Ancient Diet Reconstruction: A Case Study of Sidon, Lebanon

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(Received: 09/ 04/ 2015 ; Received in Revised form: 04/08 / 2015 ; Accepted: 12/ 10/ 2015)

The present work is associated with dietary reconstruction using $\delta^{13}C$ and $\delta^{15}N$ analysis of humans from the site of Sidon, a Middle Bronze Age (2000BC-1550BC) settlement in Lebanon. The main objective of this research is to focus on collagen extraction of 23 individual bones, discovered in a cemetery, College site (season 2001-2002) in ancient Sidon. Collagen could only be extracted from the 8 adults and 11 subadults and one faunal sample excavated during the 2001-2002 seasons. Carbon and nitrogen stable isotopes, which are two important tools in palaeodietary analysis, can tell us about the protein sources of the diet. $\delta^{13}C$ values shows the proportion of terrestrial against marine protein in the diet and what sort of photosynthetic pathways, including C_3, C_4, or CAM, were consumed in populations during their lifetime, while $\delta^{15}N$ values reveal the proportion of animal against plant protein and also provide an indication of the age of weaning. In this study according to the carbon isotope values, the results show that these individuals were consuming terrestrial food stuffs, typically C_3 plants, including cereals such as wheat, barley, rice, as well as lentils and milk products. The nitrogen isotopes indicate that protein originated from a mixture of terrestrial plant and animal food. The animals probably were herbivores such as sheep and goats, which consumed C_3 plants. Also, the nitrogen values estimated age of weaning in infants in this population. Infants were breast-fed and their weaning may have been occurred between the ages of 18 months and 3-4 years. The most surprising results of both isotopes are that no trace of C_4 plants or marine products was seen, while the site is situated along the Mediterranean Sea.

Keywords: *Bronze Age, stable isotopes, palaeodiet, Lebanon, Sidon, $\delta^{13}C$, $\delta^{15}N$*

Introduction

The name of the present city of Sidon – or Saïda in Arabic – is known from early antiquity, most particularly from Akkadian texts. In the el-Amarna archives it is written as „ i d u - n u , in which form it is later found in the annals of the Assyrian kings in relation to their military expeditions towards the Levantine coast. The Ugaritic epic of Kirta mentions the goddess of the Sidonians („DYNM) 1. In Egyptian the town is attested as Di- d u - n 3 in Papyrus Anastasi. Written „DN in Phoenician and in Hebrew, it is transcribed as Sidvn in Greek. The persistance of the form of the name is thus remarkable (Briquel-Chatonnet 2006: 2). The Bronze Age in Lebanon is very poorly understood. This period, which covers a broad period between 3100-3000 to about 1100-1050 (Monks 2000: 117), can be divided into three phases based on cultural and regional distinctions: Early, Middle and Late. Sidon's importance as the most ancient or the most well-known of the Canaanite and Phoenician coastal cities has largely been inferred from textual documents on the works of the Greek poet Homer as well as from the Old Testament (Doumet-Serhal 2003a: 2). Phoenicians, who came to the eastern shore of the Mediterranean from southern Babylonia, occupied Sidon during the historical period (Eiselen 1966: 27). Curtis (2003a) states that Sidonian and Phoenician occurred in parallel lines, and were understood to be synonymous. There has been relatively little excavation in Sidon. The general aim of this work is to examine the diet of the Sidon people during the Bronze Age and also, to attempt to determine which terrestrial, marine, animal and plant proteins were used by this population.

The present article aims to reconstruct general dietary habits of the Bronze Age site of Sidon in Lebanon. Three specific objective of this study have

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been identified:
1. To obtain the general dietary information for people buried in Sidon.
2. To explore individuals of different age.
3. To determine possible age of weaning from infants and juvenile individuals.

Methods and Materials

The methodology applied involved the analysis of ^{13}C and ^{15}N stable isotopes obtained from human bone collagen. From the perspective of the archaeologist, Van der Merwe and Vogel have traced the first stable isotope studies of past diet in the 1970 for diet reconstruction from its origins in physics, plant physiology and applications in archaeology. The potential of isotopic analysis for human diet reconstruction was recognized a decade before its first application. A major application of the carbon isotope work has been the study of the rise of maize agriculture in North America (Mays 2000: 426). Carbon and nitrogen stable isotopes are most commonly studied in human remains. The first tissue to be used in archaeological stable isotope studies of human palaeodiet was the collagen of bone. Because its isotopic composition reflects the individual's diet, its chemistry is well defined, and its amino acid composition varies only slightly between species and also is slowly turned over throughout life. Turnover rates of collagen are poorly documented, but complete replacement may take 10-30 years in an individual (Mays 2000: 426). The significance of this work is isotopic analysis of the Sidon people during the Bronze Age which is the first work carried out in the east of the Mediterranean, especially in Lebanon.

The Site

This paper will concentrate on Sidon, which is circumscribed by two small rivers. The site, which is situated in south of Lebanon and 20 km north of Tyre (Markoe 2000: 199) and about 35 kilometers south of Beirut, was an important Phoenician harbor (Fig. 1) (Curtis 2003a). Sidon or Saida (33 34'N, 35 22'E) is situated on the NW slope of a rocky promontory (Doumet-Serhal 2003b: 6).

The Old Testament mentioned of Sidon as "the first born of Canaan". According to the Old Testament (Eiselen 1966: 27), Sidon, which is situated on a small promontory bordered by a line of reefs hugging the coastline, (Markoe 2000: 199) was a city of the Phoenicians (Eiselen 1966: 27). The Phoenicians, who came to the eastern shore of the Mediterranean from southern Babylonia, occupied Sidon during the historical period (Eiselen 1966: 27). Most information about Sidon comes

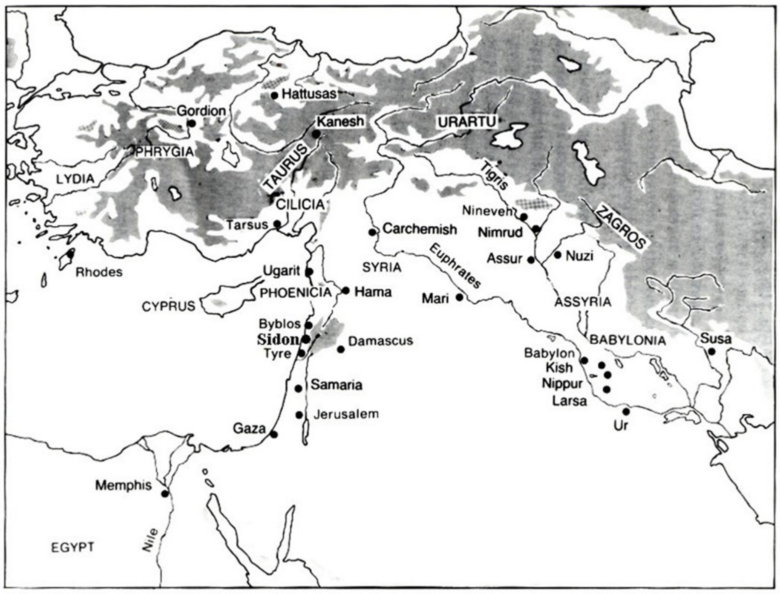

Fig 1. *Near East (From: Aubet 1996: 6)*

from contemporary Egyptian, Assyrian, Babylonian and Greek records (Curtis 2003b). At the time of Sidon's foundation, during the third millennium BC, maritime harbour technology was still very much in its infancy (Marriner & Morhange 2006).

There is no evidence for use of the famed cedars of Lebanon, which Doumet-Serhal says may have been reserved for export to Egypt and Mesopotamia, where they are frequently mentioned in contemporary texts. Inside the building's ancient storerooms, built of stone and not the usual mudbrick, the team uncovered a cache of more than 350 pounds of burnt barley as well as a quantity of burnt emmer, one of the oldest domesticated types of wheat, first found in Syria as early as the Neolithic period. Why and how they were burned remains unclear. In addition to grain, the diet of the ancient Sidonians included sheep and goat, which was typical for the region. The team also uncovered a surprising amount of evidence for the consumption of wild game, including bones from lions, bears, deer, wild boar, hippopotamus, and wild cattle. Since this wild diet is quite different from what's known from that of other towns on the coast, Doumet-Serhal suspects that hunting here may have been an elite activity, hinting at the possible presence of a king and court in these early days. By the middle of the third millennium b.c., however, Sidon appears to have been abandoned, although the reasons for this are uncertain and there are, as yet, no signs of violent destruction (Lawler 2012: 50).

Burials

The individuals were generally buried in small caves, either natural or artificial, between the Early and Late Bronze Ages in Phoenician cities. The most important materials, which were buried with the body, were jars containing liquids, dippers to draw the liquid from the jars, bowls containing food, the personal belongings of the dead such as weapons, personal ornaments and many other tools (Baramki 1961: 96; Eiselen 1966: 139). Eiselen has classified the Phoenician's tombs into three types. These types, which based on their structures, are as follows:

Rectangular caves: these kinds of tombs are entered from the top by vertical shafts ten to three meter in depth and one to two meter in width.

Arched caves: these kinds of tombs include niches inside the walls for coffins, air holes as communication with the surface above, and square holes in the ground.

Cemented caves: these tombs, which were built of lime, are decorated in Roman, Greek and Christian styles. A number of these tombs also have air holes (Eiselen 1966: 139).

An important cemetery with stone coffins and a temple, which was sacred to the god Eshmun, was found on the outskirts of Sidon during the nineteenth and early twentieth centuries, but relatively little was known about the city centre (Curtis, 2003a). Many burials comprised important amounts of animal bone, including goat, sheep, cattle and other large ungulates.

The graves discussed here, which dated to the Middle Bronze Age (c. 2000-1500 BC) and contained skeletons and a rich collection of grave-goods, were discovered on the site in the third season, in 2001. There is a predominance of single burials during this period, which may reflect an association with the burial traditions, and culture of the previous period. Two kinds of burial have been recognized in this site. The first group consists of bodies, which were laid in graves lined with stones. The bodies of the second group, which were probably of babies or small children, were placed in large jars (Curtis 2003a).

The presence of different types and structures of graves confirms that the site of Sidon was a very important urban society on the Mediterranean coast during the Middle Bronze Age. Nineteen burials (Table 1) were discovered during season 2001, Ogden and Schutkowski (2003) divided them base on burial types, age and sex as follows:

Burial 1: Jar burial, containing bones of a child of 3 to 4 years of age.

Burial 2: Jar burial mainly consisting bones of a child of approximately 7 years. Several skeletal elements were also present from another child of similar age and also from a neonate.

Burial 3: Simple, adult, mid-twenties but there is ambiguous evidence to sex.

Burial 4: Constructed grave containing twelve teeth, a child of approximately 15 months.

Burial 5: Flexed inhumation of an adult male, late 30s, the long bladed of an axe perpendicular to the handle and bones and teeth from sheep and goats.

Burial 6: The simple inhumation of an adult male, in his early thirties, along with the smaller adult, two additional incomplete adults. Substantial pieces of the ribs of a large ungulate were also present among the many fragments of non-human bone.

Burial 7: Constructed grave with multiple fragmented burials. There is evidence for three individuals, two adults, one of whom was probably a middle-aged male.

Burial 8.1: Burial, in the floor, of a child of about 5 years old.

Burial 8.2: Jar burial beneath the floor containing the remains of a child of 12-18 months.

Burial 9: Stone-lined grave containing a child of approximately 3 to 4 years of age. There was also a quantity of non-human bone.

Burial 10: child of 3 to 4 years old, beneath a dish.

Burial 11: Jar burial of infant of approximately 18 months, with an adult mandible and fragment of non-human bone.

Burial 12: Supine burial with axe, male, about 20 years. Pieces of pottery and egg-shaped pebble were also found, along with non-human bones and teeth.

Burial 13: Flexed remains of a child of approximately 5 years of age, with gold and silver artefacts.
Burial 14: Jar burial containing remains of a

Table 1. *Burials excavated in 2001 (From: Ogden and Schutkowski 2003:10).*

Burial	Type	Components	Sex	Age
1	Jar	Partially articulated-most body regions represented	?	3-4 years
3	Simple sand	Cranium, arms, pelvis and upper legs	?	mid 20s
4	---	2 teeth, isolated fractured elements of gracile left arm, hand, leg and foot	?	Adult
5	Rectangular-brick	Fragmented but nearly complete: many elements of non-human bone	M	Late 30s
6.1	Simple sand	Fragmented but nearly complete	M	Early 30s
6.2		Humeri, lower legs and feet	?	Adult
7.1	Constructed grave	Most bones present, but fragmented: skull thick and sutures closed	M	40 years
7.2		Maxilla only	?	7-8 years
8.1	In plaster floor	Articulated jaws and endocast	?	5 years
8.2	Jar beneath floor	Most body regions represented	?	12-18 months
9	Stone-lined	Most body regions represented	?	3-4 years
10	Beneath dish	Most body regions represented: no skull other than 2 deciduous teeth	?	3-4 years
11.1	Jar	Cranium and jaws	?	18 months
15	Jar	Most body regions represented	?	Neonate
16	Rectangular-stone	Originally No 19, renumbered on site as burial 16. most body regions represented	?	8-9 years
17	Jar	Most body regions represented	?	3-4 years
18	Jar	Partially articulated; most body regions represented	?	4 years

juvenile of approximately 13 years. Most regions of the skeleton are represented.

Burial 15: Jar burial containing the remains of a neonate of approximately 38 weeks gestation.
Burial 16: The Flexed inhumation in a stone lined grave of a child of 8 to 9 years of age. Most regions of the skeleton are represented in the extremely fragmented and fragile remains.

Burial 17: Jar burial of the fragmented remains of a child of 3 to 4 years of age.

Burial 18: Jar burial of the fragmented and partially articulated bones of a child of approximately 4 years (Table 1).

The human bones discovered in season 2001-2002 were sent to the University of Bradford for analysis (Ogden and Schutkowski 2003: 1). Due to the nature of the depositional environment during recovery all skeletons suffered from loss of substance and were extremely fragile and fragmented, with evidence of multiple breakages. Postmortem breakage of bones, which had occurred long ago when some collagenous matrix remained, could often be realigned, whereas the many recent breakages of the now collagen-depleted bone were left with heavily eroded breakage surfaces that prevented reassembly of the bone (Ogden & Schutkowski 2003: 1).

Method of collagen extraction

As it has been mentioned above, the general aim of this paper is to examine the diet of the Sidon people during the Bronze Age and also, to attempt to determine which terrestrial, marine, animal and plant proteins were used by this population. In this paper, collagen has been extracted from ribs sample. We analyse bone collagen because its chemistry is well defined, its isotopic composition reflects that of the individual's diet, and the composition of amino acid differ somewhat between species. The method for collagen extraction is developed in 1971 by Longin, and involves the conversion of the protein-remnants to gelatine with the aim of eliminating humic substances and any other contaminants in the process. Since then, it has become clear that this method was not always successful at eliminating such contaminants to the levels required for many dating applications. In 1998, Brown *et al*. modified the original method as to include refluxing in a weak acid solution (0.01M HCL) at lower temperature (58° C) to remove carbonate, phosphates and fulvic acid followed by ultrafiltration. These modifications maximise product yield while minimising the degradation of the extracted protein-remnants, significantly improving the yield of larger peptides as compared to the Longin method. Radiocarbon dating from several bones showed that the ultrafiltration step removes some particulate contaminants usually left in the Longin products, which were of hygroscopic nature. In the modified method the product is non-hygroscopic, so it is easier to handle (Brown *et al*. 1998: 175). Also radiocarbon studies have demonstrated that collagen prepared without a NaOH treatment may have significant contamination with humic acids and other base-soluble substances. Therefore NaOH pre-treatment is highly recommended (Ambrose 1990: 448).

Sampling Strategy

In order to define an optimal method of sample preparation, it is necessary to find conditions, which maximize the dissolution of apatite while minimizing damage to the proteins (i.e., the collagen). In this paper, we therefore used the modified Longin method. The initial stage, rib samples (of high bone turnover) were taken from individuals. It was attempted to clean the selected samples by using air powered powder abrasion. The powders were blasted onto the bone samples to remove the dirt and contamination. After cleaning, the samples were weighed and prepared in batches of ten. For the first ten samples, start mass was between 200-400 mg.

The samples were then put in a weak HCL solution (0.5 M) and left in the refrigerator (approx. 4º C) to demineralise. They were then treated with acid to dissolve the mineral phase of bone. The samples were checked every day and after 8 days the entire first batch was ready to be taken out of the acid. They were then rinsed to neutrality with deionised water three times and prepared for the heating block. The test tubes were filled with deionised water and two or three drops of 0.5 M HCL to obtain a pH 3 for the solution. This allows collagen fibrils to go into solution. The samples were then left in the heating block at 70º C for 48 hours. After removal from the heating block the solution was filtered using Ezee filters to remove larger non-collagen matter and then filtered with ultrafilters to remove particles that are of smaller molecular size than the collagen (Brown *et al.* 1998:172). The filtered samples were left in the freezer at –20º C to freeze for several hours and then were transferred to the -40º C freezer. After being solidly frozen, the samples were transferred to the freeze-dryer for 48 hours. This process turned solid ice to gas by sublimation.

At the end of the fourth stage, the remaining dried substance is pure collagen. It must be weighed and transferred to microtubes as soon as possible, to avoid moisture absorption from the air. Due to poor preservation, the collagen yields were very poor. For the second batch we decided to raise the start mass to between 1000-2000mg. The samples were weighed (0.3-0.5 mg) and transferred into tin capsules and for every ten samples of collagen a standard sample of methionine was also weighed. Finally, they were ready for the mass spectrometer, a Thermo Finnigan Delta Plus XL.

Mass spectrometry

Mass spectrometric methods are the most useful way of measuring isotope abundances. They should not be confused with organic mass spectrometers, which are used to characterize complex organic molecules (Katzenberg 2000: 311). A mass spectrometer separates charged atoms and molecules on the basis of their mass based on their movement in magnetic or electrical fields (Hoef 1997: 21). Isotope ratio mass spectrometers are composed of four components: an inlet system, an ion source, a mass analyzer, and a series of ion detectors (Katzenberg 2000: 311).

The stable isotope analyses are done on mass spectrometers automatically and measure the isotope ratio of a sample and then compare it with the isotope ratio of a standard. The sample and standard are alternately introduced into the source of the mass spectrometer in the form of a gas, through a suitable gas, for example CO_2 for $\delta^{13}C$ and N_2 for $\delta^{15}N$, which is usually analyzed to determine isotope ratios. After the collagen is purified, it is located in a quartz tube. The tube is evacuated and sealed with a flame and placed in a furnace and heated at 1000-1050º C and then slowly cooled (Schwarcz and Schoeninger 1991: 291). When the samples are dropped into the reactor, the helium stream is enriched momentarily with pure oxygen and the sample is oxidized by 'flash combustion' reaction. Complete oxidation of the sample exchanges all organic and some inorganic matters into combustion products. The resulting gaseous products pass through a reduction furnace and a water trap prior to entering the chromatographic column with helium acting as a carrier gas (ConFlo III Operating Manual 05/01).

A database was produced of carbon and nitrogen values from individual samples of bone collagen extracted that were submitted for reconstruction of diet of ancient Sidon people. The carbon values are presented in the Table 2 and plotted in Figure 2. They have ranges between –19.65 and –17.95 ‰ indicating protein from terrestrial food, typically feeding on C_3 plants, including cereals such as wheat, barely, rice, lentils and milk products. The results supported the existence of C_3 plants, which were consumed by individuals consistent with the expected plants found in Levant . Also, the $\delta^{13}C$ value from one faunal sample show a strong C_3 signal, and this is likely due to consumption of C_3 plants. Surprisingly, traces of marine products such as fish, shellfish have not been seen in these individuals.

The nitrogen values, which range between 6.2 and 8.45 (except infants) are presented in Table 2 and plotted in Figure 2. The $\delta^{15}N$ value of an organism is about 2-4 ‰ higher than the food, which is consumed. Therefore, if $\delta^{15}N$ value terrestrial herbivores are approximately 3 ‰, terrestrial carnivores are approximately 2- 4 ‰ higher, at about 5-7 ‰. For omnivores like humans the $\delta^{15}N$ values will tell us if they are behaving more like herbivores

Table 2. *Results and details of the isotope analysis*

Name	Mass(mg)	Burial	$\delta^{13}C$	$\delta^{15}N$	C/N	Age	Sex
Si 4	1009	15	-18.4	9.55	3.24	neonate	-
Si 5	1031	8.2	-18.4	10.8	3.33	12-18 m	-
Si 2	1020	11.1	-17.9	9.6	3.3	18 month	-
Si 12	1054	4	-19.25	7.55	3.25	adult	-
Si18	1013	17	-19	8.4	3.35	3-4 years	-
Si 19	1067	5	-19.3	7.95	3.25	late 30s	-
Si 21	2021	19	-19.3	6.2	3.37	8-9 years	-
Si 22	1057	3	-19.2	6.5	3.22	adult	-
Si 24	1070	25	-19.1	7.7	3.25	adult	-
Si 25	1009	23	-19	8.15	3.31	adult	-
Si 28	1050	22	-19.6	7.8	3.27	adult	-
Si 7	1016	6.1	-18.9	7.45	3.23	early30s	Male
Si 8	2065	6.2	-19	7.5	3.22	adult	-
Si10	330	10	-18.9	7.45	3.41	3-4 years	-
Si11	430	7	-19.4	6.6	3.49	adult	Male
Si13	282	7	-19.15	6.25	3.42	adult	Male
Si14	267	9	-19.5	7.95	3.45	3-4 years	-
Si17	435	8.1	-18.8	8.45	3.46	5 years	-
Si1	257	1	-18.7	7.5	3.38	3-4 years	-
Si23	464	18	-19.6	7.55	3.51	adult	-
Si6	475	5	-19.8	3.8	3.56	sheep/goat	-

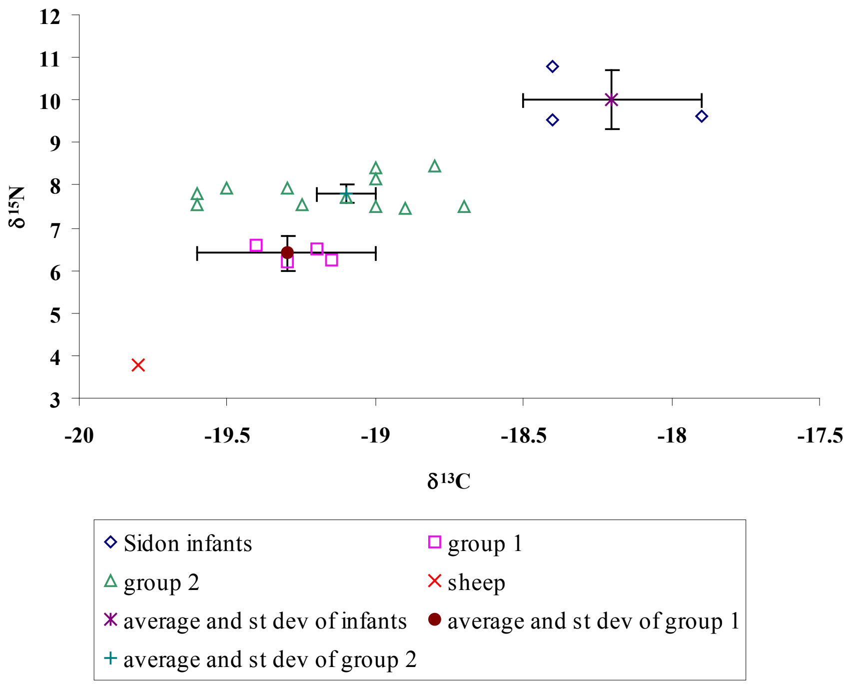

Fig 2. *Result of the isotope analysis (group 1: mostly terrestrial plant base, group2: mixture of both plant and animal proteins)*

(consuming plant protein) or carnivores (consuming animal protein). On this basis, in the present paper we can classify individuals in two groups, namely those with evidence of a mostly terrestrial plant base and those with evidence of a mixture of both plants and animal proteins. The samples of four individuals, Si_{11}, Si_{13}, Si_{21} and Si_{22} (group I) show that they consumed plant protein, while the second group of individuals, which include Si_{12}, Si_{18}, Si_{19}, Si_{24}, Si_{25}, Si_{28}, Si_{7}, Si_{8}, Si_{10}, Si_{14}, Si_{17}, Si_{1}, Si_{23} (group II), consumed both plant and animal proteins. These individuals probably used animal protein (meat and milk) from herbivores that were mainly consuming C_3 plants. According to the $\delta^{15}N$ values of these individuals and $\delta^{15}N$ value of the only animal sample, Si_{6}, which was probably a sheep or goat, it can be assumed that cattle protein was not a significant part of the diet of these individuals (Fig. 2), however, more faunal samples are needed to indicate which animal proteins were likely used by the people of ancient Sidon. The University of Aix-en-Provence in France has undertaken plant and animal analysis.

There is not sign of marine proteins from $\delta^{15}N$ values (usually >12) in these individuals. The $\delta^{15}N$ values can also determine age of weaning in this stage. Three samples, Si_{4}, Si_{5}, Si_{2} were neonate and two infants with $\delta^{15}N$ values 9.55, 10.8 and 9.6 respectively, indicate that they were still breast-fed. As shown in Figure 3, individuals are also divided into three age groups such as infant, juvenile and adult. Three of them, namely Si_{2}, Si_{4} and Si_{5}, are infants that in comparison with the other individuals are situated rather high and to the right in the area of the graph. The only source of dietary nitrogen in the breast-feeding infants is through the milk of their mothers. As the isotopic composition of the infant's collagen directly related to the breast-milk, therefore $\delta^{15}N$ values in infants are 2-3‰ higher than their mothers diet (Fig. 3) (Richards *et al.* 2003: 73; Schurr 1998: 329).

As has been shown in Table 2, the ages of these infants ranged between 1-18 months, therefore it can be assumed that infants were still breast-fed and their weaning may have occurred after 18 months, because when the children are consuming similar food to the adult, their $\delta^{15}N$ values are lower or equivalent to the adult values (Richards *et al.* 2003:74), while the $\delta^{15}N$ values of the above infants are higher than their mother's at least until 18 months after their birth.

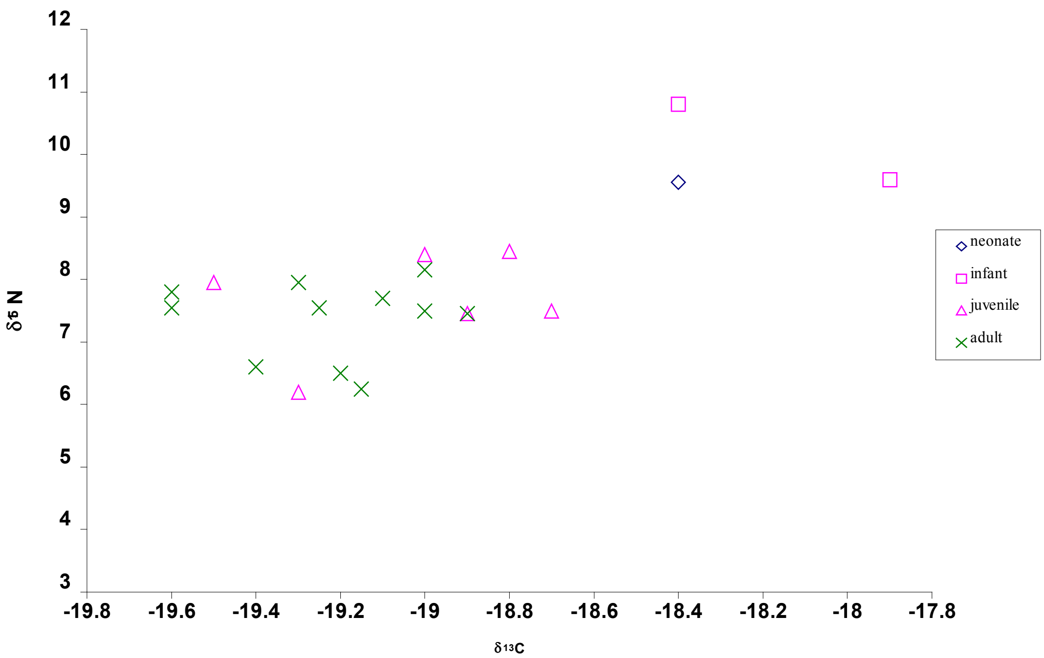

Fig 3. *Results of the isotope analysis according to age of individuals.*

Discussion

The stable isotope analysis of the bones from Sidon has provided preliminary indications of human diet of this important site during the third millennium BC (Fig. 2). As shown in this figure, we are able to draw some conclusions about the dietary patterns of the Sidon people. It appears that there were no significant differences they all had generally the same diet. The $\delta^{13}C$ values indicate that there were C_3 plant input in the diets of these individuals, as well as protein originating from herbivores such as goat and sheep. No clear evidence of C_4 plants or marine products has been seen in these samples.

Evidence of C_3 plants was also discovered from Syria (Amouq A) during the Middle Bronze Age, and indicated the cultivation of wheat, emmer and hulled barley, C_3 plants similar to those of the Sidon. More evidence, including C_3 plants and olive tree pollen, has been discovered from Jericho in Palestine during the Early Bronze Age (Renfrew1973: 201). The evidence of olive tree pollen discovered from Palestine (Jericho) is dated to the Early Bronze Age (Renfrew 1973: 201), it is comparable with olive tree pollen of Sidon in the Middle Bronze Age. Therefore it may be assumed that there were commercial contacts between Sidon and those sites in other parts of Levant, Mesopotamia in the east, and Greece and Egypt in the west. As this site is located in the eastern part of the Mediterranean, it may be also assumed that Sidon was a centre of production for items such as cedar wood, and an intermediary center for long-distance trade. Compared to other areas of Eurasia, land-based vegetation history from the eastern Mediterranean is relatively poor. Dry climate and the frequency of limestone bedrock are not favorable to bog development and hence the preservation of pollen grains in the sedimentary record. This relative absence of anoxic basins is a clear limiting factor in many areas of the Levant and the Near East, and there have been very few serious land-based studies of Holocene vegetation change and anthropogenic impact (Marriner *et. al* 2004: 86).

Moreover, the Figure 3 shows that some of the juveniles and adults had generally the same diet with protein coming from terrestrial food, typically C3 plants. The most surprising point is that no isotope indication of any fish, shellfish and C4 plants was found in the diet of the analyzed individuals. As stated above, two small rivers surrounded the harbor of Sidon during the Bronze Age (Markoe 2000: 199). Therefore marine food could potentially have been one of the most important sources of the diet of the inhabitants of Sidon, while based on the present analysis no evidence of this food source was seen of this site. It may be possible, but unlikely, that these skeletons belonged to trader people who came from the east. In fact, this site was a commercial port during the third millennium BC, which could be supported by evidence discovered from the site. A number of evidence supporting, was discovered from burials. For example a long-bladed axe, which is widely distributed throughout the coastal Levant and seems to be restricted to a relatively short time-span during of the Middle Bronze Age, was discovered from burial 7 (Si19). A knife, with a distinctive curved cutting edge, which functioned as a weapon, was also found in burial 4 (Si12). This knife appears only in a minority of tombs, such as at Tell el Daba'a in Egypt. A Minoan cup imported from Crete also attests to long distance trade, as do a few Egyptian imports. It seems that from the beginning of the third millennium BC the region of Syria-Palestine gravitated around great coastal cities, which maintained intensive political and commercial relations (such as trade of wood and oil) with Mesopotamia and Egypt. During the Bronze Age these cities became the principal intermediaries in trade between the great Syrian states and the Nile valley (Figure. 4). In exchange for products such as Elba metal, fabric, perfumes, wine, oil, and ewes and also, Byblos exported linen and, in particular precious metals, such as gold and silver. As can be inferred from certain Mesopotamia texts and from archaeological finds, Byblos and Ugarit also maintained trading relations with Crete, Mari and Ur during this period (Aubet 1987: 20). Also during the Late Bronze, Aegean imports to Sidon were more frequent. A large number of Mycenaean sherds and terracotta, as well as the head of a small figurine with a psi shape, were found (Carayon et. al 2011/2012: 11).

Jansen (2002) states that traders carried out lapis lazuli to the Indus Valley overland and it was then

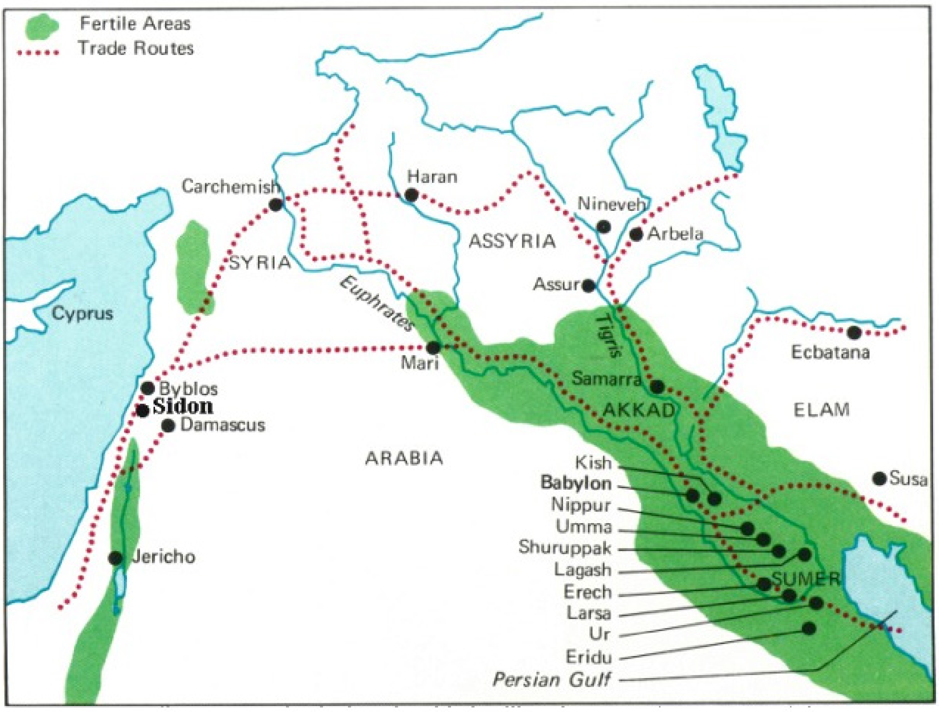

Fig 4: *Long-distance trade routes during the third millennium BC (Bronze Age) in Near East (From: Bottero 1973: 25).*

shipped to the Arabian Peninsula and possibly to the last destination in Egypt by maritime route. As the discovery of many items such as seals, beads and ceramics in Mesopotamia testify to the interaction between Mesopotamia and the Indus Valley (Possehl 2002: 37), further excavations and the discovery of more evidence may link the port of Sidon to the East, especially Mesopotamia and the Indus Valley.

Going back to the plot of the isotopic values in Figure 3, we can see that three individuals are slightly different. These are Si_4, Si_5 and Si_2, who are situated more to the right and higher within the plot than the rest of the samples in δ^{15} values. They are infants aged 1-18 months. Results, the high δ^{15} N values in these infants indicate that they were still breast-fed. As the isotopic composition of an infant's collagen directly relate to that of the breast-milk, δ^{15}N values in collagen rise during breastfeeding to give values of 3-4 ‰ greater than maternal collagen. It may be assumed that weaning occurred between the ages of 18 months and 3-4 years old. because after weaning, when the children are consuming similar food to the adults, δ^{15}N values are lower or equivalent to the adult values. It can be seen in the samples of Si_{18}, Si_{14}, Si_{10} and Si_1, which have been aged between 3 and 4 years (Fig. 5), also have δ^{15}N values are similar to adult, or lower than adult. Therefore weaning age probably occurred between these ages. A potential problem with using δ^{15}N values in this way is that these individuals may have died in infancy of unknown causes. As δ^{15}N

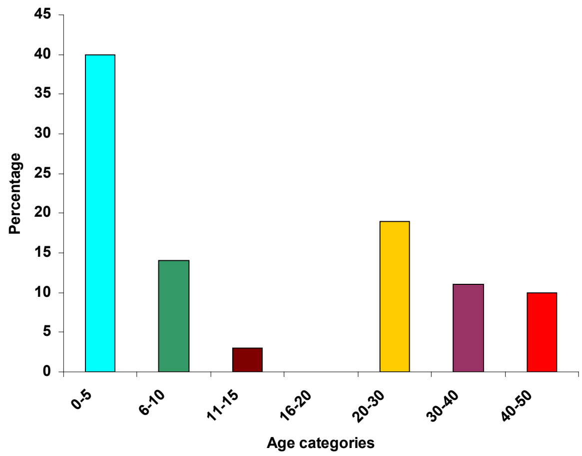

Fig 5. *The age distribution at Sidon, Season 2001 (From: Ogden and Schutkowski 2003:10)*

may be raised in situations of nutritional stress, it may not possible to separate the trophic effect of breast-feeding from cause of death in some cases. One way to avoid the problem of analyzing bones from individuals who died in infancy or early childhood is to analyze tissues that were formed early in postnatal development that can be isolated from older children and adults. Analysis of nitrogen isotopes in dentine collagen and carbon isotopes in enamel apatite can provide information about nursing and weaning for individuals who survived into at least late childhood. (Katzenberg 2000: 319).

Conclusion

In conclusion, it may be stated that the three primary objectives set at the beginning were achieved. The first goal was to obtain general information about the diet of the individuals buried at Sidon. This was achieved with the use of ^{13}C and ^{15}N stable isotopes, which were analyzed from the human bone collagen. The preparation of the samples and the process of their analysis demonstrated that the preservation of collagen was very poor, due to climate and soil conditions. The $\delta^{13}C$ and $\delta^{15}N$ values inform us that the protein of the diet came from a terrestrial plant base (C_3 plants) and mixture in plant and animal products. These values also indicate that herding animals such as sheep or goat provided the animal protein in the diet of this ancient site. There have been no C_4 pathway plants as a food source, nor any fish or seafood.

The second goal was to explore whether there were dietary differences between individuals of different ages. According to the isotopic values, we are able to divide individuals in three age groups, including infants, juveniles and adults. Infants, who were breast-fed, have been aged between neonates to eighteenth months. Juveniles were aged between 3-4 and 8-9 years old (Table 2). The $\delta^{13}C$ and $\delta^{15}N$ values show that adults and juveniles had relatively the same diet. The high $\delta^{15}N$ values for infants answers our last objective and determines the possible age of weaning. The ages of these infants ranged between 1-1/5 years old (neonate-18 month), therefore it may be assumed that they were still breast-feeding and their weaning may have occurred after these ages. It is difficult to be more precise about the timing and duration of weaning because of uncertainties over collagen turnover rates in the bones of these young people. Specific work on tooth dentine $\delta^{13}C$ and $\delta^{15}N$ values will allow us to define further the age of weaning in this population. According to the result of this analysis, numbers of deaths in infancy and early childhood are higher than in the adolescence (Fig. 5), Since $\delta^{15}N$ values may be elevated in situations of nutritional stress, analysis of nitrogen isotopes in dentine collagen and carbon isotopes in enamel apatite can provide information about nursing and weaning for individuals, who survived into at least late childhood.

The stable isotope analysis of human and faunal remains from Sidon has provided preliminary indicators of the adult human diet at Sidon for the individuals discussed. Although the previous archaeological studies allow us to have a general and limited understanding of this site, further work will allow archaeologists to identify other important aspects such as social organization, palaeoenvironment, trade and economy of the above mentioned settlement. Unfortunately, due to the nature of the depositional environment, the bones were extremely fragile and fragmented and it was not possible to provide a reliable assessment of sex in all material based on morphological features. Biomolecular techniques, such as PCR (Polymerase chain reaction) method may help in the determination of sex of these individuals. PCR is the most sensitive technique used for most ancient DNA work. PCR is an enzymatic reaction that copies a distinct sequence of DNA many times.

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Finally, the combination of stable isotope and trace element analysis in bioarchaeological research should be generally beneficial. Trace element analysis complementally provides more information about dietary habits of the people buried in Sidon. Further new and important additions have emerged about the history of Sidon, the archaeology of the Lebanon and life in ancient times.

Acknowledgment

I would like to thank and show my gratitude to Professor Mike Richards, Professor Holger Schutkowsky and Dr. Marianne Schweich for sharing their precious time with me during the course of the lab work of this project.

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