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Bioarchaeology-related studies in the Arabian Gulf: potentialities and shortcomings

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Abstract: Archaeological studies provide a powerful tool to understand the prehistoric societies, especially when combined to cutting-edge morphological and molecular anthropological analyses, allowing reconstructing past population dynamics, admixture events, and socio-cultural changes. Despite the advances achieved in the last decades by archaeological studies worldwide, several regions of the World have been spared from this scientific improvement due to various reasons. The Arabian Gulf represents a unique ground to investigate, being the passageway for human migrations and one of the hypothesized areas in which Neanderthal introgression occurred. A number of archaeological sites are currently present in the Arabian Gulf and have witnessed the antiquity and the intensiveness of the human settlements in the region. Nevertheless, the archaeological and anthropological investigation in the Gulf is still in its infancy. Data collected through archaeological studies in the area have the potential to help answering adamant questions of human history from the beginning of the structuring of genetic diversity in human species to the Neolithisation process. This review aims at providing an overview of the archaeological studies in the Arabian Gulf with special focus to Qatar, highlighting potentialities and shortcomings.

Keywords: prehistoric societies; human skeletal remains; morphological analyses; molecular anthropological analyses; socio-cultural changes; Neolithisation process; Qatar

Introduction

Archaeological studies hold the promise of providing comprehensive frameworks of prehistoric societies especially when coupled with advanced molecular analyses. Bioarchaeology, defined independently by Clark and Buikstra in 1970s (Clark 1972; Clark 1973; Buikstra 1977; Wright & Yoder 2003; Knüsel 2010), represents a branch of archaeology which aims at studying human remains from archaeological sites. Human skeletal remains are considered part of the cultural heritage defined for the first time in 1954 in the Convention of Aja and then by the UNESCO in 1970 as "every artifacts or natural/biological formation considered important for religious, archaeological, historical, artistic, and scientific purposes" (Cattaneo & Gibelli 2014). Therefore, archaeological skeletal series have the potential to enhance the understanding of our history adding useful data for a more extensive comprehension of contemporary human beings.

Anthropological and bioarchaeological investigation helped answering lots of adamant questions that otherwise would remain still open. The analysis of skeletal remains plays an important role in the reconstruction of past population dynamics, lifestyles, dietary habits, admixture and migration events, as well as health status with possible implications even in the history of medicine (Armelagos & Van Gerven 2003; Knudson & Stojanowski 2008). Field anthropology along with mortuary archaeology allow the interpretation of the burial context, the funerary practices, and the decomposition modalities (Duday et al. 1990; Duday 2008; Willis & Tayles 2009) as well as their continuity and/or shifts amongst different pre-historic and/or historic periods in different countries (Duday et al. 1990; Duday 2008; Willis & Tayles 2009). Toward this aim, both the position of the skeletal remains and the taphonomic processes should be taken into account (Duday et al. 1990; Duday 2008). The changes occurred during the decomposition process (e.g. the

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chronology of the dislocation of labile and persistent articulations) represent the basis for reconstructing the original position of the buried individual, the arrangement of clothing, furnishing and grave goods as well as the architecture of the tomb itself (Duday et al. 1990; Duday 2008).

Despite important advances have been made by archaeology-related studies worldwide, several regions of the World have been spared from this scientific advancement due to reasons of different nature. The scientific value of archaeological and anthropological studies is strictly dependent on the resources available. In the regions of the World where prehistoric populations are well studied, it is because resources have been made available to allow archaeological excavation and scientific analysis to be undertaken. In Qatar the archaeological research is still in its infancy although recent works have offered a unique opportunity to understand Qatari prehistoric populations (Cuttler et al. 2013a; Izquierdo Zamora et al. 2015a; Izquierdo Zamora et al. 2015b; Cuttler & Izquierdo Zamora 2019). This review provides an overview of the bioarchaeological studies in the Arabian Gulf with special focus to Qatar, highlighting potentialities and shortcomings.

The Arabian Gulf region

The Arabian Gulf constitutes a unique potential source of data on human past history since it represents the earliest corridor of '*sapiens*' "out of Africa" as well as one of the hypothesized areas where Neanderthal introgression occurred (Grün et al. 2005; Green et al. 2010; Groucutt & Petraglia 2012; Prufer et al. 2014; Lazaridis et al. 2016; Stewart et al. 2020). As recently discussed by Petraglia et al. (2019), the Arabian Gulf is extremely important for investigating not only human migrations, but also Pleistocene climatic variations. The region has been reported to be the venue of contacts and trades with both neighboring and foreign cultures which, in turn, might have provided non-indigenous objects (Potts 2009).

The area is enriched of Prehistoric archaeological sites (Groucutt & Petraglia 2012; Petraglia et al. 2019); however, despite its unquestionable value and importance from historical, archaeological and anthropological point of view, some areas remain under-investigated (Groucutt & Petraglia 2012; Petraglia et al. 2019; Petraglia et al. 2020). It is worthy noticing that even though the number of anthropological studies in the Gulf is significantly smaller than the number of studies available for other areas, researches conducted in the past years have provided important insights on funerary practices, biology, and population dynamics in the Middle Eastern region (Coppa et al. 1985; Macchiarelli 1989; Coppa et al. 1990; Mack & Coppa 1992; Bondioli et al. 1998; Littleton 1998; Santini 2002; Coppa & Cucina 2007; Salvatori 2007; Weeks 2010; Porter & Boutin 2012; Gregoricka 2013a; Gregoricka 2013b; Zazzo et al. 2014; Broushaki et al. 2016; Gallego-Llorente et al. 2016; Lazaridis et al. 2016; Hüneburg et al. 2019; Petraglia et al. 2019; Williams & Gregoricka 2019; Petraglia et al. 2020).

In this perspective the National Priority Research Project (NPRP) "Human Populations and Demographics in Qatar from the Neolithic to the late Iron Age" that we are currently carrying out, represents one of the recent efforts for a better understanding of Qatari Prehistory aiming at reconstructing not only population dynamics but also cultural changes, lifestyle, dietary patterns and human genetic diversity both temporally and spatially in ancient Qatari populations.

Initially, the Gulf was recognized as a single region that played an important role in the Mesopotamia-Indus trades (Konishi et al. 1988). Nowadays, however, it is known that the Gulf region experienced the coexistence of different stable cultures spread in at least four main regions: i. southern Iran, from the Shatt al-Arab to the Strait of Hormuz; ii. southernmost Mesopotamia; iii. northeastern Arabia, Bahrain, and Qatar; iv. southeastern Arabia, the UAE, and Oman (Potts 2009). Archaeological investigations in Iran started much earlier than in the other countries of the Gulf Area with the initial excavations being undertaken in Bahrain in 1879 (Rawlinson 1880; Potts 2009).

The fieldwork in this early stage of research mainly focused on the above ground graves as most visible structures. In the lack of extensive and multilayered settlement mounds, as known from Mesopotamia, Anatolia and Levant, the graves were used to establish the periodization of the region (Magee 2019). With a suggested number of 172,000 graves (Larsen 1983) Bahrain had the largest burial ground in the region and probably the greatest concentration of the burial mounds in the world. Due to development and infrastructure projects many of these mounds have been demolished so that today only around 20,000 grave mounds are preserved. Around 8,000 graves have been investigated and they are still subject to research (Højlund 2007).

The excavations in Bahrain revealed various evidences dating back to the 3rd–2nd millennia BCE including "Gulf-type" seals and vessels representing a clue of long-distance maritime and land routes between Mesopotamia, Iran, and Indus region (Potts 1983; Rice 1983; Rice 1984; Al-Khalifa & Rice 1986; Konishi et al. 1988). Soon it was understood that Bahrain was the center of the Land of Dilmun as it was named in the texts found in the Mesopotamian city of Uruk. Based on this discovery the chronology was settled as Early Dilmun (2500–1800 BCE), Middle Dilmun (1880–1000 BCE) and late Dilmun (1000–400 BCE) covering the Bronze and Iron Ages. Also, the Hellenistic Period (300 BCE–600 CE) was named after the Greek name of the Island, the Tylos Period (Mughal 1983; Killick & Moon 2005; Højlund 2007). Three major archaeological sites (Qala'at Bahrain, Barbar and Saar) delivered information about the daily life, beliefs and organization of the populations lived in Bahrain. The archaeological site of Saar offered the unique opportunity to study a settlement (Killick & Moon 2005)

and its graveyard (Mughal 1983; Killick & Moon 2005; Højlund 2007). Other burial grounds contain grave mounds from almost all prehistoric periods. Until now Early Dilmun (Højlund 2007) and Tylos (Salman & Andersen 2009) graves were studied in detail but no osteoanthropological research was performed. First bioarchaeological studies were reported as early as beginning of 1980s (Frohlich 1982) but in depth research followed only by the end of 1990s (Littleton 1998; Littleton 1999). Recently also bones from the older excavations became the subject of "The Dilmun Bioarcheological Project", which aims at studying the skeletons transferred to US in mid 1940s (Porter & Boutin 2012; Boutin 2016).

Important discoveries were also made in Umm an-Nar island (UAE) that unraveled circular burials along with painted potteries, vessels and bronze artifacts (Konishi et al. 1988). This discovery named the related period, Umm an-Nar Period (c. 2700–2000 BCE). Even other periods of the UAE Bronze Age were named after places where different types of graves were discovered, e.g. Jebel Hafit Period (c. 3200–2700 BCE) and Wadi Suq Period (2000–1300 BCE). This underlines the importance of graves as one of the main focus of the research. This is also valid for the Neolithic Period (c. 6000–3500 BCE) for which burials provided important evidence including the discovery of more than 500 individuals in the mass cemetery of Jebel Buhais 18 (Kutterer 2010).

Key archaeological sites like Jebel Hafit, Al Ain, Dibba, Tell Abraq, Mleiha and Jebel Buhais provided information about the changing styles in mortuary practices of the populations once living in the United Arab Emirates. As summarized by Martin (2007), bioarchaeological research in the United Arab Emirates is well developed. Specifically, the detailed study and publication of the skeletal remains from Jebel Buhais demonstrated the importance of the study of larger skeletal inventories and provided important information about the Neolithic populations (Uerpmann et al. 2006; Kutterer 2010).

As outlined by previous researches, bioarchaeological examination has been also performed on Neolithic and Bronze Age skeletal remains in southeastern Arabia (Cope et al. 2005; Blau 2007; Martin 2007; McSweeney et al. 2008; Baustian & Martin 2010; Gregoricka 2013a; Gregoricka 2013b; Williams et al. 2014; Zazzo et al. 2014). The study by Gregoricka (2013a) represents the first attempt to better understand how the transition between the Umm an-Nar (2700–2000 BCE) and the Wadi Suq period (2000–1300 BCE) affected local populations, investigating temporal variations in residential mobility, geographic origin and dietary pattern reconstruction through the analysis of carbon and oxygen stable isotopes (Gregoricka 2013a). The research contributed to the understanding of the social adaptation of populations in Southeastern Arabia and to its complexity that is probably higher than supposed by previous speculations (Gregoricka 2013a). Mobility was also investigated by the analysis of strontium isotopes outlining the presence of non-local individuals and suggesting the relevance of inter-regional exchanges; the results are indicative of the fact that trading represented an important resource for the area influencing even social aspects (Gregoricka 2013b).

As reported by Zazzo et al. (2014), the very first evidence of funerary practices in the Sultanate of Oman was provided by the excavation and the analysis of the Neolithic graveyard (ca. 3800–3300 BCE) recovered at Ra's al-Hamra (Macchiarelli 1989; Mack & Coppa 1992; Coppa et al. 1985; Bondioli et al. 1998; Coppa et al. 1990; Santini 2002; Coppa & Cucina 2007; Salvatori 2007). More recently, the study by Zazzo et al. (2014) aimed at shedding light on the lifestyle of this Omani coastal population. The radiocarbon dating along with the stable isotope analyses suggested a sedentary rather than seasonal lifestyle of this population although its mobility along the Omani coasts could not be excluded (Zazzo et al. 2014). Similarly to the UAE, also Oman's chronology of the 4th–2nd millennium BCE is dominated by graves and their material culture. Important sites like Ra's al-Hadd, Wadi Suq, Bat, Amlah, Masyar, Shir, Sinaw, Daba, Amlah and Ra's al-Jinz provided information about the burial customs from different periods (Munoz 2019).

Northwest Arabia has also started being subjected to bioarchaeological research. This is particularly relevant to study environmental changes and to understand how those changes might have influenced the population, the regional connection as well as the stratification within the society. New research at Qurayyah (Luciani & Alsaud 2018; Luciani et al. 2018), Tayma (Lora et al. 2010; Petiti 2013; Petiti et al. 2014), Mada'in Saleh (Bouchaud et al. 2015) provided extremely useful information about oasis populations and their hierarchic societies and connection. In northwestern Arabia, Qurayyah, located north of Tabuk (Saudi Arabia), has been investigated since the last decades of 20th century and recently it has been the subject of study from a research group led by Luciani (Parr et al. 1970; Ingraham et al. 1981; Longden & Garfi 2001; Bussas et al. 2008; Intilia et al. 2009; Luciani 2014; Hüneburg et al. 2019).

The site has been occupied by human populations from the Pre-Pottery Neolithic B until the Byzantine period (Parr et al. 1970; Ingraham et al. 1981; Luciani & Alsaud 2018; Hüneburg et al. 2019). Researches in the area have the potential to improve knowledge on this oasis, with a particular focus on water management strategies, geomorphology and the development of the stable human settlements (Hüneburg et al. 2019). Tayma, another relevant archaeological site, is located at a little more than 200 km southeast of Tabuk (Eichmann et al. 2006). OSL and ^{14}C analyses proved that the site dates to the 3rd millennium BCE (Engel et al. 2009); according to Engel et al. (2009), the architectural vestiges of the walls of the city were completed at the beginning of the 2nd millennium BCE with the most ancient parts most probably dating back to the half of the 3rd millennium BCE (Klasen et al. 2011). The research by Wellbrock et al. (2011) investigated the climatic variations in the area from the Holocene to the present days. Even though Tayma

is now characterized by an arid climate (Eichmann et al. 2006; Engel et al. 2009; Wellbrock et al. 2011), it had more abundant annual precipitation during mid-Holocene and it was likely characterized by a monsoonal climate in the late Holocene (Wellbrock et al. 2011).

The reconstruction of ancient climates represents not only an interesting research field, but it is also extremely important to reconstruct the dynamics of specific geographic areas (Schoeninger 2011) as in this case the Arabian Gulf. Important archaeological sites have been also recovered in the Emirate of Fujairah, which has been recently subjected to excavations that unearthed burials dating back to Late Bronze-Iron Age (Pfeiffer et al. 2018). The excavation aimed at preserving the archaeological context as well as to promote anthropological research, taking into account the structure, the dating and also the use of the excavated burials (Pfeiffer et al. 2018). The research led the authors to hypothesize a spatial distribution of the burials, the most part of which was used for secondary internments even though a co-existence of primary and secondary graves could not be excluded in one of the areas (Pfeiffer et al. 2018). The authors suggest that further investigations are needed with the recovered material being helpful in shedding light on lifestyle, funerary practices and even paleodemographic patterns (Pfeiffer et al. 2018). The results of the bioarchaeological research of the site is still under preparation (Pfeiffer pers. com.); such results will likely help to understand the relation between the individuals buried in these collective graves.

Several additional studies are now tackling issues related to population dynamics in Middle East. This represents a topic of the utmost importance as there is no evidence of a continuity in occupation from the Middle and Upper Paleolithic periods to the mid-Holocene (Potts 2009). The variations in the sea levels and the geomorphological modifications that interested the Gulf region had an impact on human populations in the area, although this is not completely understood yet (Lambeck 1996; Teller et al. 2000; Potts 2009). Evidences of Paleolithic occupation were demonstrated in Iran, in the interior of Fars and in Zagros (Piperno 1974; Smith 1986; Potts 2009); few years ago, Gallego-Llorente et al. (2016) have, for the first time, sequenced and analyzed the ancient genome of an Early Neolithic woman from the Zagros Mountains (Iran) providing evidence that the population of Western Iran has an ancestry related to pre-Neolithic hunter-gatherer Caucasus' populations and different from the Neolithic Anatolians (Gallego-Llorente et al. 2016). Two additional studies have also focused on Zagros in Iran:

a) Broushaki et al. (2016) provided sequences of four Early Neolithic genomes, comprising one to 10X coverage from a well-preserved sample of a male from Wezmeh Cave (Zagros). Such research concluded that in Southwest Asia farming was adopted by various genetically distinct hunter-gatherer human groups, and that genetic pool of pre-Neolithic population was conserved as a consequence of the spread of farming into surrounding regions (Broushaki et al. 2016);
b) Lazaridis et al. (2016) presented whole ancient genomes from 44 ancient Near Easterners from Natufian hunter-gatherers to Bronze Age farmers outlining the first sight on the demography of human populations that shifted to agriculture; they also suggested that the genetic pool of the Near East was conserved during the course of the transition to farming. Of note, the data obtained by the authors are consistent with the idea that the spread of agricultural technologies was certainly faster than the movements of people, rejecting the hypothesis that only a farming population substituted the hunter-gathers (Lazaridis et al. 2016).

Qatar: present and past

Qatar is a peninsula on the Eastern border of Saudi Arabia, with a population of ~2.5 million, of which ~300,000 are nationals. Due to its location, Qatar, and Middle East in general, have played a central role in human evolution as they served as a passageway for human migrations between the Asian and African continents (O'Regan et al. 2011; Groucutt & Petraglia 2012; Stewart et al. 2020).

Qatari population's genetic makeup has been traditionally influenced by a conservative cultural and geographical isolation, in a predominantly tribal structure within which genealogical ancestry is well documented (Hunter-Zinck et al. 2010). Qatari families are usually large and tribes remain genetically isolated. In recent population history (~1–2000 years), the spread of Islam through the Arabian Peninsula led to high levels of religious immigration into Arabia, creating significant genetic diversity on the peninsula. Despite the production of genetic data related to Qatar and Middle East in general is increasing dramatically (Hunter-Zinck et al. 2010; Omberg et al. 2012; Tadmouri et al. 2014; Tomei et al. 2015; Fakhro et al. 2016; Zayed 2016), a critical unmet research and public need relies on the understanding of the prehistorical habits of people living in these regions of the World.

The study of prehistoric societies with a nomadic way of life and their socio-economic relationships with other prehistoric populations has several complications. While the archaeological record is often the only way by which prehistoric populations can be researched, it is difficult to trace it within the Qatari landscape given that settlements for mobile populations are either ephemeral or non-existent. Within Qatar, Neolithic and Bronze Age settlement sites have not been not chronologically or spatially extensive enough to provide the necessary archaeological data to unravel the prehistory. This has resulted in a chronological framework with significant gaps in the archaeological record, leading to misunderstandings in the interpretation of Qatar's prehistory,

dynamics of mobile populations and their interaction with the landscape.

However, recent archaeological studies have discovered thousands of new prehistoric burials (Al-Naimi et al. 2012; Cuttler et al. 2013a; Cuttler et al. 2013b; Cuttler & Izqierdo Zamora 2019) that represent a great opportunity to understand the relationship between population dynamics and sociocultural changes in prehistorical Qatari societies. Despite the potential offered by these types of findings, unfortunately, prehistorical burials are under critical threat from the quick urbanization and infrastructure development that has been occurring at high speed in Qatar in the recent years.

Traditionally, the burial cairns from Qatar were only associated with two periods, 'Ubaid-related cultures of the 5th millennium BCE (Midant-Reynes 1985; Tixier 1980), and what was considered to be a rise in population during the Seleucid to the Sasanian periods (late 1st millennium BCE–early 1st millennium CE) (Konishi et al. 1988; Konishi et al. 1994; Schreiber & Muhle 2008 unpublished data; Cuttler et al. 2011; Cuttler et al. 2013a; Muhle & Schreiber 2012; Kjaerum et al. 2017; Madsen et al. 2017a; Madsen et al. 2017b; Madsen et al. 2017c). The research and systematic survey conducted by the Qatar National Historic Environment Record Project (QNHER) team in 2009 in northern Qatar (Cuttler et al. 2013b), firstly highlighted the presence of up to 10 burials per km^2, suggesting that the density and number of these features is much higher than previously thought (Cuttler et al. 2013a; Cuttler et al. 2013b). These many thousands of burial mounds are clearly the most ubiquitous prehistoric monument in Qatar representing one of the most important archaeological resources for the investigation of Qatar's prehistory, and in many cases they are the only surviving monument type from some periods (for example, almost nothing is known about groups inhabiting Qatar from the Chalcolithic to the Late Bronze Age, c. 3,800–c. 1,100 BCE) (Cuttler & Izquierdo Zamora 2019). The investigation of prehistoric cemeteries offers what is probably the only opportunity to fill the chronological gaps in our knowledge for the various and complex societies that occupied the peninsula of Qatar prior to the rise of Islam. Research by the QNHER suggested that the characteristics of burial sites is influenced by the local topography, hydrology and geomorphology, revealing marked differences in their distribution, density and typology depending on their location in different parts of the country and the period of their construction (Cuttler & Izqierdo Zamora 2019). The excavations undertaken so far on burial cairns in Qatar have predominantly been of small-scale and did not include many of the modern scientific techniques (including molecular analyses). Additionally, the survival of organic remains in the undisturbed tombs has been quite poor. Several efforts are now trying to fill this knowledge gap including a National Priority Research Project funded by Qatar Foundation which aims at understanding the prehistoric Qatari Society from Neolithic to the late Iron Age (NPRP10-0208-170411). Several cemeteries, belonging to this time frame are currently being investigated as part of this National Priority Project as further described below.

- Wadi Al Debaian is a multiperiod site located in the northwest of Qatar and situated on the former Holocene coastline approximately 3 m above the sea level, 2.5 km from the modern day shoreline, and approximately 3.5 km southwest of the UNESCO World Heritage site Al Zubarah. The site was investigated by the Qatar National Historic Environment Record (QNHER) team of the Birmingham University between 2010 and 2014 (Cuttler et al. 2013b; Izquierdo Zamora et al. 2015a; Cuttler & Izqierdo Zamora 2019). The excavations have yielded remains of human activities, like pits, hearths and postholes dating from c. 7500–4500 BCE. Within the site a possible Neolithic cemetery (HAR20775) has been discovered during 2012 where at least four grave cuts have been recognized, two of which have been excavated and yielded undisturbed burials.
- Wadi Al Jalta (HAR1801) is located 3.5 km west of Al Khor bay in northeastern Qatar. The wadi was a former torrential valley still defined by the outline of eroded hills that surround it. The site is located at the top of one of the hills on the southern edge of the wadi. The hill is a 70 m long and 30 m wide platform that rises approximately 11 m high while forming the most prominent feature within the wadi. The slopes of the hill are subject to continuous erosion. The site contains 17 cairns in different preservation stages. Previous investigation of the site, including excavation of eight of the cairns by the French archaeological missions to Qatar (Inizan 1980; Tixier 1980; Midant-Reynes 1985) and five cairns by the QNHER team of the Birmingham University (Cuttler et al. 2014 unpublished data), revealed remains of inhumations within eight of these monuments. Four cairns are still unexcavated; however, their deflated surface could be indicative of bad preservation or even the disturbance of the graves.
- Hainat Al Joua (HAR23336) is located approximately 4 km north of Al Khor and 4.5 km west of Al Thakira in northwest Qatar. The geology of the area is very similar to Wadi Jalta which is just 3.8 km south. Here two eroded hills are surrounding a wadi and the site is located at the top of one of those hills. Beside the continuous erosion the slopes of the hills indicate that the area was used for quarrying farouche (beach stone). Just recently a group of at least three larger burial cairns and further smaller and deflated possible burial cairns have been discovered in this site. The larger cairns are preserved around 1 m in height and 4–5 m in diameter and they seem to be still intact and undisturbed. There are no indications on the time-frame these burials date back to, except their morphological similarities and their close spatial proximity to the Neolithic burials of Wadi Jalta site.

- Al Ghafat (HAR20075) is located approximately 40 km west of Doha on the top of one of narrow hills surrounding a rawdha. A total of seven pre-Islamic cairns in different preservation stages have been identified. Previous investigation of the site by the QNHER team of the Birmingham University (Cuttler et al. 2014 unpublished data) revealed the presence of two graves with human remains whereas five cairns are still unexcavated. A second site in this area contains 16 cairns in different preservation stages. Five of the cairns were excavated by the QNHER team of Birmingham University, four of which contained human remains in single or multiple burials (Izquierdo Zamora et al. 2015a) and some intact grave goods like a soft stone bowl. Eleven cairns in this site are still unexcavated.
- Asaila is located approximately 55 km west of Doha. The area contains several cairns – only few hundred meters from each other – that are built on a raised shoreline overlooking the plain. The largest cairns are located in tree clusters very close and most probably also contemporary to each other:
  Al Kharsaah (HAR5047) contains a cairn cluster of at least five large cairns on the top of a hill overlooking the entire surroundings. These cairns are among the largest of Qatar, showing diameters ranging from 7 to 11 m and approx. 2 m of height. Cairns are arranged in two groups (ca. 80 m to each other): the west one contains three cairns, whereas the eastern one two cairns. The presence of additional circular structures between the two groups might be the indication of further smaller and deflated burial cairns as well as of structures related to the funeral practices. The same is true for the stone semi-circular annexes attached to some of the cairns that represent a unique and unusual feature for Qatari cairns.
  The site Rawdat Lebretha (HAR1748) contains five large well preserved cairns (10 m in diameter and 1.5 m height), the larger of which shows some evidence of a possible ring wall. Two further possible cairns are located on the southern edge of the shoreline south of this cairn cluster. These cairns are under actual threat due to the extension of the neighbouring animal camp but also the use of the area for littering.
  Furthermore, the site Asaila (HAR5811) contains also at least five graves, one of which appears deflated and relatively small (3 m in diameter) with respect to the others (6–7 m in diameter and 1.5 m height).
- Lisha archaeological site (HAR1) is located approximately 87 km northwest of Doha, on a flat plateau immediately south of the modern Al Zubarah road. It contains several cairns scattered as single graves or as clusters. In particular, there are two broad rows of clusters NW-SE oriented with a third possible row of outliers approximately 35 m south. The main cluster, centred upon a low plateau, contains ca. 22 graves. Most of the cairns show a deflated surface (max. 1 m height) as a probable consequence of robbing. All graves are circular with diameters generally ranging from 5 to 6 m with some exception showing diameters ranging from 7 to 8 m. All cairns are made of irregular angular stone boulders with obvious bonding material.
- Umm Al Maa (HAR20225) is located on the west coast of Qatar, approximately 80 km northwest of Doha. The area is interspersed with mild hills up to 10–20 m above the sea level.
  The first investigation in the area was made in the 50's by the Danish archaeological expedition during which fifteen out of the fifty recovered graves were excavated (Glob 1957; Glob 1959; Kjaerum et al. 2017). In 1987–1988 and 1990–1991 the Japanese Archaeological Mission to the Arabian Gulf excavated six further cairns and re-examined the ones previously excavated by the Danish team (Konishi et al. 1988). Twenty-five further graves were excavated during 2008 and 2009 by a German team who suggested that the actual cemetery in Umm Al Maa might contain "several hundreds if not thousands" of cairns (Schreiber & Muhle 2008 unpublished data; Schreiber et al. 2009 unpublished data; Muhle & Schreiber 2012).

All skeletons and bone fragments retrieved from the aforementioned excavations are currently stored at the collection of the Department of Archaeology in Qatar Museums Authority and are being analyzed as part of the Qatar Foundation-funded project NPRP10-0208-170411.

In addition to the importance of performing archaeological studies *per se*, these researches offer the opportunity for collaboration between Qatari institutions, as well as between Qatari and international institutions having the potential to help Qatar to become internationally recognized in the field of anthropology and to produce high quality research that eventually will have an important impact on the international scientific community.

The potentials of the integration of archaeological, morphological, and molecular anthropological investigation

Archaeological research provides information not only about how humans once lived but also, and most importantly, how they interacted with their environment. By performing thoroughly documented excavations, archaeologists are able to record remains of human activities throughout millennia and collect samples to be studied by scientists from other disciplines. Through an interdisciplinary connection, archaeologists collaborate with geologists, botanists, zoologists, biological anthropologists, geneticists, microbiologists, climate scientists, etc. to reconstruct in-depth information about human activities in the past and humans' ability to adapt to their changing environment.

"Why excavating and studying human skeletal remains?" Human bones represent a valuable biological archive of information about the life history of the individual they belong to (Ubelaker 1999). As described by Wright & Yoder (2003) bioarchaeological investigation does not represent only a mere analysis of human skeletal remains but it also produces evidence related to history and culture.

The recent advances in archaeoanthropology and the combination of multiple approaches (including morphological and molecular analyses) allowed an unprecedented level of detail of the anthropological investigations (e.g. Ciaffi et al. 2015; Alt et al. 2016; Baldoni et al. 2016; Baldoni et al. 2018; Scorrano et al. 2019). The bioarchaeological field experienced several changes in the recent past as a consequence to the technological progress, but also to the adoption of an evolutionary and population-level perspective (Klaus 2014). The environment certainly represents an important aspect to investigate; both archaeobotanical research as well as metagenomics and metaproteomic analysis of dental calculus represent important tools for enlarging the perspective of the analyses (e.g. Brown & Brown 2011; Warinner et al. 2014a; Warinner et al. 2014b; Warinner et al. 2015; Velsko & Warinner 2017; Baldoni et al. 2018; Gismondi et al. 2018; Jersie-Christensen et al. 2018; Gismondi et al. 2020). The morphological examination of human skeletal remains is fundamental for the reconstruction of the biological profile of a given individual (e.g. sex, age at death, stature etc.) and, when combined to metric analysis, it represents a useful tool for investigating activity patterns, health status, standards of living of ancient populations and also the interactions with the environment (Steckel 1995; Alesan et al. 1999; Larsen 2000; Larsen 2002; Wright & Yoder 2003; Giannecchini & Moggi-Cecchi 2008; Ciaffi et al. 2015; Baldoni et al. 2016; Baldoni et al. 2018; Gnes et al. 2018; Scorrano et al. 2019). Data collected from a large number of individuals may shed light on population dynamics (mortality patterns, demographic composition etc.) (see for example Alesan et al. 1999; Jordana & Malgosa 2002; Jordana et al. 2010; Gnes et al. 2018; Baldoni et al. 2020). As clearly outlined by Chamberlain (2006), it is extremely challenging to reconstruct population dimensions and dynamics only by archaeological evidence. In this perspective, the estimation of population parameters and the reconstruction of demographic patterns paired with material data are extremely important for the interpretation of burial sites (Chamberlain 2006). However, it is clear that reconstructing the paleodemographic framework from archaeological skeletal series is far from being easy as pointed out by various researches (Bocquet & Masset 1977; Bocquet-Appel & Masset 1982; Van Gerven & Armelagos 1983; Buikstra & Konigsberg 1985; Wood et al. 1992; Alesan et al. 1999; Pinhasi & Mays 2008). The excavated skeletal series should ideally represent all died individuals within a population, unfortunately archaeological and anthropological practice reveal that the ideal situation is almost always different from the reality (Alesan et al. 1999; Pinhasi & Bourbou 2008; Pinhasi & Mays 2008). Even though the concept of the "osteological paradox" (Wood et al. 1992) is far from being overcome, accuracy should be paid for evaluating if a specific skeletal series can actually fall into the paradox (Mays 1997; Pinhasi & Bourbou 2008). Moreover, as mentioned by Pinhasi & Bourbou (2008), it should be borne in mind that there is not an unequivocal interpretation of data.

Dynamics of past human populations also differ on the basis of the activity performed. In this perspective, certainly the material artifacts, often used for this purpose, are valuable sources of information although data should be integrated with the information obtainable from the analysis of musculoskeletal stress markers on bone tissue (Kennedy 1989; Capasso et al. 1999; Villotte 2006; Mariotti et al. 2007; Milella et al. 2012; Villotte & Knüsel 2013; Baldoni et al. 2018).

Last, but not least, population dynamics often suffer from the impact of pathogens and diseases that could affect human health leading also to death (Ortner 2003). Unfortunately, although numerous diseases leave marks on bones, the analysis of skeletal remains alone allows only a partial acquisition of knowledge of health problems; in fact, most diseases do not necessarily affect bones and/or may affect bones in different ways (Ubelaker 1999; Mays 2010). It is also worth noticing that the evaluation of pathological modifications on skeletal remains is strictly dependent on their state of preservation considering not only the macroscopic preservation of the bones but also the microscopic one (Turner-Walker 2008). The attention in terms of diseases on skeletal series gradually shifted from the individual level to the population level (Pinhasi & Bourbou 2008; Pinhasi & Mays 2008).

The recent years have witnessed a growing interest in the analysis of the prevalence of pathologies in past populations combining the obtained data with archaeological and/or historical evidences (Pinhasi & Bourbou 2008; Pinhasi & Mays 2008; Fornaciari et al. 2018). Even though data obtained by the morphological analysis of archaeological human skeletal remains are undoubtedly extremely useful for investigating our past history, a more accurate reconstruction of past human populations may be achieved if these data are integrated with those coming from molecular analyses (Brown & Brown 2011). The analysis of ancient biomolecules – ancient DNA (aDNA), proteins, lipids and carbohydrates – currently represents a highly valuable tools for a deeper investigations of our past history (Brown & Brown 2011; Cappellini et al. 2018). An extremely important aspect of human life history is represented by diet; the role of diet is widely investigated by employing the analysis of carbon and nitrogen stable isotope from bone proteins (Katzenberg 2000; Hedges & Reynard 2007; Schoeninger 2011; Lightfoot et al. 2012; Killgrove & Tykot 2013; Alexander et al. 2015; Ciaffi et al. 2015; Baldoni et al. 2016; Baldoni et al. 2018; Killgrove & Tykot 2018; Villalba-Mouco et al. 2018; Alexander et al. 2019; Baldoni et al. 2019; De Angelis et al. 2019; Rolandsen

et al. 2019; Schrader 2019; Scorrano et al. 2019; Gismondi et al. 2020; Varano et al. 2020)

In this perspective, as clearly outlined by a multitude of scientific researches, the use of carbon and nitrogen stable isotopes is extremely useful not only for evaluating dietary habits of past human populations but also to investigate wider topics as for instance the domestication process of plant and animal species, the Neolithisation process, the existence of variations in alimentary patterns with respect to sex and age at death, breastfeeding and weaning habits, the diachronic dietary variations over the centuries etc. (e.g. Wright & Schwarcz 1998; Richards et al. 2002; Müldner & Richards 2005; Fuller et al. 2006; Müldner & Richards 2007; Kellner & Schoeninger 2008; Schoeninger 2011; Killgrove & Tykot 2013; Alexander et al. 2015; Ciaffi et al. 2015; Makarewicz & Sealy 2015; Tsutaya & Yoneda 2015; Baldoni et al. 2016; Baldoni et al. 2018; Killgrove & Tykot 2018; Redfern et al. 2018; Villalba-Mouco et al. 2018; Baldoni et al. 2019; Alexander et al. 2019; De Angelis et al. 2019; Jordana et al. 2019; Rolandsen et al. 2019; Scorrano et al. 2019; Gismondi et al. 2020; Varano et al. 2020). Furthermore, despite its potential in paleodietary reconstruction, stable isotopes are widely employed for investigating migrations and residential mobility (Schoeninger 2011; Gregoricka 2013a; Gregoricka 2013b; Zazzo et al. 2014; Pellegrini et al. 2016; Francisci et al. 2020).

As widely discussed in literature, recent years have also been interested by an enormous increase of human paleogenetic studies and of ancient whole genome data production (Green et al. 2010; Rasmussen et al. 2010; Reich et al. 2010; Stoneking & Krause 2011; Meyer et al. 2012; Prufer et al. 2014; Skoglund et al. 2014; Allentoft et al. 2015; Haak et al. 2015; Slatkin & Racimo 2016; Green & Speller 2017; Cappellini et al. 2018; Pinhasi et al. 2019).

Archaeogenetics represents one of the foundations of bioarchaeological researches; as reported by Brown & Brown (2011) it allowed investigating the route of early *sapiens* out of Africa as well as shedding light on the diffusion of agricultural crops. Furthermore, archaeogenetic gives the chance to analyze ancient genomes leading to the generation of an enormous amount of information, ranging from individual's sex to genetic markers of specific pathologies and phenotypic predictive traits (Skoglund et al. 2014; Cappellini et al. 2018; Houldcroft et al. 2019; McHugo et al. 2019; Zaorska et al. 2019; Segurel et al. 2020). Technical improvements have allowed access to a huge amount of genetic information from previously uninvestigated substrates (Green & Speller 2017) as well as a growing interest in environmental DNA (Willerslev et al. 2003; Willerslev et al. 2007; Pedersen et al. 2015; Thomsen & Willerslev 2015; Pedersen et al. 2016; Cappellini et al. 2018).

In particular, dental calculus, widely investigated in the last years, represents a valuable record of the human microbiome (Preus et al. 2011; De La Fuente et al. 2012; Adler et al. 2013; Warinner et al. 2014b; Warinner et al. 2015; Weyrich et al. 2015; Velsko & Warinner 2017; Jersie-Christensen et al. 2018). It offers the possibility to investigate oral health, phytotherapeutic practices, medicinal habits and human diet (Warinner et al. 2014a; Warinner et al. 2015; Cristiani et al. 2016; Hardy et al. 2016; Velsko & Warinner 2017; Weyrich et al. 2017; Baldoni et al. 2018; Hendy et al. 2018; Power et al. 2018; Cummings et al. 2018; Eerkens et al. 2018; Gismondi et al. 2018; Gismondi et al. 2020).

Shortcomings

The majority of burials excavated during the past decades in Qatar have not been the subject of modern analyses, such as aDNA, isotope analyses etc. When aiming at assessing biomolecules in human remains retrieved from archaeological investigations, there are several technical problems that should be taken into account. One of the major shortcomings is the preservation of the human bones, which is a consequence of the *post-mortem* degradation process. As described in literature, the decomposition of human body involves several processes at both macroscopic and microscopic level (Bell et al. 1996; Wandeler et al. 2003; Pruvost et al. 2007; Dabney et al. 2013; İşcan & Steyn 2013).

In Qatar, no aDNA analysis has been attempted on prehistoric skeletal remains so far. Thus, there is currently no precedent to demonstrate the success of this analysis. As it stands, it is almost impossible to judge whether the bioarchaeological analysis will yield some key, rare or critical data.

Major advancements have been made in the bioarchaeology field; despite bioarchaeology research in Qatar is yet in its infancy, we believe that by following the recommendations of studies previously conducted, this research will lead to major breakthroughs that, in turn, will allow a better understanding of the prehistorical Qatari society.

Concluding remarks

The Arabian Peninsula encloses a huge amount of data and information on our history. Given the potential of the analyses on human skeletal remains, their application on archaeological skeletal collections from the Arabian Gulf Area will enhance a better understanding of past population dynamics, admixture events, and socio-cultural changes. The information achievable from this unique area could answer the adamant questions of human history from the beginning of the structuring of genetic diversity in *Homo sapiens* to the Neolithisation.

The solicitation of an increasing numbers of projects focused on the preservation of Arabic archaeological sites even with the collaboration of international institutes will certainly help the development of high-quality research that will dramatically impact the international scientific community.

Authors' contributions

MB, ST and CML conceived the study. MB, FS, CML, and ST wrote the manuscript. MAH, AEB, FAN, and TL participated to the discussions related to the writing. All the authors made intellectual contributions and approved the final manuscript.

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