992). As the osteological paradox suggests, a lack of skeletal defects can indicate death by fast acting pathogens or intentional childhood sacrifice. The lack of lesions seen in sub-adult remains is just as informative about the health condition of a community as is the presence of skeletal lesions. A high rate of deaths among sub adults might be attributed to poor living conditions, lack of key elements in the diet, and/or a high rate of fast acting lethal infections (Larsen, 1997, Goodman and Martin, 2002; Ortner, 2003). Previous work on dental defects for this group supports part of this scenario. The burials from RH5 show a high rate of enamel hypoplasia defects, up to 98% of the permanent teeth exhibit them (Mack and Coppa, 1992; Coppa et al., 1993; Cucina, 2007). According to Cucina (2007) the timing of some of the EH defects can be explained by post-weaning episodes related to immune susceptibility of the sub-adults due to loss of maternal antibodies. This would make them more likely to have a negative outcome if faced with viral infection. The archaeological record suggests food was abundant (Biagi and Travers, 1985; Biagi and Nisbet, 1992, 1999, 2006; Salvatori, 2007; Marcucci et al., 2011; Marcucci, 2014; Cleuziou and Tosi, 2020), so, dietary issues does not seem to be a casual factor for their deaths. Normally, small numbers of individuals living together is often seen as a health hygienic situation and less likely to promote viral infections (Armelagos, 2003), still this seems to be a more like outcome.

No statistically significant difference in cranial pitting/dietary lesions was documented between adults and sub-adults. Given the location of some cranial pitting, vitamin C deficiency is possible among these individuals.

The adult skeletal remains show patterns of skeletal lesions that are consistent with a food gathering lifestyles that requires considerable labor. Many of these lesions are the result of chronic problems such as repetitive locomotion and periods of dietary deficiencies associated with seasonal food insecurity. For example, DJD and OA skeletal lesions reflect old age and daily work efforts as these individuals gathered and fished for a living. The OA frequency of the adult burials reflects typical arthritic condition seen among other laborers in prehistoric communities. DJD analysis shows that left elbow joint and left shoulder joint have higher frequencies of lesions than other joints. This result suggests a possible physical stress of the upper limbs that might be associated with fishing activities (for example the use of nets).

As for dental pathologies, none of the teeth found on Area 43 has caries. Dental defect patterns highlighted in Area 43 reflect dietary patterns typical of hunter and gathers or fishing communities (Larsen et al., 1991; Littleton and Frohlich, 1993; Larsen, 1995; Ortner, 2003; Waldron, 2009).

Before reorganizing the results and reconstructing the formation of Area 43 of the RH5 graveyard, a paleopathological comparison with contemporary burial samples was carried out. The aim of the comparison was to determine health status of Neolithic communities characterized by different economic subsistence.

Although the skeletal remains from RH5 Area 43 are fragmented, commingled and partially burnt; a comparison with data from RH5 non-Area 43 showed no differences in skeletal lesion frequency. Since the skeletal lesion frequency does not differ and there is no other archaeological evidence suggesting they represent different communities (see paragraph 6.1.5), it is reasonable to combine this material into one large sample to compare paleopathological data to other Neolithic sites. Data from RH5 were compared to other Neolithic sites that were supported by either pastoral or agricultural economies.

6.1.3 Comparison with other Neolithic sites

Paleopathological data from RH5 were compared to lesion frequencies reported for coastal Omani sites. A comparison was also done with a pastoral community from the same region and for several agricultural communities from different geographical areas.

- *Comparison with Neolithic coastal Omani communities*

Oral lesion frequencies were compared with several regional coastal sites (Tabs. 6.2-6.3). The sites used for comparison are the Omani coastal funerary complexes of Suwayh (SWY-1), Ra's al-Khabbah (KHB-1), Wadi Shab (GAS-1) and Ra's al-Hamra 6 (RH6) (Munoz, 2017). Zooarchaeological data recovered from these sites suggests the same subsistence strategy as RH5. The main source of supply for the coastal Neolithic communities of Oman was fishing. This activity was accompanied by the exploitation of lagoon resources and mangroves. Another component of the subsistence of these communities was animal husbandry (Uerpmann, 2003; Gregoricka, 2011; Munoz, 2017).

Table 6.2. Dental and oral pathology frequencies between RH5 and other coastal Omani Neolithic sites.

	SWY-1[1]		KHB-1[1]		GAS-1[1]		RH6[1]		RH5	
	n	%	n	%	n	%	n	%	n	%
Caries	0/42	0.0	0/31	0.0	0/64	0.0	0/126	0.0	0/1459	0.0
AMTL	2/21	9.5	0/30	0.0	5/45	11.1	4/80	5.0	65/1983	3.3
Periapical lytic lesions	5/6	83.3	0/22	0.0	4/34	11.8	9/50	18.0	19/1900	1.0

[1] Munoz, 2017

Table 6.3. Comparison of dental and oral defects frequencies between RH5 and other coastal Omani Neolithic sites, examined by a Fisher's exact test.

	RH5 with SWY-1	RH5 with KHB-1	RH5 with GAS-1	RH5 with RH6
Caries	1.0000	1.0000	1.0000	1.0000
AMTL	0.1541	0.6232	0.0177*	0.3400
Periapical lytic lesions	0.0001[x]	1.0000	0.0006[x]	0.0001[x]

* Indicated statistically significant results at P = 0.01.

[x] Indicated statistically significant results at P = 0.001.

No caries is found among the remains from the sites compared. The absence of caries reflects a low-sugar diet that is well suited to the type of subsistence known for Omani Neolithic fishing/gathering communities. The comparison of antemortem tooth loss highlights statistically relevant difference between RH5 and Wadi Shab (GAS-1). Significant differences for periapical lytic lesions are seen in almost all sites, except Ra's al-Khabbah (KHB-1). Factors related to diet could be an explanation to the differences in antemortem tooth loss and periapical lytic lesions. Different food items in the diet or different food processing might also be the reason for this. The differences could also be related to genetic traits of both communities. An examination of enamel thickness might help to determine if this is the case. Additionally, considering the number of alveoli and teeth compared, the difference may depend on sample size issues. That is most Neolithic fishing communities consist of small burial samples.

- *Comparison with Neolithic pastoral nomads' community*

The archaeological burial site of Jebel al-Buhais 18 was used for comparison with the RH5 site. It is located in Sharjah, UAE (Kiesewetter, 2006). The site is situated on the al-Madam Plain which is east of the Jebel al-Buhais. Jebel al-Buhais is part of a foothill chain at the western edge of the al-Hajar Mountains (Kiesewetter, 2006). Zooarchaeological data recovered from the site of Jebel al-Buhais 18 indicated that this community lived by herding sheep, goats, and cattle. This lifestyle was supported with some foraging and hunting as well (Kiesewetter, 2006; Uerpmann and Uerpmann, 2020b). Given the comparative paleopathological data provided by Kiesewetter (2006) it was only possible to compare dental/oral defects, OA, DJD and porotic hyperostosis frequencies (Tabs. 6.4-6.7). The comparison with RH5 for dental/oral pathologies, DJD and porotic hyperostosis is based on entire site sample. Paleopathological data used for OA comparison are from RH5 Area 43 remains only.

Table 6.4. Dental and oral pathology frequencies between RH5 and Jebel al-Buhais 18 (BHS18) examined by a Fisher's exact test.

	BHS18[1]		RH5		
	n	%	n	%	P
Caries	0/2499	0.0	0/1459	0.0	1.0000
Antemortem tooth loss	44/2147	2.0	65/1983	3.3	0.0150*

[1]Kiesewetter (2006); BHS18 represents a Neolithic pastoral community.
* Indicated statistically significant results at P = 0.01

Table 6.5. Degenerative joint disease frequencies among adults from RH5 and the Jebel al-Buhais 18 (BHS18) Neolithic site, examined by a Fisher's exact test.

	BHS18[1]				RH5				P	
Joint	Ln	L %	Rn	R %	Ln	L %	Rn	R %	L	R
Shoulder	2/25	8.0	5/26	19.2	6/40	15.0	4/38	10.5	0.4711	0.4669
Elbow	4/24	16.7	8/26	30.7	9/69	13.0	9/75	12.0	0.7349	0.0364^
Hip	2/22	9.1	3/15	20.0	4/45	8.9	2/49	4.1	1.0000	0.0793
Knee	1/9	11.1	0/10	0.0	15/68	22.1	8/61	13.1	0.6755	0.5899
Ankle	9/9	100.0	10/12	83.3	3/61	4.9	3/55	5.4	0.0001[x]	0.0001[x]

[1]Kiesewetter, (2006); BHS18 represents a Neolithic pastoral community.
^ Indicated statistically significant results at P = 0.05
[x] Indicated statistically significant results at P = 0.001

Table 6.6. Osteoarthritis frequency comparison among RH5 Area 43 and Jebel al-Buhais 18 (BHS18) Neolithic site, examined by a Fisher's exact test.

	BHS18[1]		RH5 Area 43		
	n	%	n	%	P
Cervical vertebrae	28/142	19.7	11/60	18.3	1.0000
Thoracic vertebrae	1/17	5.9	18/72	25.0	0.1067
Lumbar vertebrae	15/25	60.0	8/58	13.8	0.0001[x]

[1]Kiesewetter, (2006); BHS18 represents a Neolithic pastoral community.
[x] Indicated statistically significant results at P = 0.001

Table 6.7. Porotic hyperostosis frequency comparison among RH5 and Jebel al-Buhais 18 (BHS18) Neolithic site, examined by a Fisher's exact test.

	BHS18[1]		RH5		
	n	%	n	%	P
Adults	18/140	12.8	16/86	18.6	0.2551
Sub-adults	4/31	12.9	10/44	22.7	0.3727

[1]Kiesewetter, (2006); BHS18 represents a Neolithic pastoral community.

The comparison between RH5 and BHS18 highlighted several paleopathological issues. As in the RH5 site, the presence of caries was not detected in Jebel al-Buhais 18, suggesting that both communities may have had diets low in carbohydrate/sugary foods.

A significant difference in DJD frequency for left and right ankle between these communities could be related to work activity. The community from Jebel al-Buhais 18 seems to be subjected to a higher stress of the lower limbs compared to the RH5 community. People from BHS18 lived on herding. It is probable that during this activity the community should walk on more difficult terrain than the RH5 community did. Additionally, the Jebel al-Buhais 18 burials show a statistically higher frequency of lumbar osteoarthritis and of DJD of the right elbow compared to RH5 Area 43. This might reflect differences in work related behavior seen between fishing communities and pastoral communities.

- *Comparison with Neolithic agricultural communities' sites*

Paleopathological data from the RH5 graveyard were compared with dental and skeletal lesion data from several Neolithic agricultural communities from different geographical areas (Tab. 6.8). Data used for comparison come from Alepotrypa Cave in Greece (Papathanasiou, 2005), Moravian sites (Smrčka and Tvrdý, 2009), Catal Hüyük in Turkey (Angel, 1971; Boz, 2005), southern Levant sites (Eshed et al., 2006) and northeastern Hungarian sites (Ubelaker et al., 2006).

The comparison between the RH5 skeletal remains and human remains from different Neolithic agricultural communities highlighted statically relevant differences between the two economic strategies. Skeletal remains from the fishing community of RH5 show lower percentages of cranial pitting compared to human remains from Alepotrypa Cave, Moravian sites and Catal Hüyük. The same difference was highlighted in the comparison of oral defects. All Neolithic agricultural communities show statistically higher percentages of caries, antemortem tooth loss and periapical lytic lesions compared to the RH5 burials. It is possible that fishing and gathering of wild plants as a means of supporting a small group of people living in this area was an ideal means. Paleopathological evidence suggests at least that as a lifestyle it caused individuals of RH5 lower frequencies of chronic conditions than those observed among Neolithic farmers. So besides offering a good source of food it also seems to have been less a stressful ecological niche for local inhabitants of the area.

Table 6.8. Frequencies of pathologies among the RH5 graveyard and Neolithic agricultural sites examined by a Fisher's exact test.

Neolithic site	Lesions	Origin	Sample size	RH5 sample size	Prob with RH5
Alepotrypa Cave[1]	Cranial pitting [a]	Diet	29/58	26/130	0.0001[x]
	Dental caries [a]	Infection	14/436	0/1459	0.0001[x]
	OA all vertebrae [b]	Activity	44/360	37/190	0.0309^
Moravian sites[2]	Cranial pitting [a]	Diet	20/45	26/130	0.0028*
Catal Hüyük[3]	Cranial pitting [a]	Diet	59/143	16/86	0.0004[x]
	Dental caries [a]	Infection	32/485	0/1459	0.0001[x]
	Antemortem tooth loss [a]	Infection	69/660	65/1983	0.0001[x]
	Periapical lytic lesions [a]	Infection	23/513	19/1900	0.0001[x]
Southern Levant sites[4]	Dental caries [a]	Infection	54/804	0/1459	0.0001[x]
Northeastern Hungary[5]	Cranial pitting [a]	Diet	6/35	26/130	0.8129
	Dental caries [a]	Infection	46/735	0/1459	0.0001[x]
	Antemortem tooth loss [a]	Infection	56/936	65/1983	0.0010[x]
	Periapical lytic lesions [a]	Infection	25/973	19/1900	0.0020*

[1]Papathanasiou, 2005; [2]Smrčka and Tvrdý, 2009; [3]Angel, 1971 for cranial pitting, Boz, 2005 for dental and oral pathologies; [4]Eshed et al., 2006; [5]Ubelaker et al., 2006.
[a] Data used for comparison are from Area 43 + non-Area 43 of RH5 graveyard.
[b] Data used for comparison are from Area 43 of RH5 graveyard.
^ Indicated statistically significant results at P = 0.05
* Indicated statistically significant results at P = 0.01
[x] Indicated statistically significant results at P = 0.001

6.1.4 Mortuary practices and the burning of bones

Several skeletal elements from RH5 Area 43 were removed during excavation without accurate documentation. For this reason, it was not possible to reconstruct the exact position of a large number of skeletal remains. What the analysis of combustion patterns revealed is the presence of apparently burnt bones at higher temperatures especially in the HSR sector. With the help of more detailed excavation plants, efforts were made to identify the location, within the sector, of the remains with yellowish-white coloring. This coloring is associated by Mays (1998) with combustion temperatures above 650°C. The position of the yellowish-white skeletal remains that could be identified highlighted the presence of a localized accumulation in the position that Santini (2002) identified as Cluster 43.3. Another accumulation of burnt bones was identified during excavation. Cluster 43.1 (sectors HSS-HST) had burnt skeletal remains and peridotite pebbles cracked by fire exposition (Santini, 2002). According to what proposed by the archaeologist, it was not excluded that an intentional fire was lit inside the tomb itself after the deposition. Part of the remains analyzed (Grave 19) have the same coloring as those located in the HSR sector. According to what Salvatori (2007) reported, however, the entire Area 43 would have been subject to the action of fire. It is not easy to reconstruct what happened ex post, also given the limit provided by the available documentation. What can be detected, however, is the presence of burnt skeletal remains not in the entire Area 43 but rather in some specific sectors. The few burnt remains found in the other sectors, in fact, may have been subject to washout or post-deposition processes that altered their original location.

The histological data showed that traces of bioerosion, in varying percentages, were detected on both burnt and unburnt bones (De Cataldo et al., 2020b).

The burnt remains show a remarkable variability in percentages of bioerosion among the samples. It is important to distinguish the samples based on the percentage of bioerosion. Some samples show high percentages of bioerosion. Since the action of fire reduces and interrupts the action of microorganisms that feed on organic components, the presence of traces of bioerosion in high percentages indicates that before combustion the remains underwent a decomposition process. It is probable that some of the remains from Area 43 of RH5 were also exposed before being burnt and subsequently buried. The percentage of Ct.BAD in the burned samples shows considerable variability. It is possible, therefore, that the exposure of the remains took place at different times and could be related to functional needs or ritual practices.

As for the samples with minimum or zero percentages of bioerosion, however, it seems plausible to exclude a length period of exposure before burial. If we consider, in fact, that bioerosion can be related to the action of intestinal microbiota (Kellerman et al., 1976; Booth and Madgwick, 2016), it is reasonable to hypothesize that a practice of burning the body before burying it in the ground existed among these Neolithic fishing people.

Considerable variability in the percentages of bioerosion was also found in human remains that do not show signs of combustion. If the action of microorganisms acts in the same percentages once the remains are buried, one would expect to detect similar percentages of bioerosion in all the remains where the action of fire did not reduce/eliminate the organic components. Even among the unburned remains, however, the analysis revealed a considerable variability in the

percentages of Ct.BAD. It is more probable, therefore, that even some of the unburnt remains underwent an exposure, of variable duration, before the actual deposition.
Given what the literature suggests, the absence of bioerosion and diagenetic patterns in Group 0 is associated with corpses buried shortly after death (White and Booth, 2014). When the cortical bone shows some diagenetic features (Group 1) is it possible to suggest that burial happened after a short period of surface decomposition. The third group, instead, is related to corpses buried after an extend period of surface decomposition.

Exposure of human remains to the open air is often associated with the presence of marks related to rodents or carnivores' activity. In the remains of RH5 Area 43 only three fragments present signs related to the action of animals. Only one of these presents alterations on the surface related to exposure to open air. Despite the absence of such signs, 20% of the human remains from Area 43 analyzed show surface alterations attributable to exposure to the open air. Therefore, as suggested by Kiesewetter (2006) for the site of Jebel al-Buhais 18, it is possible to hypothesize that the remains subjected to exposure were positioned in places protected from animal attacks. For the other remains clearly characterized as secondary depositions during field excavations, the absence of cut marks suggests that no dismemberment was done before the deposition. Therefore, it is possible to suggest that the deceased were buried after death and consequently the bones were moved into a different position.

6.1.5 Analysis of the hypotheses specific to the formation of Area 43 burial deposition

Several hypotheses were analyzed to interpret and better understand the dynamics that led to the formation of Area 43 of the RH5 graveyard. Catastrophic event, changes in mortuary practices, differences in population and functional reasons were considered.

- *Hypothesis 1 – catastrophic event (H1)*

The first hypothesis (H1) that was analyzed is that of a catastrophic event that would have led to an increase in mortality. This highest mortality would have arisen, archaeologically and anthropologically, in the formation of Area 43. A catastrophic event was thought as one of the possible origins of this sector of the graveyard. Two events were considered, an epidemic event (H1a) and a conflict between groups (H1b).

- Hypothesis 1a (H1a)

In the case of an epidemic event, the analysis of osteological findings should highlight a higher mortality than the rest of the graveyard. Unfortunately for resolving the argument, it appears that there is no demographic difference between Area 43 and the rest of the graveyard, either by sex or by adult and sub-adult numbers. The absence of paleopathological lesions that would have led to the death of individuals, however, could be interpreted as a manifestation of acute illness that might be epidemic (De Cataldo et al., 2021). This possibility is unusual given the small size of the community and the food wealthy ecological system it is found in. Furthermore, a comparison between demographic data from Area 43 and the rest of the RH5 graveyard did not show an increase in mortality. The hypothesis that an epidemic event may have led to the formation of this sector of the graveyard does not seem supported.

- Hypothesis 1b (H1b)

Another hypothesis that was considered is that of a conflict between groups. The conflict would have caused the death of several people leading to the formation of such different deposition. In the case of a conflict, data expected are the presence of traces of violence (both in the form of skeletal lesions – fractures – and as archaeological materials) and a difference in mortality between the Area 43 and the rest of the graveyard. As previously explained, no different mortality was detected, neither by age group nor by sex (De Cataldo et al., 2021). The study conducted on skeletal remains revealed the absence of unhealed traumatic lesions, except for the discovery of a shark tooth that was found in the body of a lumbar vertebra (L3) by Prof. A. Coppa during the excavation phase. The tooth is fixed in the front part of the vertebral body to indicate a blow from the front (Santini, 2002; Salvatori, 2007).
Previously other shark teeth were found in other burials as reported by Santini (2002). The presence of holes on these archeozoological remains, however, led to interpret them as personal ornaments. The discovery of one of them still fixed in a vertebral body allowed archaeologists to interpret them as weapons. As reported by Santini (2002), it is also important to highlight how these perforated shark teeth are the only weapons found in the graves of RH5. In Area 43 eleven perforated shark teeth were found, six inside the commingled remains and five inside Grave 68 inferior. In the remaining 182 tombs of the RH5 graveyard, only four burials had shark teeth. Three not perforated shark teeth were recovered inside Grave 4. Graves 329 and 404 each had a shark tooth, only that of Grave 329 appears to be perforated. From Grave 411, five not perforated shark teeth were recovered. Four were located near the skull and the other

one was near the column. If we consider perforated shark teeth as weapons and not, as previously believed, as ornaments, we note a much higher percentage of shark teeth found inside Area 43 in comparison with the rest of the graveyard.

Shark teeth were used as projectile frames. It seems unlikely, however, that arrowhead made of shark teeth were used as offensive weapons. The resistance of these products, in fact, allows to hypothesize rather a use connected to fishing activities (Charpentier et al., 2009, 2016; Charpentier, 2020). It seems more reasonable to identify as offensive weapons stone arrowheads found in various Neolithic sites on the Arabian Peninsula (Charpentier, 2008; Kutterer et al., 2012; Méry and Charpentier, 2013; Méry et al., 2016). In general, in Arabia traces of violence were witnessed in funerary contexts mainly in the form of blunt force traumas, sharp injuries, pointed traumas (Kiesewetter, 2006). One of the funerary contexts where a high number of traumas was documented is the graveyard of Jebel al-Buhais 18 (BHS18). In this site the presence of multiple traumas was interpreted by anthropologists as a result of community conflicts (Kiesewetter, 2006). Contrary to BHS18, however, in Area 43 no traces of violence or trauma were found. The only exception is the shark arrowhead stuck in the lumbar vertebra. Paleopathological data, therefore, did not provide enough information to support the hypothesis of conflict between groups.

- *Hypothesis 2 - coexistence of different groups or differences within the same population (H2)*

Two other hypotheses were also considered to explain the presence of apparently different funerary practices within the same graveyard. The coexistence of two different groups (H2a) or the presence of social differentiations or changes in mortuary practices within the same population (H2b).

- Hypothesis 2a (H2a)

Archaeologists documented the presence of personal ornaments inside Area 43 which has not been found in the rest of the graveyard (Salvatori, 2007). An example are the ornaments made with soapstone beads oval in section or the necklaces made up of cylindrical beads carved from birds' long bones. Although archaeological material may suggest differentiation inside or between populations, the study conducted on osteological materials did not allow to detect data that can support this interpretation.

- Hypothesis 2b (H2b)

As previously reported, Santini (2002) proposed an interpretation of Area 43 based on excavation data. She suggested that Area 43 was formed by six different clusters, labeled 43.1-6 (Fig. 3.4). According to the description provided by Santini (2002), the Cluster 43.1 (quadrants HSS-HST), containing the remains of three individuals, showed no recognizable pit margins and the stone coverings were disturbed. The skeletal remains were burned. Some peridotite pebbles were cracked by fire exposition, suggesting that an intentional fire was set up after deposition. The Cluster 43.2 (quadrants HSM-HSN-HSR-HSS) contained the remains of at least 11 individuals. A semicircular structure was preserved but the surface of the cluster was highly disturbed. Cluster 43.3 (quadrant HSM) was partially covered by Cluster 43.2. Although strongly disturbed, a semicircular alignment of stones was recognized. In this cluster some skeletal elements were still in anatomical connection. Some of the bones were also burnt. The Cluster 43.4 corresponds to the Grave 69. This was a large circular grave made up of two different levels, separated by a layer of pebbles. The human remains were highly fragmented, and the skeletal elements recovered from the upper level were burnt. Quadrants of the western part of Area 43 were occupied by Clusters 43.5 and 43.6. These clusters were highly disturbed. In Cluster 43.6 the skeletal remains laid on top of a stone floor. Under this pavement was Grave 221, a single burial related to the first period of the graveyard.

Stratigraphic relationship between the clusters was confused by later disturbances. The only clusters for which it was possible to detect a stratigraphic relationship are Clusters 43.2, 43.3 and 43.4. Cluster 43.2 overlaps Cluster 43.4 and covers Cluster 43.3. Cluster 43.4 was partially covered by Cluster 43.3. The clusters, therefore, were built in at least three phases. The analysis of stratigraphic and archaeological data allowed Santini (2002) to suggest a change in funerary rituals. This change would take place at the end of the graveyard and settlement sequences, in a period in which the population would carry out a process of collectivization of resources.

Salvatori (2007) dated the Area 43 at the 2nd period of the graveyard. A clear differentiation in chronology was not performed on skeletal remains within Area 43. The chronological ranges of the three periods of use of the RH5 graveyard, identified by the archaeologists (Salvatori, 2007), were analyzed. The time limits of the phases are largely overlapping. Radiocarbon analyzes carried out on some of the burials from the 3rd level (1st period of the graves) show a range between 3810-3500 BC. The chronology of 1st and 2nd level burials, between 3650-3370 BC., is not clearly distinct. Grave 69, attributed to Area 43, has a radiocarbon dating between 3770-3500 BC. As can be seen from the dating, it is not easy to accurately distinguish the chronologies of the various burials and the attribution of Area 43 to the 2nd level does not seem sure either. If, however, we accept the attribution of Area 43 to the second period of the graveyard, Santini's hypothesis has little supporting data. If there was a change in funerary practices, manifested in Area 43, it is assumed that this change would also have affected the burials of the last phase of the graveyard. These burials, on the other hand, had the same characteristics as the burials of the first period, both in structure of the grave and in grave goods.

- *Hypothesis 3 – functional reasons (H3)*

The observation of the excavation map of Area 43 highlighted the presence of a "corridor" which is completely free of skeletal remains (Fig. 3.3). This "corridor" separated the skeletal remains in the sectors HSM-HSN-HSR-HSS-HST from the human remains in the sectors HSL-HSQ. The first sectors, as reported by Santini, contained three different funerary actions (Clusters 43.2, 43.3, 43.4). The quadrants HSL-HSQ (corresponding to Cluster 43.6 reported by Santini, 2002) contained an assembly of several aligned long bones. This disposition indicates that the bones, after the disappearance of soft tissues, were collected and orderly arranged. The corridor might be interpreted as a voluntary left space. This space would have separated an area (HSM-HSN-HSR-HSS-HST) in which several funerary interventions were carried out from an area (HSL-HSQ) created with the aim of hosting, in secondary and orderly deposition, part of the remains from elsewhere.

In quadrants HSQ-HSV-HSW (corresponding to Cluster 43.5 reported by Santini, 2002) several disturbed human remains were found. According to Salvatori (2007) the disturbance might be related to the massive covering of the underlying Grave 221. The skeletal remains from those sectors of the Area 43 "had conformed to the wide dislocations of the covering stones" causing the disturbed appearance of the remains.

If the disconnected aspect of the skeletal remains from HSQ-HSV-HSW sectors was related to the underlying Grave 221 as reported by Salvatori (2007), the situation in correspondence of the HSM-HSN-HSR-HSS-HST sectors appears to be partly different. Considering what reported by Santini (2002), the funerary actions that took place in those sectors could be the cause of the disconnected appearance of the skeletal remains deposited (see paragraph Hypothesis 2b). Additionally, traces related to a non-funerary use of the layers covering Area 43 were documented. Several post-holes and traces of habitation levels were documented in the upper layers of the area. It is, also, likely that the various post-depositional disturbances that altered the skeletal remains in Area 43 might be related to the different use to which the area was subsequently destined.

A careful investigation of the spatial distribution of skeletal remains could have provided important data for understanding the dynamics that led to the formation of this area of the graveyard (Tuller et al., 2008). Unfortunately, not all skeletal remains were spatially localized during the excavation phase. Furthermore, the detailed plans created during the field excavations do not contained metric references and spatial reference points. The absence of metric and spatial references did not allow the creation of an accurate spatial map that would have provided additional data on the context analyzed.

It is not easy to reconstruct the processes that led to the formation of Area 43. Various hypotheses were considered. Some of them, such as the hypothesis of the epidemic event or of the conflict between groups, do not present enough supporting data. Anthropological analysis conducted on human skeletal remains from Area 43 allows for the reconstruction that Area 43 underwent. It shows a variety of burial practices, characterized by burnt, fragmented, and commingled remains. It is also clear that the formation of these burial features is not the result of a single event but of a series of actions and practices that occurred over a considerable time and contributed to the commingled state of the burials found in Area 43.

6.2 Daba al Bayah – Large collective grave 1 (LCG-1)

The study of skeletal remains from the Daba al Bayah funerary complex is only preliminary and incomplete. However, it is possible to define some important taphonomic and paleopathological data based on the analysis carried out.

Before discussing the taphonomic and anthropological data from LCG-1, a paleopathological comparison with contemporary communities was carried out. Data from the analysis of mandible and maxillary bones were compared with several Bronze Age sites.

6.2.1 Comparison with other Bronze Age sites

Frequencies of oral defects from the LCG-1 skeletal remains were compared to frequencies of oral pathologies from several Bronze Age sites (Lukacs, 1992; Littleton and Frohlich, 1993. Tabs. 6.9-6.10). These sites include burials from Bronze Age Bahrain (dated 2300-1800 BC), the skeletal remains from Bronze Age Shimal (Ras el-Khaimah, UAE) dated from 2000 to 1600 BC and the remains from Harappa (Punjab Province, Pakistan) dated between 2500-2000 BC.

Table 6.9. Oral defects frequencies among Daba LCG-1 and other Bronze Age sites.

	Bronze Age Bahrain[1]		Bronze Age Shimal[1]		Bronze Age Harappa[2]		Daba LCG-1	
	n	%	n	%	n	%	n	%
AMTL	288/928	31.0	39/110	35.5	70/821	8.5	489/1466	33.3
Periapical lytic lesions	20/928	2.1	--	--	23/751	3.0	155/724	21.4
Dental caries	41/308	13.3	2/43	4.6	51/751	6.8	12/81	14.8

[1]Littleton and Frohlich, 1993; [2]Lukacs, 1992.

Table 6.10. Comparative statistical analysis among Daba LCG-1 and the other Bronze Age sites for oral defects.

	Daba LCG-1 with Bronze Age Bahrain	Daba LCG-1 with Bronze Age Shimal	Daba LCG-1 with Bronze Age Harappa
AMTL	0.2443	0.6757	0.0001[x]
Periapical lytic lesions	0.0001[x]	--	0.0001[x]
Dental caries	0.7177	0.1352	0.0149*

* Indicated statistically significant results at P = 0.01.
[x] Indicated statistically significant results at P = 0.001.

Statistically significant results were highlighted comparing Daba LCG-1 and skeletal remains from Bahrain for periapical lytic lesions. The Daba LCG-1 remains show a higher percentage (21.4%) of periapical lytic lesions compared to Bronze Age Bahrain (2.1%). Statistically significant results were highlighted comparing Daba LCG-1 and Harappa for all oral defects. The Daba LCG-1 site shows higher percentages of all oral defects analyzed compared to the Harappa site.

6.2.2 Taphonomic data from previous studies

Todero (2013) analyzed part of the mixed skeletal remains found inside LCG-1. After dividing the remains between adults and sub-adults, Todero (2013) analyzed the most represented skeletal elements from this site. The skeletal element considered were axis, humerus, ulna, talus, and calcaneus (Tab. 6.11). Based on this analysis the minimum number of adult individuals present in LCG-1 is 153, determined by the right humeri.
As for the sub-adults, the temporal bones were considered. Based on these skeletal elements, he determined that the minimum number of sub-adult individuals is 35. A minimum number of 188 individuals, both adults and sub-adults was identified in the LCG-1 tomb.

The count of small bones from hands and feet was conducted to better understand the taphonomic events that originates the accumulation of human remains inside the LCG-1 tomb (Fattore, 2013) (Tab. 6.12). Based on the greater difference of small bones count compared to the long bone count done by Todero (2013), Fattore hypothesized that LCG-1 is not the place of the first inhumation of the corpses. At least 81% of the bones of the feet and 91% of bones from hands are missing.

Table 6.11. Count of adult skeletal remains by A. Todero (2013).

Skeletal element		
Axis	94	
	Ln	Rn
Humerus	128	153
Ulna	118	119
Talus	147	128
Calcaneus	104	88

Table 6.12. Small bones count by L. Fattore (modified from Fattore, 2013).

Skeletal element	Ln	Rn
1st cuneiform	30	30
Medial cuneiform	15	15
Lateral cuneiform	31	30
Cuboid	35	34
Navicular	51	48
1st metatarsal	32	50
2nd metatarsal	45	46
3rd metatarsal	61	60
4th metatarsal	49	48
5th metatarsal	54	56
Phalanges	19	
Other distal phalanges	2	
Scaphoid	13	9
Lunate	6	8
Triquetal	--	--
Trapezium	4	6
Trapezoid	5	4
Capitate	16	12
Hamate	10	9
1st metacarpal	14	17
2nd metacarpal	50	49
3rd metacarpal	34	53
4th metacarpal	22	27
5th metacarpal	16	16
Phalanges	8	
Other phalanges	32	
TOTAL	492	470
	962	

6.2.3 Assessing Daba LCG-1

The observation of the mandibles from LCG-1 allowed for the documentation of antemortem tooth loss and periapical lytic lesions. Consequence of this loss is the considerable remodeling and bone loss visible on the mandibles. Two scenarios were hypothesized in the analysis of mandibles and maxillary bones from LCG-1. It could be assumed that the tomb was mostly used to host the remains of old individuals. Other hypotheses are related to dietary factors or to work activity. The analysis of the sub-adult remains allows to determine that individuals lost teeth at young age (15-18 years). Considering these data, the hypothesis related to dietary factors seems more probable. Unfortunately, the pandemic situation connected to Covid-19 prevented to analyze post-cranial bones to have more precise information about the age of the individuals buried in the LCG-1 tomb. What seems to emerge, however, from the comparison with other Bronze Age sites is that the loss of teeth documented in skeletal remains from LCG-1 does not differ from the AMTL frequencies documented in other Bronze Age sites (Littleton and Frohlich, 1993). Littleton and colleague studied various sites in the Arabian Gulf, from the Neolithic to the Islamic period. The data they collected made possible to reconstruct the subsistence economy of the ancient populations from the Gulf and the consequences of the diet on oral health. The communities of farmers, unlike the communities of hunters/fishermen-gatherers, had a diet rich in cariogenic foods which is manifested in high rates of caries and extensive AMTL. Data relating to oral pathologies from the studies of the mandibles and maxillaries of LCG-1 appears to be in line with the reconstruction provided by Littleton and Frohlich for ancient Arabian Gulf communities (1993).

As far as funerary practices concern, the bone count done by Todero and Fattore suggested that the skeletal remains inside LCG-1 were not deposited in as primary depositions (Fattore, 2013; Todero, 2013). However, it must be considered that the site of Daba LCG-1 was subjected to a partial sampling of the remains. The excavation of the LCG-1 was initially carried out without following accurate excavation methods and creating an exhaustive documentation. The skeletal remains were removed without documenting their position or articulation. This greatly limits the interpretative work that can be done by osteologists/anthropologists.

6.3 Daba al Bayah – Large collective grave 2 (LCG-2)

6.3.1 Demographic assessment

In the LCG-2 primary burials, the number of individuals under 5 years of age represents the 43.65% of the sample. Individuals who died between 0-4 years of age are usually underrepresented in archaeological samples (Macchiarelli and Salvadei, 1994; Ubelaker and Pap, 1996; Alesan et al., 1999), but data from LCG-2 suggest that the same underrepresentation is not present within this sample. Based on this, the sample from Daba LCG-2 appears more accurate in creating life expectancy and mortality rates. Although the same problems of the paleodemographic study highlighted in the study of the RH5 site are also applicable to the Daba site. In this case, the analysis carried out is only preliminary and was conducted on a limited number of burials that do not represent the totality of the LCG-2 skeletal sample. Life expectancy at birth for the Daba LCG-2 primary burials is almost 20 years. Using the formula proposed by Bocquet and Masset (1977) the life expectancy at birth increases up to 25.36 years. Those values are similar to what reported for several Bronze Age and Iron Age sites after the application of the formula proposed by Bocquet and Masset (1977) for stationary population (R = 0): 24.01 years and 24.75 years for the Bronze Age sites of Sarata-Monteoru (Romania) and Lerne (Greece) (Bocquet and Masset., 1977); 22.8 years for the Hungarian Bronze Age site of Tiszafüred (Ubelaker and Pap, 1996). 23 years for the Iron Age site of S'Illot des Porros in Majorca, Spain (Alesan et al., 1999).

Compared to the under-representation of individuals between 0-4 years of age found in the Neolithic sites of Ra's al-Hamra 5 and Jebel al-Buhais 18 (Kiesewetter, 2006), the higher number of individuals belonging to this age group in Daba LCG-2 could be related to several reasons. It could be the result of changes in funerary practices from a period in which infants were buried in different places to a period in which the same funerary structure was used to bury both infants, sub-adults, and adults. Another hypothesis is related to taphonomy. The burials of RH5 and BHS18 were not built inside monumental stone structures, but in simple pits sometimes covered with stones. The loss of individuals in the two Neolithic contexts may therefore be the result of taphonomic factors that did not occur in the same way in the closed and monumental funerary context of Daba.

Changes in lifestyle may be another data to be considered. The Neolithic sites of Ra's al-Hamra 5 and Jebel al-Buhais 18 (BHS18) are considered as sites of seasonal occupation (Kiesewetter, 2006; Salvatori, 2007). The Daba LCG-2 complex, on the other hand, is dated to the Iron Age period and seems to refer to a sedentary community. It is possible that sedentarism itself could explain the absence of underestimation of 0-4 individuals in the Daba LCG-2 site compared to the two Neolithic sites. The seasonality of the Neolithic sites means that the graveyards of RH5 and BHS18 are representative of only a part of the community, the one that died during the seasonal occupation of the two sites.

Change in the subsistence economy is another factor that needs to be considered. As explained in Chapter 2, during the Neolithic period agriculture and food production were still a very marginal activity in Arabia. The subsistence for both RH5 and BHS18 was still based on hunting, fishing, herding, and foraging. During the Iron Age, however, the subsistence of the local populations was mainly based on agriculture. The advent of sedentary living and the development of a subsistence economy based on agriculture caused an increase in infectious diseases, nutritional stresses, and inflammatory skeletal lesions (Armelagos et al., 1991; Barrett et al., 1998; Armelagos, 2003; Eshed et al., 2010; Harper and Armelagos, 2010). The seasonality of production and the increase in size of agricultural communities compared to those of hunter-gatherers are some of the factors that have contributed to this (Armelagos and Dewey, 1970; Barrett et al., 1998; Armelagos, 2003; Harper and Armelagos, 2010). All these factors contributed to a higher mortality. It is therefore possible that the high number of individuals aged between 0-4 years found in the Daba LCG-2 site is related to the different subsistence economy and to a higher mortality at birth.

6.3.2 Paleopathological assessment

The comparison of skeletal lesion frequencies between adults and sub-adults highlights that sub-adult skeletal elements lack indicators of chronic stressors. On sub-adult individuals from EIA period no skeletal lesion was detected. For the LIA period, only 13.3% of sub-adult individuals analyzed show lesions related to dietary and infectious lesions. The percentages are higher compared to the percentage of adults that do not present lesions related to chronic stressors. Despite the high percentage of sub-adults who do not have skeletal lesions, the mortality of sub-adult individuals is significantly high (33 sub-adults over 63 individuals). These data lead to hypothesize that acute ailments burden this community and contributed to the high death rate among its sub-adults (Wood et al., 1992).

By comparing both adults and sub-adults within the LCG-2 primary burials a better assessment of the general health status for the Iron Age community of Daba LCG-2 is reconstructed.

The analysis of cranial pitting/dietary lesions highlighted no statistical differences. The location of pitting on cranial vault and/or orbits suggests possible iron or vitamin C deficiency. Relevant appears the comparison of infections (for EIA period). Adult individuals from EIA period show statistically significant higher percentage of infection than sub-adults.

Adult skeletal remains from both periods show patterns of chronically formed skeletal lesions probably related to work activity and lifestyle. The DJD and OA skeletal lesions are reflective of age and daily work efforts. It might be related to agricultural lifestyle. OA frequency of the adult burials reflects typical arthritic condition seen among other laborers in prehistoric communities. No statistically differences are found comparing skeletal lesions by sex, although male individuals show higher percentages of infections compared to females.

For the EIA skeletal remains, the comparison of AMTL between males and females is significant. The significance persists even by analyzing the percentages based on the count of alveoli analyzed. No differences were found comparing the LIA individuals by sex for oral defects. The difference found between males and females of EIA period regarding oral defects does not seems to be related to age (mean age of 38.1 for males and 39.6 for females). The difference highlighted might be the result of a different diet or might be related to different life activities.

6.3.3 Paleopathological comparison with other Iron Age sites

Frequencies of oral defects from the LCG-2 primary burials were compared to frequencies of oral pathologies from several contemporary sites (Littleton and Frohlich, 1993; De Maigret and Antonini, 2005. Tabs. 6.13-6.14). These sites include burials from Iron Age Bahrain (dated 750-500 BC), and the skeletal remains from Iron Age Galilah dated from 1000 to 750 BC. Other sites used for comparison are Falaika (Kuwait) dated between 300-100 BC and the Yemen necropolis of Al-Makhdarah (MKD), dated to the 1st millennium BC. Given the similarity of results for oral defects between EIA and LIA period, data from both periods were counted together for comparison.

Table 6.13. Oral defects frequencies in other Iron Age sites.

SITES	Antemortem tooth loss (AMTL)		Periapical lytic lesions		Caries	
	n	%	n	%	n	%
Daba LCG-2	134/376	35.6	25/234	10.7	20/213	9.4
Iron Age Galilah[1]	59/167	35.3	--	--	3/261	1.2
Iron Age Bahrain[1]	301/834	36.1	44/834	5.2	85/495	17.2
MKD[2]	68/675	10.1	10/582	1.7	9/193	4.7
Failaka[1]	4/207	1.9	8/207	3.9	11/207	5.3

[1]Littleton and Frohlich, 1993; [2]De Maigret and Antonini, 2005.

Table 6.14. Comparative statistical analysis among Daba LCG-2 and the other Iron Age sites for oral defects.

	Daba LCG-2 with Iron Age Galilah	Daba LCG-2 with Iron Age Bahrain	Daba LCG-2 with MKD	Daba LCG-2 with Falaika
AMTL	1.0000	0.8971	0.0001^{x}	0.0001^{x}
Periapical lytic lesions	--	0.0061*	0.0001 ^{x}	0.0066*
Caries	0.0001^{x}	0.0078*	0.0820	0.1357

* Indicated statistically significant results at P = 0.01.
^{x} Indicated statistically significant results at P = 0.001.
A comparison of lesions between adults is done using the Fisher's exact test.

Significant results were highlighted comparing the frequency of AMTL in Daba LCG-2 compared to the sites of Al-Makhdarah (MKD) and Falaika. The Daba LCG-2 skeletal remains show a higher percentage of antemortem tooth loss (35.9%) compared to the other sites (10.1% for MKD and 1.9 for Falaika). As for periapical lytic lesions significant appears the difference between Daba LCG-2 and the sites used for comparison. The Daba LCG-2 burials show higher percentages of periapical lytic lesions (10.8%) compared to the other sites (5.2% for Bahrain, 1.7% for MKD and 3.9% for Falaika). The comparison of caries frequencies between Daba LCG-2 and the other sites highlights statistically significant results. In teeth from Daba LCG-2 the percentage of caries is 9.3%. Statistically lower is the percentage in the Iron Age Galilah site (1.2%). On the other hand, the site of Iron Age Bahrain shows higher percentages of caries (17.2%) compared to Daba LCG-2.

The data reported regarding the oral and dental pathologies of adult individuals from Daba LCG-2 allow to reconstruct a subsistence economy for this community based on the consumption of foods high in fermentable carbohydrates. Among these it is possible to hypothesize a high consumption of dates. This data is in line with what reported by Littleton and Frohlich (1993) and by Nelson and colleagues (1999) for several sites of the Arabian Gulf and in the Arabian Peninsula. The high consumption of foods rich in fermentable carbohydrates since young age, as evidenced by the presence of caries in several sub-adult individuals from Daba LCG-2, might have led to early tooth loss and, therefore, to the high frequency of AMTL among this community.

6.3.4 The reuse of the tomb

During the 2013-2015 field excavations several Bone Clusters were identified and documented. Data from anthropological reports (Fattore, 2013; Fattore et al., 2015) are reported to make a preliminary summary of the taphonomic information concerning the Bone Clusters.
As previously explained, the “Bone Clusters” were divided into three types: wide, spot, and tridimensional. During the excavation, anthropologists often found connected districts inside disarticulated skeletal bone assemblages. This was documented especially in tridimensional clusters. The skeletal districts most found in connection were hands, feet, and portions of spine (manly lumbar). In some cases, it was realized that these were primary depositions intruded upon (e.g., BC 10). Other clusters (BC 33 and 51), however, had large quantities of scattered bones and only a few districts in connection. Furthermore, whitened and exfoliated skeletal remains were found in BC under29. These characteristics were interpreted as result of an exposition at the sun before redeposition (Fattore et al., 2015). The persistence of connections and the presence, in some cases, of bones that show clear indicators of exposure, led anthropologists to hypothesize the phenomenon of natural mummification (Fattore et al., 2015). This phenomenon would have made it possible to maintain labile connections. However, not all the phalanges of the hands and feet, except for those articulated, were preserved. As reported in the report (Fattore et al., 2015), this would be indicative of a relative wide time span between the first deposition and the redeposition in LCG-2. Another important fact highlighted by Fattore and colleagues (2015) was the presence of skeletal remains in excellent condition within the Bone Clusters. Some skeletal remains, that are generally fragile and subject to post-mortem damage, were found almost intact in this collection of bones. This led to hypothesize that the decomposition took place in an empty and protected space (Fattore et al., 2015).

Regarding the analysis of the skeletal remains from Chambers A and B, the data reported in the result section allows to hypothesize that the continuous use of Chamber A led several previous depositions to had been intruded upon. In some cases, bones were collected and accumulated in the northern part of the chamber as commingled remains. As for Chamber B, during the field excavation several layers of deposition were identified, separated by few centimeters of soil. Some individuals were deposed at the same moment. Starting from the upper layers, this is the case for individuals 14A, 14B, 14C whose skeletal remains were intersected with each other. Similar situation was also identified for individuals 14I and 14J. Individuals 14H, 14R and 14S laid in the lower levels of Chamber B. All were deposed with the lower limbs and the pelvis flexed to bring the left leg to a higher level compared to the right one. None of them had the left lower limb. The loss of articulation of the left limb seems to be the result of subsequent depositional interventions. It is possible to hypothesize that to lay the remains of all individuals within the same space, the oldest depositions were often intruded upon. Except for the last burial recovered, the depositions in Chamber B did not contain grave goods that allow the reconstruction of precise chronology. Furthermore, it has not yet been possible to accurately date the different individuals. This greatly limits the reconstruction of the actions that took place within Chamber B. At the moment it is not possible to quantify the time elapsed between the various depositions. A more precise dating could be obtained with the use of radiocarbon analysis.

All the archaeological and taphonomic data collected from the human skeletal remains of Daba LCG-2 allow to reconstruct a complex situation of reuse of the large funerary structure. Archaeologically, a clear break was highlighted between the northern part of the tomb and the southern part (Genchi, 2019). The excavation revealed, in the northern part of the structure, the remains of depositions dated to the Early Iron Age period with limited interventions dated to the subsequent phases. In the southern part, on the other hand, several interventions over time were highlighted. At the end of Early Iron Age, probably following the collapse of the western wall of the tomb, the northern part was isolated through the construction of a large block of mortar. In the following period the interventions took place in the central and southern part of the tomb. The formation of some of the Bone Clusters should be dated back to this phase and it is probably related to the reuse of the inner spaces of the tomb. Human remains from previous depositions were collected and reorganized. This action would also have continued in the third phase of the tomb. It is not easy to distinguish the formation of the Bone Clusters within the two periods.

Differences in the location of the burials were documented. According to table 3.1, during Early Iron Age period the burials were located mostly inside the LCG-2 tomb. During the second period (Late Iron Age) the inner part of the tomb was still used but most of the burials were recovered inside Chambers built on the original walls of the structure. During the third period (Pre-Islamic period), all the burials were recovered inside Chamber A. Although the excavation is still in progress it seems clear that a change in the use of the structure developed during the centuries.

Another important fact that emerged from the review of the LCG-2 excavation reports is that of the exhibition practice. As already demonstrated in the Neolithic site of RH5 Area 43, the practice of exposing human remains before deposition was a practice used in prehistoric Omani communities. This exposure left traces on the skeletal remains. These traces were documented by Fattore and colleagues (2015) also on some elements of the Bone Clusters. According to

Fattore and colleagues (2015), this practice led to the maintenance, despite the displacement of the skeletal remains, of some labile joints. Future studies need to be done on skeletal remains from Bone Clusters to better quantify the number of human skeletal remains treated with this practice.

6.4 Interpretation of the two Omani contexts studied

Based on archaeological and anthropological data, important information about the type of society, its organization and its mortuary behaviors are provided (Tab. 6.15).

During the Neolithic period the human society of the Oman Peninsula was based on independent local groups which came together to control a territory and its resources (Cleuziou and Tosi, 2020). The basic social entity was the nuclear family. Several nuclear families lived and moved together among seasonal camps (Gregoricka, 2011). During the Neolithic period the economy subsistence was based on hunting, gathering, and fishing as documented in the coastal site of RH5. In this period the graveyards were associated with the settlements (e.g., RH5, RH6) and were structured with the purpose of grouping the dead in the same place within the dwelling area. Most of the burials from this period consist of primary single depositions (Santini, 1987; Charpentier et al., 2003; Gaultier et al., 2005; Salvatori, 2007; Munoz et al., 2010) although the presence of multiple primary burials, including up to five people buried simultaneously, were documented in both Ra’s al-Hamra 5 and Jebel al-Buhais 18 (Kiesewetter, 2006; Salvatori, 2007). Connection during life (family or emotional bonds), simultaneous or close death of the individuals and practical reasons such the desire to save time and resources might be all reasons for the creation of multiple burials during this period (Munoz, 2013).
The long-debated Area 43 of Ra’s al-Hamra 5, based on anthropological data and on information provided by Santini (2002) and Salvatori (2007), also seems to have been originally structured like the rest of the graveyard, with single and multiple pits, some covered with stones. Despite the common traits found within the RH5 burials (type of burial, position and orientation of the individual buried, grave goods and personal ornaments), not all the individuals received the same burial treatments. Burning and exposure of the remains are some practices attested in the RH5 graveyard. Additionally, some individuals received a more complex and expensive burial treatment (Munoz, 2020). According to the reconstruction provided by Munoz (2020), for example, the individual from the Grave 411 was tied with ropes and wrapped in a shroud.

Then was recovered by wadi pebbles, fishes, shells, mammal parts, stone artifacts, and several turtle heads. The whole was closed with a coverture in mats and polygonal stones. This variability reflects individual expression in mortuary practices and might be the manifestation of a certain degree of social differentiation (Munoz, 2020). The prevalence of single depositions and the variability documented seems to reflect a type of society in which the collective value, perhaps present in the social structure, is not reflected in the funerary context.

Between the fourth and the third millennium BC a process of transformation of the social organization began (Cleuziou and Tosi, 2020). Important factor within this process was the intensification of trade relations with Mesopotamian environments and with the Iranian coasts of the Gulf (Frenez, 2020; Weisgerber, 2020b; Frenez et al., 2021). The intensification of the resources in the area, the development and affirmation of agriculture based on the oasis system allow the development of a more stable and more widespread settlement model in the peninsula. This probably reflected a demographic growth of local populations and appeared in an expansion of settlements and a change of funerary practices. Despite this transformation, real urban centers nor a state apparatus with centralized management structures did not develop during Bronze Age and Iron Age. The society was based on complex intersections of tribal alliances (Bortolini and Tosi, 2011; Cleuziou and Tosi, 2020). It is in this socio-cultural context that the two collective tombs of Daba al Bayah developed.

The two large collective tombs of Daba housed the remains of hundreds of individuals. The analysis of artifacts and skeletal remains does not seem to highlight a selection by age, sex or grave goods of the individuals buried in the two tombs (Nava et al., 2015; Fattore et al., 2018; Genchi et al., 2018, 2021). The large number of individuals and the large quantity of archaeological materials (softstone vessels, pottery container, metal tools and weapons, ornaments) found underline the importance of Daba as a sacred area and in the absence of a centralized government authority Daba might had been an inter-tribal aggregation point (Nava et al., 2015; Fattore et al., 2018; Genchi, 2020; Genchi et al., 2021). Based on the data from funerary contexts, therefore, it is possible to hypothesize that these groups shared a similar social structure, characterized by a heterarchic tribal society (Bortolini and Tosi, 2011; Nava et al., 2015; Fattore et al., 2018; Genchi, 2020).

Although similar for structure and number of individuals, the two tombs differ considerably in extent of use and grave goods. Contrary to LCG-1, LCG-2 tomb was used for a longer time span. The phases of use identified in the LCG-2 tomb saw the construction of the structure and its reuse by different groups. Several interventions took place inside the tomb: removal, collection and stacking of the remains from previous depositions (Bone Clusters) and construction of new spaces (Chambers) for new depositions. The various funerary actions did not allow, at the current state of the research, to accurately reconstruct the original deposition modalities of the individuals from the first phase. Another important difference between the two tombs was seen in the type of grave goods found. Many weapons were found in the LCG-1 tomb (Genchi, 2020). This data allows to hypothesize that the individuals buried within the tomb belonged to a society characterized by a strong warrior connotation or to a more limited segment of the society perhaps dedicated to the defense of the group. In the LCG-2 tomb, on the other hand, the type of grave goods found is more varied and consists also of work tools and a greater number of objects of personal adornment than in LCG-1 (Genchi, 2020). Based on these data, therefore, it is possible to hypothesize a reduction of the warrior connotation of the community or it is possible to hypothesize a wider use for the LCG-2 tomb.

Table 6.15. Archaeological and anthropological data from the sites of Ra’s al Hamra 5 (RH5), Daba LCG-1 and LCG-2.

	RH5	**DABA LCG-1**	**DABA LCG-2**
Chronology	Neolithic (3800-3300 BC)	Late Bronze Age-Early Iron Age (1500-1100/1000 BC)	Early Iron Age-Pre-Islamic period (1350 BC-300 AC)
Type of burial	Single and multiple; primary and secondary burials	Collective grave – Probable secondary deposition	Collective grave – Single and multiple; primary and secondary burials
MNI	77 (Area 43) + 182 (non-Area 43)	153 adults + 35 sub-adults	Under excavation. From excavation reports, hundreds of individuals
Paleodemography	Under-representation of sub-adults (0-4 yrs; 5-9 yrs). High mortality between 5-14 yrs	--	High percentage of 0-4 yrs individuals- Low life expectancy at birth
Paleopathology	Oral and skeletal lesion frequencies lower compared to Neolithic agricultural communities	High frequency of dental and oral defects (AMTL and caries) since young age	Skeletal lesions reflective of age and daily work efforts. Dental and oral defects related to the consumption of food high in fermentable carbohydrates
Mortuary practices	Common traits in burials but variety in the funerary treatment (combustion and/or exposure of the remains, more complex and expensive ritual for some)	No selection by age or sex	No selection by age or sex. No clear difference in burial treatments between the different phases of use
Subsistence economy	Hunting/fishing and gathering	Agricultural	Agricultural
Type of society	Independent local groups based on nuclear families living in seasonal camps	Heterarchic tribal society	Heterarchic tribal society
Grave goods	Almost exclusively objects of personal ornament	Several weapons → strong warrior connotation or limited segment of the society	Less weapons; more work tools and objects of personal adornment → reduction of warrior connotation or wider use for the tomb

6.5 THE PROBLEMS IN FUNERARY TERMINOLOGY

The analyzes conducted on the materials of RH5 and the preliminary study on the skeletal remains from the funerary complex of Daba al Bayah highlighted different funerary actions and practices. The data provided by anthropological and archaeological studies allowed to reconstruct information related to the societies that originated the two funerary contexts.

When trying to create standard terminology that works in any context and in any language, needs to be considered that a language is not only terms, but it is also the reflection of an attitude and a culture. This complexity makes it difficult to translate a concept expressed in a language using a single term. Hence, the standardization of terminologies applied to funerary contexts is problematic. This is due partly to language translate issues, but also problematic because agreement among different academic traditions of archaeological research differ greatly. Furthermore, as reported by Chambon (2000) and demonstrated with the analysis of the two tombs of Daba al Bayah, there are not identical tombs. The analysis of funerary architectures can allow the identification of stereotypes and, consequently, facilitate the development of appropriate terminologies. When human behavior or actions are considered, the situation is much more complex.

The term "collective burials" proposed by Duday (2006) is a very broad and general term that allows to enclose different examples of deposition and is therefore applicable in any context without the need to create a chronological or geographical classification. It is also true, however, that a funerary context reflects a population, and its approach to death.

The burials, in fact, reflect funerary actions carried out by a community or a group connected by ideological, political, social reasons or familiar bonds. To better understand these connections, it is necessary to conduct a careful and multidisciplinary study and consider several indicators: archaeological, anthropological, historiographic, and sociocultural.

Archaeologically, important information is reconstructed by analyzing the structure of the burial and the grave goods. The monumental nature of a burial can provides information about the workforce employed in its construction and, consequently, about society. The use of a large workforce, in fact, requires a complex organizational capacity of the community. The articulation of spaces within the funerary context can reflect social differentiations, familiar bonds and can indicate planning for long-term use. A reflection of social differentiations can also be seen in the diversifications of grave goods. Grave goods can also provide important information about the rite and can help in defining a relative chronology of the analyzed context. The relative chronology, the absolute chronology, and the stratigraphy, allow to reconstruct the actual use of the funerary context and the various actions and phases that took place within it. Among the anthropological indicators, taphonomic data are the first to be detected. These can provide information on the type of burial, the type of rite and post-depositional processes. The study of the skeletal remains, then, can provide important information on the demographic profile of the individuals buried. This allows to observe the possible presence of a differentiation by sex or age. Through the study of skeletal remains it is also possible to observe the health conditions of a community (pathologies related to metabolic stress, presence of trauma, infections, etc.) and sometimes to hypothesize activities in life by observing markers of stress and skeletal injuries. Through isotopic analyzes and aDNA studies it is also possible to reconstruct mobility, paleodiet, maternal and parental kinship, population continuity and replacement. All this information must be compared with archaeological data to provide information on the interaction between the different communities, the capacity to exploit the territory and the social and family organization of the analyzed community. For historical societies, it is also possible to use direct or indirect information from literary and epigraphic sources. Such information can help in understanding socio-cultural dynamics that otherwise would not have been easily understood using only data from archaeological material.

The anthropological analyzes conducted allow to exclude the site of Ra's al-Hamra 5 (RH5) from the terminological debate about collective graves. The reason for this includes the fact that the presence of skeletal remains belonging to several individuals within the same area is the result of a series of interventions that altered the original limits of the burials (see paragraph 6.1.5).

Different appears the situation in the funerary complex of Daba al Bayah (Tab. 6.15). Although the LCG-1 tomb provides little stratigraphic data, the monumentality of the structure and the absence of selection by sex, age or grave goods allow to recognize a collective value for this tomb structure. Additionally, the second tomb LCG-2 yields addition critical data concerning the social value of tombs. Even though this tomb is only partially excavated, it is possible to distinguish at least 3 phases of use (Early Iron Age-EIA, Late Iron Age-LIA, Pre-Islamic period-PIR). It was a tomb that was used over a considerable length of time.

In tombs characterized by prolonged use over time it is therefore appropriate that the analysis of all information is carried out considering phase by phase and not the tomb as a whole.

In the analysis of the phases of the LCG-2 tomb, the PIR phase needs to be analyzed separately from the two Iron Age phases. During the PIR period, in fact, the use of the funerary structure seems limited to Chamber A, not to the entire burial structure. It is not possible, therefore, to exclude that the structure was used more for convenience than for the desire to seek a

connection with the previous phases. Although also within the Chamber A, various stratigraphic sequences corresponding to various funerary actions that followed one another were highlighted thus testifying a continuity of use of the same Chamber A.
During the EIA and LIA phases the use of the entire structure and of the areas adjacent is evident. As with the LCG-1 tomb, LCG-2 shows a random mix of burials. The construction of a structure so monumental it is to be linked to the desire of the community to bury the individuals all together within the same tomb. Furthermore, it was hypothesized for the funerary complex of Daba not only a value limited to a single community but a value as an inter-tribal point of aggregation (Bortolini and Tosi, 2011; Nava et al., 2015; Fattore et al., 2018; Genchi, 2020). Accordingly, the tombs from Daba are characterized with strong social value.

Knünsel and Robb (2016) has suggested that funerary terminology is more interpretative than descriptive. Schmitt and Déderix (2018) reported on how the term "collective", used by Duday (2006) and other scholars (Bray and Trump, 1970; Joukowsky, 1980) to describe the depositions of several individuals staggered over time, is not a neutral term but rather it is linked to social behavior of a community. The use of the term “collective burials” is complicated; it is used both to describe archaeological facts and to interpret function (Schmitt and Déderix, 2018). In this context, the two tombs of Daba seem to fit both uses of the term "collective". These are tombs that contain the remains of several individuals whose deposition happened in a long-time span, and additionally a strong social value as a point of intertribal aggregation seems to have been recognized as the origin of their construction and use.
Not all actions that take place inside a tomb are necessarily connected to social behavior, sometimes are simply functional. However, it is appropriate to consider that at the origin of a single structure aimed at hosting the remains of several individuals for an extended period of time, there is an organization. This organization is the manifestation of the will of a community or a group to allocate space to that specific funerary use. This suggests a certain degree of social implication. Considering this and bearing in mind that funerary terminology does not define all the information that can derive from the study of a funerary context, the terminology proposed by Duday (2006) is valid except in cases where the absence of social implications is recognized.

Conclusion

Two aims were presented at the onset of this dissertation. The first goal was to assess demographic and health status of two prehistoric Omani communities. The first site studied was the Neolithic fishing site of Ra's al-Hamra 5 (RH5), specifically the Area 43. The second site studied was the funerary complex of Daba al Bayah. Within this burial complex two different tombs were studied, the Large Collective Grave 1 (LCG-1) and the Large Collective Grave 2 (LCG-2).

The second goal was to reconstruct the mortuary practices within the two sites analyzed. Mortuary practices within Ra's al-Hamra 5 were studied with a multidisciplinary approach. Fire action, diagenetic alteration of the bone surface and traces of manipulation were observed in skeletal remains from Area 43. Diagenetic changes within the skeletal remains were also analyzed using histological methods. Both Ra's al-Hamra 5 Area 43 and the Daba al Bayah funerary complex were also studied for mortuary practices analyzing previous studies conducted on the skeletal remains.

Additionally, a re-examination of the terminology used in English and French literature for funerary contexts that contain skeletal remains of several individuals was assessed. The analysis was done using the examples of the two Omani sites studied.

- *Demography and paleopathology of Ra's al-Hamra 5 (RH5)*

The analysis of skeletal remains from RH5 Area 43 for demographic assessment found that a minimum number of individuals of 77 was determined in the burial sample. No statistically significant difference was found comparing the individuals from Area 43 and non-Area 43 by age groups. The analysis of life tables from Area 43 and non-Area 43 burials showed similar trend for both life expectancy and mortality rates within the two sectors of the graveyard.

The paleodemographic data from the RH5 graveyard allowed to detect an underestimation of sub-adult individuals from birth to 4 years of age. This underestimation was also documented in the contemporary site of Jebel al-Buhais 18 (BHS18). The loss of 0-4-year-old individuals could be related to a greater fragility of the bones which would therefore have been lost due to diagenetic and taphonomic factors. The fact that only few individuals under 2 years of age were found in single burials at the RH5 site, and that most of them were found associated with burials of adult individuals, also allowed speculation that these individuals were buried elsewhere. The comparison of the life tables from the sites of RH5 and BHS18 also documented a higher mortality of individuals aged between 5 and 14 years at the RH5 graveyard. In both sites there seems to be an underestimation of these age groups and for this reason it is not easy to understand if the difference is related to simple numerical variations or if it is related to the high percentage of spina bifida documented in the RH5 burials.

The paleopathological assessment of skeletal remains from RH5 Area 43 found that no differences were highlighted between Area 43 adult and sub-adult individuals for skeletal lesions, except for periostitis. Adults show statistically significant higher percentage of periostitic lesions than sub-adults. Suggesting that adults were able to survive the origin of these lesions better than sub-adults.

Over 93% of the Area 43 sub-adult do not exhibit skeletal lesions. Hence, the health problems for the younger individuals from this community seem to be acute in origin. It appears that sub-adults were subjected to stresses that acted quickly and resulted in death.

The comparison of lesion defects between non-Area 43 and Area 43 showed similar dental defect patterns. None of the teeth found at the RH5 site have caries, reflecting dietary patterns typical of hunter and gatherers or fishing communities.

The comparison of oral defects between the RH5 (Area 43 and non-Area 43) skeletal remains and other Omani Neolithic fishing/gathering communities highlighted similar patterns. None of the teeth from the sites presents caries. This corresponds to the data that we know for these communities, characterized by a low-sugar diet.

The comparison between the RH5 (Area 43 and non-Area 43) skeletal remains and burials from Jebel al-Buhais 18 highlighted dietary patterns typical of low sugar diets. Compared to RH5 samples, the site of Jebel al-Buhais 18 shows significant higher frequencies of lumbar OA and DJD in ankle and elbow. The difference in OA and DJD frequencies between the two communities might be related with the physical stress associated with herding activities and travelling on uneven terrain.

The comparison of skeletal and oral lesions between the RH5 site and the Neolithic agricultural communities highlighted significantly higher percentages of all the lesions in agricultural communities. The oral defect frequencies reflect a diet rich in carbohydrate and sugars.

- *Demography and paleopathology of the Daba al Bayah tombs*

The general comparison between mandibular and maxillary sockets from the Daba LCG-1 skeletal remains found statistically significant higher percentages of AMTL on almost all the lower sockets. The comparison of oral defects between Daba LCG-1 and skeletal remain from other Bronze Age sites showed similar frequencies of antemortem tooth loss. Paleopathological data reflects a diet rich in cariogenic foods.

The analysis of skeletal remains from the Daba LCG-2 primary burials for demographic assessment allowed to distinguish the individuals by general age groupings: 4 individuals are fetal/perinatal individuals, 26 are infants (0-3 years of age), 5 are children (4-8 years), 2 are juvenile (9-12 years), 2 are adolescents (13-19 years) and the remaining 34 individuals are adults. Of the adults, 12 are male or probably male and 19 are female or probably female. It was not possible to determine the sex of 3 adult individuals. Distinguishing within the three identified periods of use of the tomb, the analysis highlighted that in both Early Iron Age and Late Iron Age the percentage of infants (0-3 years) is higher compared to other sub-adult age groups. Compared to the Neolithic sites of Ra’s al-Hamra 5 and Jebel al-Buhais 18, it appears that the 0-4 age group is not underrepresented. Taphonomic data, higher mortality, burial practices, or the sedentary lifestyle compared to the seasonality of the Neolithic sites were considered as explanation for the high number of 0-4 individuals recovered in the Daba LCG-2 tomb.

The analysis of skeletal lesions from the Iron Age burials of Daba LCG-2 highlighted a general lack of indicators of chronic stressors in sub-adult skeletal elements from the EIA period compared to adult remains. These data lead to hypothesize that acute ailments burden this community and contributed to the high death rate among its sub-adults. No differences were found between Iron Age adult and sub-adult individuals for cranial lesions. Statistically significant higher percentage of infection-based lesions was found in adult individuals from the EIA period compared to sub-adults. Suggesting that adults were able to survive the origin of these lesions better than sub-adults. The comparison between the two Iron Age periods do not show differences in adult and sub-adult skeletal lesions.

Adult skeletal remains from both periods (Early Iron Age and Late Iron Age) show patterns of skeletal lesions (DJD and OA) reflective of age and daily work efforts. It might be related to agricultural or nomadic lifestyle. No statistically difference were found comparing skeletal lesions by sex. The comparison of oral defects between males and females highlighted significant results. The EIA females show significant higher frequencies of antemortem tooth loss than males. The difference might be the result of a different diet, characterized by more cariogenic foods or might be related to age. In general, data related to oral and dental defects among adult and sub-adult individuals from the Daba LCG-2 tomb allow to reconstruct a subsistence economy based on the consumption of food high in fermentable carbohydrates.

This reconstruction is in line with data reported for several other sites of the Arabian Gulf and the Arabian Peninsula.

- *Mortuary practices of Ra's al-Hamra 5 (RH5)- Area 43*

The study of skeletal remains from RH5 Area 43 highlighted that approximately 53% of the skeletal remains from RH5 Area 43 analyzed show alteration related to fire action. The analysis highlighted the presence of burnt skeletal remains not in the entire Area 43 but rather in some specific sectors. The few burnt remains found in the other sectors might have been subject to washout or post-deposition processes that would have altered their original location.

At least 20% of the skeletal remains analyzed show signs of surface alteration related to the exposure of fresh bones to open air. Additionally, histological analysis for bioerosion patterns in human bones from RH5 Area 43 highlighted at least two different deposition practices. Some of the remains were buried shortly after death, while other remains were exposed to open-air decomposition prior to both burning and burial. The almost complete absence of marks related to rodents and carnivores' activity suggests that the bodies subjected to exposure were positioned in places protected from animal attacks.

- *Mortuary practices of the Daba al Bayah tombs*

The excavations, still in progress, in the Daba al Bayah funerary complex allowed to reconstruct important data on the funerary practices of the communities who lived in the area during the Bronze Age and Iron Age. The limited data available for the excavation phases of the LCG-1 tomb makes it difficult to accurately reconstruct the funerary practices. Several data, however, emerged from the careful excavations done in the LCG-2 tomb.

The continuity of use of the LCG-2 tomb is documented both by the archaeological materials found and by the funerary practices recognized. As attested in other Omani sites, some skeletal remains from the LCG-2 tomb of Daba document alterations of the surface related to the practice of exposing the remains to the open air. According to anthropological and archaeological data it is also evident that different funerary actions occurred at different times. These actions appear in the form of accumulations of bones and archaeological materials (Bone Clusters), burial depositions of individuals and realization of new spaces within the structure (Chambers). The careful excavation that is being carried out, in fact, allowed to highlight a series of actions that so far have not been clearly documented in other similar contexts. The anthropological and archaeological data from the Daba LCG-2 tomb allowed to add new elements to the understanding of funerary practices and multi-period tombs of Omani prehistoric communities. In the future, an accurate study of the skeletal remains from the Bone Clusters could provide further important data that would complement our knowledge about this large funerary structure.

- *The terminological problem about "collective burials"*

The most debated term is the one concerning the so-called "collective tombs". This term, generally used in Archeothanatology to describe the depositions of several individuals staggered over time and within a single structure, was contested because it implies a social value and, therefore, it is not a neutral term. In the analysis of a funerary context, as demonstrated by the study conducted on the two Omani sites of Ra's al-Hamra 5 and Daba al Bayah, it is not only the taphonomic data that must be considered. It is indeed one of the several data that must be considered to allow the reconstruction, as accurately as possible, of all the information that a funerary context can provide. Based on these, in fact, it is possible to reconstruct important data about the type of society, its organization, its rites and its mortuary behaviors. Considering that the creation and use of structure aimed at hosting the remains of several individuals whose deposition is staggered over time implies organization and a certain degree of social implications, it seems appropriate to use the term "collective" proposed by Duday (2006).

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