Paleodietary Assessment of Skeletal Remains from ‘Queen Alia International Airport’ Using Ca, Sr and Zn Analysis

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ABSTRACT

To investigate the paleodiet of the inhabitants of Queen Alia International Airport (a 3rd century AD site in Middle Jordan), the concentration of Ca, Sr, and Zn were analyzed in 22 samples from the ribs of 22 human skeletons. Ten more soil samples from 10 graves were also analyzed. The concentrations of Sr, Ca and Zn were measured using the Atomic Mass Absorption method at the laboratories of the Faculty of Archaeology and Anthropology, Yarmouk University. The correlation coefficient and the standard deviation statistics of the results pointed to little if any soil/bone exchange of the above elements and also indicated homogenous soil samples. The results show that the inhabitants at QAIA consumed both protein and plant food with no discrimination.

KEY WORDS: Paleodiet, Trace Elements, Roman Period, Ribs, Jordan.

INTRODUCTION

Trace element analysis of prehistoric skeletal remains has become widely acceptable and pertinent as a method for reconstructing paleodiet since it was approached by Brown (1973) followed by Gilbert (1975), Balkely and Beck (1981), and Lambert et al. (1979, 1982). Archaeologists have used the ratios of Sr, Ca, Zn, Ba, Mg, Cu, Fe, Pb and Cd as parameters to address paleodietary research issues, such as, dietary change (Sillen, 1981; Schoeninger, 1982), subsistence economy (Lambert et al., 1979; Shdouh, 2004) and social status (Schoeninger, 1979). The most sensitive ratios of these elements in archaeological human bones that significantly infer protein and plant consumption are strontium/calcium (Sr/Ca), strontium/zinc (Sr/Zn) and zinc/calcium (Zn/Ca) ratios (Larsen, 1997). Higher Sr/Ca and Sr/Zn ratios indicate more plant consumption as strontium replaces calcium in bone tissues when consuming plants while higher Zn/Ca ratio indicates more protein intake as zinc replaces calcium when consuming diets rich in protein (Szostek and Glab, 2001).

The physiology of the above elements is available in hundreds of studies such as the studies by Klepinger (1984), Sillen et al. (1989), Lambert et al. (1990), Radosevich (1993), Lambart and Weydert-Homeyer (1993), Harrit and Ezzo (1994) and Wiercinska (2001). These studies pointed that strontium, which replaces calcium during metabolic process, is an earth element that is absorbed and then deposited in plant tissues with concentrations lower than in soils. Consequently herbivores will have lower concentrations than in plants and carnivores then will have the lowest concentration and then archaeologically negligible. The concentration of strontium in omnivores like humans is greatly dependent on the quantity of plant consumption. It is archaeologically significant because the turnover of strontium in bones is very long, mostly ten years. Zinc, a major constituent in animal proteins, also replaces calcium in bone tissues and its concentration reflects the amount of protein intake of an individual during the last years of his life as the turn over of zinc is also long. Trace elements are subject to post-depositional changes within bones caused by soil acidity, water drainage, trace element concentrations and the burial context. Such changes have been proven to be variable from one site to another (Nelson and Sauer, 1984).
The Site of Queen Alia International Airport

The site (QAIA) was accidentally discovered during an expansion project at the Airport (fig. 1). After the Department of Antiquities in Jordan had informed about the cemetery, a salvage team excavated the site recovering 52 well-preserved and articulated human skeletons from 50 graves that were dated to the third century AD. Except for the study conducted by Al-Sa’oud (2003) on the bioarchaeology of the site, the skeletal material remained to be further investigated.

In his study of the skeletal material recovered at the site, Al-Sa’oud (2003) found higher male/female ratios with an average age at death of about 35 years. The absence of pathological lesions on the skeletons indicated a healthier population but probably died of causes that did not leave apparent marks on the bones. The very high incidence of hypoplasia on the front teeth was interpreted by him as an indication of childhood stress like malnutrition. Al-Sa’oud (2003) concluded that QAIA people were agrarians. Frohlich (1987) who previously studied a number of burials at the cemetery pointed to a site that was functioned as a military garrison based on the higher incidence of degenerative arthritis of male joints, inflammatory changes, fractures and one possible case of lower arm amputation. Actually, the site did not reveal any military-like artifacts (Al-Sa’oud, 2003) and also these kinds of pathologies were not uncommon in agrarian societies. The enclosure of the site by a pastoral land (Ibrahim and Gordon, 1987) might have enabled the inhabitants to subsist on animal husbandry beside dry farming agriculture.

Purpose of the Study

Although the number of the Roman archaeological sites in Jordan exceeds 1118 sites (fig. 2), few of them have actually revealed skeletal materials that enjoy the characteristics of good preservation and articulation. This makes from QAIA a promising potential for conducting paleodietry studies, which are scarce for this particular period and only represent the site under study. As shown in figure (2), the Roman archaeological sites nearly cover the whole country, which means that these sites occupied different geographical settings and possibly different subsistence strategies. One could not generalize statements about the Roman diet depending only on few sites. This study tries to provide further dietary information and insights on the Roman period and expands the study by Al-Sa’oud (2003) on the site by enriching the collected archaeological data.

Sampling and Analytical Methods

The study was carried out on 22 samples representing the same number of individuals. Sub-adults were excluded from the study because their diets only represent a certain group in the community and might constitute elements that were not reflected in the subsistence economy of the community as a whole. Atomic absorption Spectroscopy (UNICAM 939) was used in analyzing the samples; this technique has a long history in archaeology and proved to be reliable in dietary studies (Hughes et al., 1976). Although previous studies (Schoeninger, 1981 and 1989) on trace elements indicated that the choice of bone position in the body does not affect the results of trace element, bone samples were taken from ribs to avoid the large quantities of cancellous bone where soil particles usually trapped.

Bone samples were first treated mechanically to remove the cancellous bone using dental picks. The remaining cortical bone was double washed with distilled water. Samples were dried in room temperature for 48 hours then were ground using an agate mortar and a pestle. Five milligram powder samples were digested with nitric and perchloric acids then combusted and analyzed using the Atomic Absorption Spectroscopy (AAS). The atomic absorption analysis was carried out at the laboratories of the Faculty of Archaeology and Anthropology/Yarmouk University. To examine the exogenous diagenetic factor that could have affected the skeleton (post mortem), chemical analysis on ten random soil samples collected from graves, where the individuals came from, were carried out using the same technique as mentioned above but using Hydrofluoric acid for digestion.

Results and Discussion

The results of the concentration of the elements Ca, Sr and Zn in soil are presented in table (1). The results show a relatively low standard deviation, which consequently reflects the chemical homogeneity of these concentrations in the soil samples. To examine if there were any exchange between soil and the skeletal material, the correlation coefficient between the concentrations of the elements in the soil samples and the skeletal material was performed using the statistical package of SAS.

The correlation coefficient between soil samples of
the ten graves and the skeletal materials of these graves show negative and very low correlation for Ca ($r = -0.3$) and Zn ($r = -0.03$) but a very low but positive correlation for Sr ($r = 0.2$). The correlation coefficient between soil and skeletal results substantially indicates insignificant exchange between soil and bones.

The skeletal material used in this study was remained buried for more than 2000 years (dated to the Late Roman period ca. 63 BC). In cases of soil-skeleton exchange, standard deviation in the results of the Ca, Sr, and Zn would have then tended to become lower over time because skeletons then would have come closer to homogeneity. But the standard deviation in the trace elements of bones is very high (table 2) leading us to conclude again that there was little if any soil-skeleton exchange and thus eliminating the effect of post mortem diagenesis on the skeletal material under study.

### Table 1: Mean and standard deviation of Ca, Sr, and Zn concentration in soil samples.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Ca (ppm) soil</th>
<th>Sr (ppm) soil</th>
<th>Zn (ppm) soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>210000</td>
<td>184.32</td>
<td>142.52</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.21</td>
<td>14.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Count</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 2: Mean and standard deviation of trace element concentration in bones.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Ca (ppm) bone</th>
<th>Sr (ppm) bone</th>
<th>Zn (ppm) bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>436000</td>
<td>426.15</td>
<td>472.31</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.77</td>
<td>151.97</td>
<td>169.84</td>
</tr>
<tr>
<td>Count</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>

The ratios of Sr/Ca, Sr/Zn and Zn/Ca are shown in table 3. The results show that strontium and zinc possess nearly the same concentration in the skeletal material with a ratio close to 0.001. If both concentrations (Sr and Zn) were to be nearly equal, Sr/Zn ratio would be close to 1, which is in our study 1.009 as shown in table 3.

### Table 3: The average ratios of Sr/Ca, Sr/Zn and Zn/Ca in bones.

<table>
<thead>
<tr>
<th>Sr/Ca</th>
<th>Sr/Zn</th>
<th>Zn/Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00098 $\approx$ 0.001</td>
<td>1.009</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Comparing the ratios of the trace elements of Queen Alia International Airport with the results from Ain Ghazal (a Neolithic site) and Wadi Faynan (a Late Roman site) that were reported by Shdouh (2003), it is clear that the ratio of protein-plant consumption of the people of QAIA is different (fig. 4). The people of QAIA had probably consumed both protein and plant food without discrimination or diet preference, while the ratios in the other two sites show a tendency toward more plant consumption.

This is probably due to the subsistence strategy and the function of the site; two possible factors that were controversial in the study of Al Sa’aoud (2003) and Frohlich (1987) as mentioned above. The almost equal consumption of protein and plant diets probably reflects a community that was subsisted on both animal husbandry and agriculture. Unfortunately, the collected archaeological data from the site were not enough to support such an argument; what was recovered was a sole cemetery. This raises a further research question of why there were no architectural features at the site or the near vicinity. There is a great probability that the site was inhabited for a short period of time that did not allow the site to flourish as is the case in many other Roman sites.

### Conclusions

Unfortunately, we do not have enough archaeological data from QAIA site. A cemetery is the only archaeological feature that was recovered there, which introduces further questions about the function of the site. The recovered artifacts from QAIA were not able to conclude statements about the function of the site. The occupation was probably transitional, where the inhabitants left minimal traces behind them before they had moved to another place. Further archaeological studies like strontium isotope analysis on the skeletons and at the region would probably pointed to the origin or central places of the inhabitants. This study would be further supported by radiocarbon dating of the skeletal material.

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Figure 1: The archaeological site of QAIA.

Figure 2: The Roman archaeological sites in Jordan.
Figure 3: Sr, Ca, and Zn results.

Figure 4: Ain Ghazal, Wadi Faynan and QAIA Ca, Sr, and Zn ratios.
REFERENCES


بقيام معرفة تقييم باستعمال الدوالي العالي لمملكة مطور في مكان عظيم، تحليل (Ca) الكالسيوم والستروديشوم (Sr) و الزنك (Zn) الشرمان عبد الله*

*صاروخ إيجاد تتم هذه التركيز في العناصر ترتيبات، أدوات ودورة الأثنين إلى الأثنين. استنادًا فيما في الأثنين وعندية الأثنين في القبور العتيقة في تلك الأثارية البيانات إغناز الجملة. وتمثل الأرقام التي تم حفرية جملة خلال جميعهم تتم 2002.

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