DIETARY ANALYSIS OF CLASSIC MAYA FROM CENTRAL BELIZE

Tiyas Bhattacharyya

Thesis for the
Degree of Bachelor of Arts
in
Anthropology

College of Liberal Arts and Sciences
University of Illinois
Urbana-Champaign, Illinois

2017

Abstract

In the summer of 2016, house mounds and one large mound with a plaza in the hinterlands northeast of the ancient Maya city center of Yalbac were partially excavated as part of the Valley of Peace Archaeology project salvage program. Based on ceramics recovered from the mounds, the settlement was occupied around AD 700-1000. Three of the residential mounds contained burials. Dental and bone samples were collected from 11 individuals for stable isotope analyses of diet. Additional excavations during summer 2016 took place nearby at Cara Blanca Pool 1, a ceremonial pilgrimage site built and visited around AD 250-850. Samples from two individuals interred in Structure 3 at Cara Blanca Pool 1 were collected for diet analyses. Carbon isotope analysis of tooth enamel apatite shows that the diet of these individuals was dominated by maize. Nitrogen isotope analysis of the bone collagen shows that the diet of these individuals was mainly comprised of terrestrial animals. Based off of the analysis of the apatite and collagen, it seems that there is little variation within the diets of these individuals.

Introduction

The Maya are the indigenous people living in current day Belize, Guatemala, and Mexico. In precolonial times the Maya had a complex and stratified society. Each Maya center had its own ruler. Within this paper I am setting Yalbac as being the local center for the area that was excavated in the summer of 2016. The Maya civilization consisted of a type of homogeneity that allowed for the civilization to be secure while still being spread out over a stretch of land coined as "Mesoamerica" (Coe and Houston 2015). While there was some form of cultural cohesion there, the Maya culture included various languages that were related, but not intelligible to Maya who spoke different languages.

By the Late Preclassic period (300 BCE-250 CE) the temples, tombs, and pyramids with frontal stairways associated with the Classic period Maya were already built around great plazas (Coe and Houston 2015). Literacy and the importance of recording important dates, especially in reference to the rulers, became more prominent at the eve of the Classic Maya period (Coe and Houston 2015). The introduction of the Long Count calendar ushered in the age of the life and times of rulers and the royal house in general. The Long Count calendar became a preoccupation in terms of the writing and recordings that were made (Coe and Houston 2015).

Social inequality was prevalent throughout Maya iconography and differences in the scale of households. Another way to study the social inequality that is present archaeologically, is through differences in diet. Diet can provide insight in to how strict the structures and hierarchies actually were, especially in terms of access to different kinds of food. While archaeozoology, archaeobotany, residue studies, and pottery analysis can provide information about diet and their relationship to social hierarchies, human skeletal remains can help draw a clearer picture of an individual's place within this structured society. When focusing on human skeletal remains, stable isotope analysis of bones and teeth can provide quantitative information on the relationship between diet and status. In this paper, I focus on the dietary habits of Late Classic period (250 CE-925 CE) individuals recovered from house mounds located in the hinterlands of the ancient Maya city center of Yalbac and Structure 3 at Cara Blanca Pool 1, a site that is thought to be a major pilgrimage destination during this time. Isotopic analyses of tooth enamel, tooth roots, and bone fragments collected from a total of 13 individuals were completed.

Site Context

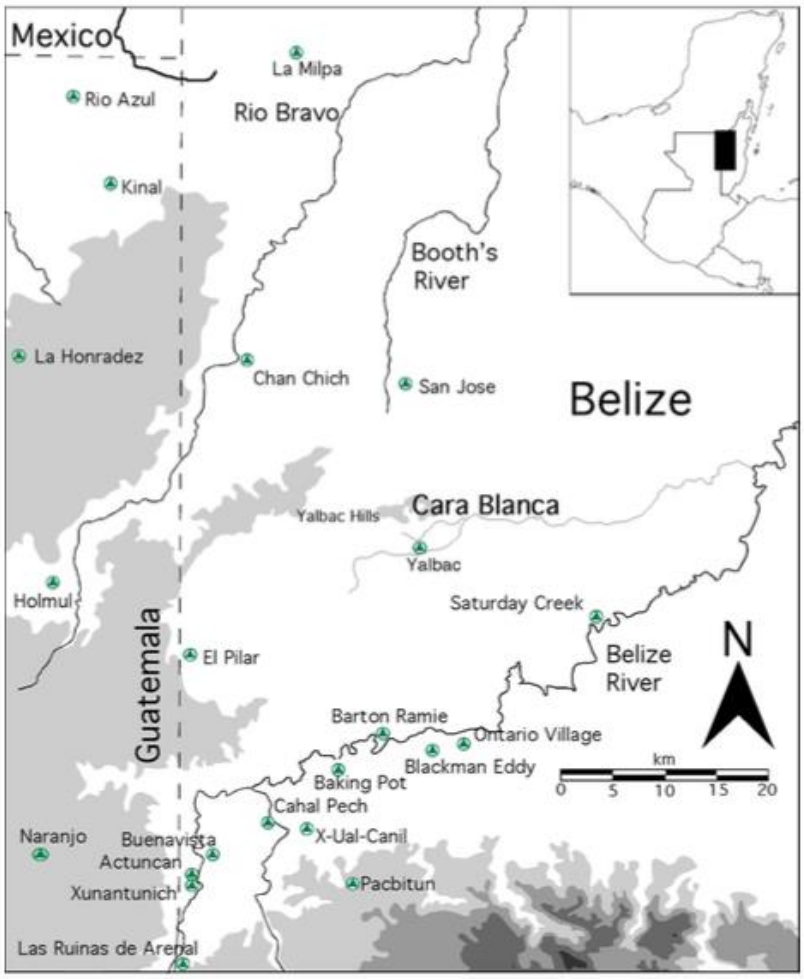
During the 2016 field season, the Valley of Peace Archaeology program, under the direction of Dr. Lisa Lucero, excavated at two different locations in central Belize, north of the country's current capital of Belmopan.

In 2010, Hurricane Richard caused great damage to the forest near the center of Yalbac, resulting in Yalbac Ranch selling a lot of land to the Spanish Lookout Corporation (SPLC) (Lucero 2017). SPLC is an agricultural business and because of this shift in ownership, some of the ancient Maya settlement areas around Yalbac have been converted into agricultural fields. Because these sites were within agricultural fields, salvage archaeology was conducted in order to excavate as many house mounds as possible before they were further damaged and erased by plowing. The excavated residential mounds that contained burials were located in two different agricultural fields, Pool 7 Mound Field (MF) and MF 4. The ceramics recovered from the mounds in Pool 7 MF and MF 4 date to around AD 700-1000. Ceramics are commonly found within Maya archaeological sites and can be used for dating based on the site stratigraphy and known ceramic types (Coe and Houston 2015). Based on this data, the house mounds we excavated date to the Classic Maya period. Because the locations excavated are in the hinterlands around the center of Yalbac, analyzing the skeletal samples could help better understand the populations outside of the city center and their status in society. This would help bring us closer to understanding the possible daily lives that were led by these individuals and their interaction with Yalbac.

The 2016 field season also continued work started at Cara Blanca Pool 1. The Cara Blanca region in Belize consists of a line of 25 pools sitting at the base of white limestone cliffs.

Pool 1 is located approximately at the center of this string of 25 pools (Fig. 2) and is thought to have been a pilgrimage destination.

Fig.1 Location of Yalbac and Cara Blanca, Courtesy of VOPA



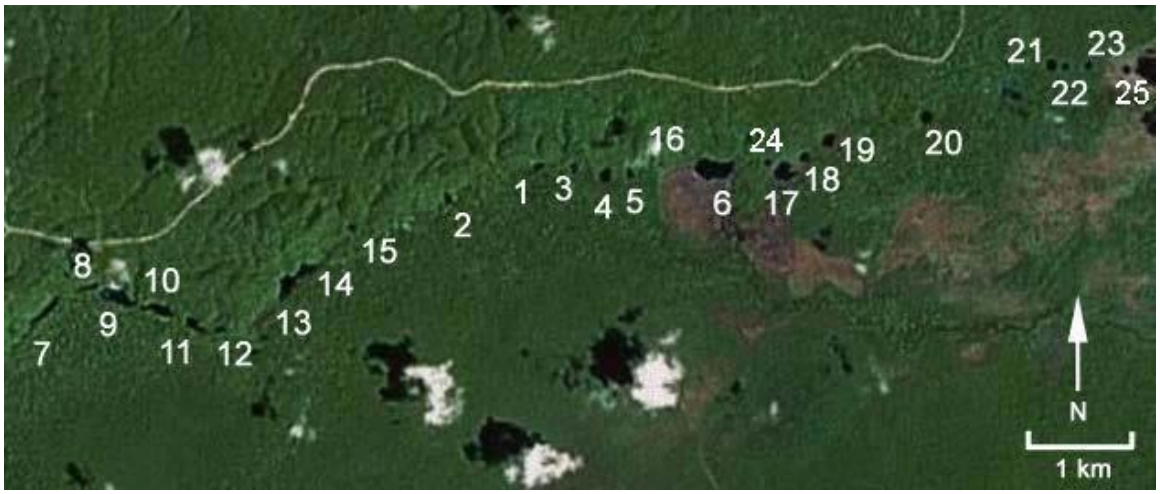


Fig. 2 Location of Pool 1 in relation to other Cara Blanca Pools. Courtesy of VOPA

Previous excavations at Pool 1 have identified a water temple and this season a sweat bath was also identified. While excavating the Cara Blanca Pool 1 site, more traditional archaeological methods were used. The 2016 field season focused on the excavation of Structure 3. The Cara Blanca Pool 1 ceramics date to around AD 250-850, placing this site within the Late Classic period as well. Being near water shows the structure's importance because of how the Maya viewed and interacted with water within their ceremonies, seeing it as a portal to the underworld (Larmon and Amin 2017). The placement of the burials within Structure 3 could imply a type of sacredness, whether it be that the individuals were important or their deaths and burials were of sacrificial means. Therefore, if there are major differences between the individuals found here versus the individuals interred in the house mounds more can be learned about who these individuals were within a societal context.

Diet Analysis

The analysis of stable isotopes has become a major way of reconstructing ancient human diet (White and Schwarcz 1989). Tooth enamel apatite contains carbonate (CO_3) whose carbon and oxygen stable isotope ratios reflect those of ingested food and water. In some cases, isotopic analysis can be used to interpret migration patterns as well (Freiwald 2011). Looking specifically at carbon stable isotope ($\delta^{13}C$) ratios can reveal if the individual ate mainly C_3 or C_4 plants. The analysis of an individuals tooth apatite who ate a C_3 based diet would have an average $\delta^{13}C$ value of -26.5‰ and for a C4 diet the average $\delta^{13}C$ value of -12.5‰ (Ambrose 1993). "Most archaeologists believe that maize was the major crop grown in Maya prehistory" (White 1989:452). Maize is a C_4 plant and therefore it can be inferred that it was a common food source. Therefore, if there were any individuals with $\delta^{13}C$ values that showed that they were not on a C_4 based diet then there could be implications on social status of the specific individuals being different than the individuals whose tooth enamel shows that they did follow a C_4 based diet. This is because it would illustrate how much access was granted to the people outside of Yalbac.

When analyzing collagen samples of the bones of the individuals found, the values of the stable isotope $\delta^{15}N$ ratios can also help further analyze the diets of the individuals. Looking at $\delta^{15}N$ values would help reveal the access each individual had to meat and it would show the type of meat in each individual's diet. If the $\delta^{15}N$ values are between 17‰ to 20‰ then the individuals would be seen as living off of predominantly marine life, whereas if the values are between 6‰ to 12‰ then they would show that they were living off of terrestrial life (Pollard & Heron 2008). Analyzing the diets of the individuals of these sites would allow comparison in diet between the individuals buried in the MF sites and the individual from the CB site. This would help better define the social strata of the people amongst the outskirts of the city center, helping gain a clearer picture of the past. Therefore, in this paper I hope to answer the questions revolving around diet and show how this helps understand the individuals found and from them the society that they lived in.

Materials

In total there were eight mounds that were excavated from Pool 7 MF and MF4. Fourteen individuals were recovered from three of these mounds and 3 individuals were found in at CB Pool 1 Str. 3 (Carbaugh 2017). The samples that I will be using are from 12 individuals from Pool 7 MF, MF4, and Cara Blanca Pool 1 Str. 3. Based off of the ceramics found around the individuals within the sites the 11 individuals excavated from the Pool 7 MF and MF4 are dated

around 700- 900 CE. The CB Pool 2 individuals are dated to be approximately from 250-850 CE based off of the ceramics recovered on top of the plaster floor above the burial.

Preservation of the bone amongst the burials was poor. The teeth were all intact and preserved the best due, to the low organic content. The roots of the teeth were not all preserved well. Some had more degradation than others but none of them were in that much of a different condition than the rest. The long bones that were used were in various states of preservation, none of them well preserved. Age and sex estimates were made based off of established standards for skeletal analysis (Buikstra and Ubelaker 1994). Dental development and attrition was the primary means of estimating age. Sex could not be estimated for the majority of the individuals due to poor preservation of the skeletal remains.

For each individual we tried to collect two teeth. One of the teeth we tried to get from each individual was an earlier tooth and the other one was a tooth developed later in their life. This was not always possible due to the fact that preservation was very poor. The reason behind attempting to get both kinds of teeth is because the first molar forms after weaning but while the individual is still a child. The third molar, on the other hand, is develops when the individual becomes older. Collecting and analyzing both kinds of teeth would help give an insight into how the individual's diet changed between the two periods presented through the teeth. The changes in diet could have many implications such as whether the individual moved, his or her status changed, or even his or her diet changed being linked to the aging. Bone on the other hand indicated the diet of the individual closer to their time of death, which limits the amount of knowledge of everyday life that can be gained. Therefore, collecting both teeth for as many individuals we could helped gain a clearer understanding of diet throughout an individual's life versus just a section of their life.

Methods

The tooth and bone samples that were used for apatite analysis were prepared using methods based on Balasse et al. (2002). The tooth samples were prepared at the University of Illinois in the Environmental Isotope Paleobiogeochemistry Laboratory.

First the enamel samples were prepared. The surfaces of the teeth samples were cleaned using a carbide drill. Then each tooth was sonicated until the distilled water that it was sonicated in was clear after sonication. After each tooth was cleaned it was placed in the desiccator to freeze dry overnight. Next, the enamel crown of the tooth for each sample was drilled with a diamond burr drill bit, making sure to avoid the dentine. To avoid cross-contamination, the drill bit was cleaned between each sample. To clean the drill bit 1 M HCL was used and then it was sonicated while in distilled water. After this a Kimwipe was used to dry it off before it was used for the next sample. The work space and microscope stage were cleaned thoroughly with a Kimwipe and ethanol. The amount drilled weighed around 15mg (0.015g). After drilling each sample, the enamel powder was put into a 1.7 ml plastic pre-weighed microcentrifuge tube and weighed. Then the empty tube and tube plus sample weights were recorded in the lab notebook.

When all the drilling was completed each tube was filled to 1.5 ml line with 50% Clorox (2.63% NaOCl) solution. This step removed most organic matter in the tooth enamel that could interfere with the next treatment step. Samples were vortexed for about 10 seconds to mix, then left open in a fume hood, loosely covered with a sheet of aluminum foil to protect from dust deposition. The following day the tubes were vortexed and centrifuged and a micropipette was used to remove the Clorox. Samples were then rinsed with distilled water 4 times. In order to

prevent cross-contamination the pipette was flushed twice with distilled water between each sample, and pipette tips were replaced after half of the samples were treated.

Then 0.1 M acetic acid was added to each sample (0.1 ml per 1 mg of sample). After exactly 4 hours the samples were rinsed to neutrality as described above. The tubes were then left open, covered with a foil sheet and but into the freezer for about ½ hour. Samples were then put into the desiccator right away to freeze dry for at least 12 hours. Dry weights of tubes were recorded in order to calculate weight % remaining after pretreatment was calculated. Samples were then analyzed on the Kiel II autocarbonate device interfaced with the Finnegan MAT 252 isotope ratio mass spectrometer at the Illinois State Geological Survey mass spectrometry laboratory.

Tooth root and bone samples were also prepared for apatite analysis. First, the tooth root and bone samples were prepared. The tooth roots were cut off from the crown using a carbide drill. Then a mortar and pestle was used to gently crush the roots. After each tooth root was crushed they were put through a collection of sieves. The bone samples were also crushed using the mortar and pestle and then the sample was passed through the sieves as well. The samples were made small enough to pass through the 0.5 mm fraction sieve. Once that was achieved tooth root samples from the sieves >0.25mm-pan were kept in different plastic microcentrifuge tubes depending on the size. Each tube was labeled according to the sieve the sample inside it was taken off of. The tools and work area were cleaned thoroughly between each sample.

For the apatite analysis the samples that were greater than 63 μm and less than 117 μm were used. First empty centrifuge tubes, with the lids off, were weighed and the weights were recorded. After that a small piece of weigh paper was torn. About .02-.05 gm of each of the samples that were greater than 63 μm and less than 117 μm was put onto the weigh paper. Then the ground up bone was put into 50 ml of centrifuge tube. Then the filled tube was weighed and the weight was recorded. The filled tube was then placed on a triple beam balance and the weight was set to 20 grams more than the tube plus beaker weight. Then about 20 grams of 50% Clorox solution was put into the tube. Every four tubes were weighed to about the same weight following this process. The tubes were then placed in a stand in the fume hood over night and they were covered with a sheet of foil.

The next morning the samples were centrifuged, then decanted with the 50% Clorox solution. Then the tubes were filled with distilled water, vortexed, centrifuged, and then decanted. This process was repeated four times. After the fourth time the 20 grams of 0.1 M acetic acid was weighed into the tube. The samples were then vortexed then the tubes were placed on a vacuum manifold and pump until tubes bubbled. After five to ten minutes the vacuum and pump were released again and this was repeated four times for each sample. After each sample finished with this process they were centrifuged and the acetic acid was decanted. Twenty grams of distilled water was added to each tube and then the samples were vortexed, centrifuged and decanted. This was repeated four times. After the fourth time the remaining distilled water was micropipetted out, while making sure not to pipette out the sample. The micropipette tip was rinsed three times in distilled water between each sample. The tubes were then left in the freezer for one hour, with a sheet of foil loosely covering them. The samples were then placed in the freeze dryer for at least 24 hours. Then the samples were weighed the weight of the dry tube was recorded and apatite yield was calculated. After this the samples were taken to the Illinois State Geological Survey to have them run on the mass spectrometer.

Tooth root and bone samples that were used for collagen analysis were prepared using methods based on Ambrose (1990), as revised in Hu et al. (2006). These samples were prepared

at the University of Illinois in the Environmental Isotope Paleobiogeochemistry Laboratory as well.

The samples that were prepared for the apatite analysis of the tooth root and bone were used for collagen analysis as well. The bone powder used for collagen analysis included the amount that was within the >0.50 mm fraction. About 1.0 g of the bone powder was put on to weigh paper. If more bone was needed than it was added from the next largest size. The weight of the sample was then recorded. Then filter funnels were labeled with tape to help differentiate between the samples during the purification process. Each funnel was filled with a very loose clump of glass wool. This was done so that the bone sample could be distributed equally and not clog the funnel during the purification process. After this the bone was spread evenly on the glass wool.

About 50 ml of 0.2 M HCl was added to the filter funnels and it was stirred with a clean glass rod whenever it got clumped. Then the samples were loosely covered with an aluminum foil and left to stand overnight. The funnels were then drained and the HCl was replaced twice daily until demineralization was complete. Once each sample finished this process, it was rinsed to neutrality by being drained 10 times with distilled water. After each sample was rinsed, about 50 ml of 0.125 NaOH was added to each funnel. Then the samples were once again covered with aluminum foil and left to stand overnight. The next day the samples were once again rinsed to neutrality with distilled water for 10 times. After being rinsed about 40 ml 10^{-3} M HCl was added to each filter funnel. The liquid level was then marked on the glass with a sharpie.

The samples were then covered with foil and placed in a gravity drying oven at about 65-70°C for about 5 hours. After the 5 hours the samples were removed from the oven and 100 µl of 1 M HCl was added to the filter funnel and the evaporated liquid was replenished with 10^{-3} M HCl. Then the samples were returned to the oven to continue to evaporate until only a small amount of liquid was left. Beakers were placed under funnels that were leaking.

The hot solution was then drained into an Erlenmeyer flask. Tape from the funnel was transferred to the flask that the sample was being drained into. In order for the solution to be drained a rubber stopper was then placed on each flask and the funnel stem was put into the stopper. A vacuum hose was attached to the side nozzle of the flask and turned on full. The top and sides of the funnels were rinsed with a little bit of distilled water and the bottom of the funnel was rinsed as well. Then the solution was pumped until bubbles stopped and the funnels were completely empty. The flasks were then placed in the oven, while uncovered, at about 65-75°C to condense the solution. This was then left overnight.

The empty 20 ml scintillation vials were weighed without their caps on. The solution within the flask was then transferred into the vials. The flasks were rinsed with distilled water and swirled within the flask. This was then added to the vial as well. The vials were then put into glass beakers which were then returned to the oven and left uncovered, so as to let the solution evaporate. They were then left in the oven overnight at 65-75°C. The next day thee vials were put into the freezer while loosely covered with foil for about one hour. Then the vials were placed in a freeze dryer for about 48 hours. The weights were then recorded and the collagen concentration and yield were calculated. The samples were then taken to Illinois State Geological Survey mass spectrometry laboratory to have the samples run on the Elemental Analyzer.

Results

In Table 1 carbon isotope results are matched up with the individuals and their sites, burials, age, sex and type of tooth. The highest 13C value is -4.00‰ and the lowest is -8.90‰.

The individual with the highest 13C value is from Pool 7 MF site Mound 4, Burial 1 (BU1), Individual G. This individual was around 3-4 years old and the tooth the 13C value came from a Deciduous right maxillary molar (Rdm^2). The individual with the lowest value is from Pool 7 MF site Mound 1, BU2, Individual A. This individual was around 16-22 years of age and the tooth this value came from was a Left maxillary third molar (LM^3). The 13C values all consistently support the idea that everyone ate a C4 based diet.

In Table 2 oxygen isotope results are matched to the same individuals. The use of different water sources is what causes the variation within the 18O pdb values (Freiwald 2011). The highest value is -1.45‰ and the lowest values is -3.44‰. The highest 18O pdb value is from the same individual whose enamel produced the highest 13C value. The lowest 18O pdb value is from MF4 Mound 1, BU5, Individual A. This individual was 15 years old and the tooth that this value came from is a LM^3.

In Table 3 the % C4 in each individual's diet is shown. The percentage is compared with the %C4 in the whole diet of the individual found through the analysis of the enamel of their earlier teeth to the percentage found within their whole diet based off of the analysis of their later tooth. This helps display the importance of maize within the diet of the individuals that were found.

Table 1. 13 C Results for tooth enamel

Location	Mound	Burial	Individual	Age	Sex	$\delta^{13}C_{VPDB}$ (dm2) (‰)	$\delta^{13}C_{VPDB}$ (P1) (‰)	$\delta^{13}C_{VPDB}$ (P2) (‰)	$\delta^{13}C_{VPDB}$ (M1) (‰)	$\delta^{13}C_{VPDB}$ (M2) (‰)	$\delta^{13}C_{VPDB}$ (M3) (‰)
Pool 7 MF	4	1	A	Young Adult (18-24 years)	Male	-	-	-	-6.4	-	-7.3
Pool 7 MF	4	1	B	Mid Adult (35-40 years)	?	-	-	-7.6	-	-	-
Pool 7 MF	4	1	C	Adolescent (15-20 years)	?	-	-	-	-5.8	-	-
Pool 7 MF	4	1	D	Young Child (3-4 years)	?	-6.4	-	-	-	-	-
Pool 7 MF	4	1	E	Adolescent (12-15 years)	?	-	-	-	-5.1	-6.0	-
Pool 7 MF	4	1	F	Adolescent (16-20 years)	Female	-	-	-	-5.4	-	-6.4
Pool 7 MF	4	1	G	Young Child (3-4 years)	?	-4.0	-	-	-	-	-
Pool 7 MF	4	4	A	Infant (3 years (+/- 12 months)	?	-6.8	-	-	-	-	-
Pool 7 MF	1	2	A	Adolescent (16-20 years)	?	-	-	-	-7.3	-	-9.0
MF 4	1 East Str.	5	A	Adolescent (15 years (+/- 3 years)	?	-	-	-	-5.8	-	-6.4
MF 4	1 North Str.	8	A	Young Adult (18-22 years)	Male?	-	-5.1	-	-	-	-
Pool 1	Str. 3	2	-	Adolescent - Young Adult (18-22 years)	Male?	-	-6.1	-	-	-	-

Table 2. 18O results from tooth enamel

Location	Mound	Burial	Individual	Age	Sex	$\delta^{13}O_{VSMOW}$ (P1) (‰)	$\delta^{18}O_{VSMOW}$ (P2) (‰)	$\delta^{18}O_{VSMOW}$ (M1) (‰)	$\delta^{18}O_{VSMOW}$ (M2) (‰)	$\delta^{18}O_{VSMOW}$ (M3) (‰)	$\delta^{18}O_{VSMOW}$ (dm2) (‰)
Pool 7 MF	4	1	A	Young Adult (18-24 years)	Male	-	-	29.5	-	29.2	-
Pool 7 MF	4	1	B	Mid Adult (35-40 years)	?	-	28.1	-	-	-	-
Pool 7 MF	4	1	C	Adolescent (15-20 years)	?	-	-	28.1	-	-	-
Pool 7 MF	4	1	D	Young Child (3-4 years)	?	-	-	-	-	-	28.8
Pool 7 MF	4	1	E	Adolescent (12-15 years)	?	-	-	29.5	29.3	-	-
Pool 7 MF	4	1	F	Adolescent (16-20 years)	Female	-	-	29.3	-	29.1	-
Pool 7 MF	4	1	G	Young Child (3-4 years)	?	-	-	-	-	-	29.9
Pool 7 MF	4	4	A	Infant (3 years (+/- 12 months)	?	-	-	-	-	-	29.1
Pool 7 MF	1	2	A	Adolescent (16-20 years)	?	-	-	28.7	-	28.0	-
MF 4	1 East Str.	5	A	Adolescent (15 years (+/- 3 years)	?	-	-	28.7	-	27.8	-
MF 4	1 North Str.	8	A	Young Adult (18-22 years)	Male?	28.0	-	-	-	-	-
Pool 1	Str. 3	2	-	Adolescent - Young Adult (18-22 years)	Male?	28.6	-	-	-	-	-

Table 3. %C4 in entire diet based off of tooth enamel analysis of individuals

Location	Mound	Burial	Individual	Age	Sex	% C4 (whole diet, earlier tooth)	% C4 (whole diet, later tooth)
Pool 7 MF	4	1	A	Young Adult (18-24 years)	Male	65	59
Pool 7 MF	4	1	B	Mid Adult (35-40 years)	?	57	-
Pool 7 MF	4	1	C	Adolescent (15-20 years)	?	68	-
Pool 7 MF	4	1	D	Young Child (3-4 years)	?	65	-
Pool 7 MF	4	1	E	Adolescent (12-15 years)	?	73	68
Pool 7 MF	4	1	F	Adolescent (16-20 years)	Female	71	65
Pool 7 MF	4	1	G	Young Child (3-4 years)	?	79	-
Pool 7 MF	4	4	A	Infant (3 years (+/- 12 months)	?	62	-
Pool 7 MF	1	2	A	Adolescent (16-20 years)	?	59	49
MF 4	1 East Str.	5	A	Adolescent (15 years (+/- 3 years)	?	69	65
MF 4	1 North Str.	8	A	Young Adult (18-22 years)	Male?	72	-
Pool 1	Str. 3	2	-	Adolescent - Young Adult (18-22 years)	Male?	67	-

Percent C4 was calculated as follows: %C4 = ((-25 - (db - Δ))/-15) x 100, where -25 is the mean pure C3 end-member, db is the d13C value of bone collagen or apatite, Δ is the diet-apatite spacing (9.4‰ for non-ruminants and 13.5‰ for ruminants), and 15 is the

Figure 3 shows δ18O pdb and δ13C of each sample in a bivariate scatterplot. This shows a relatively even distribution of 18O with no true outliers. 13C values cluster close to the mean with the exception of the lowest and highest values. However, whether they are statistically significant outliers has not been determined. Also this graph reiterates the fact that the diet of the individuals mainly consisted of C4 plants. In the case of the ancient Maya this would have been maize.

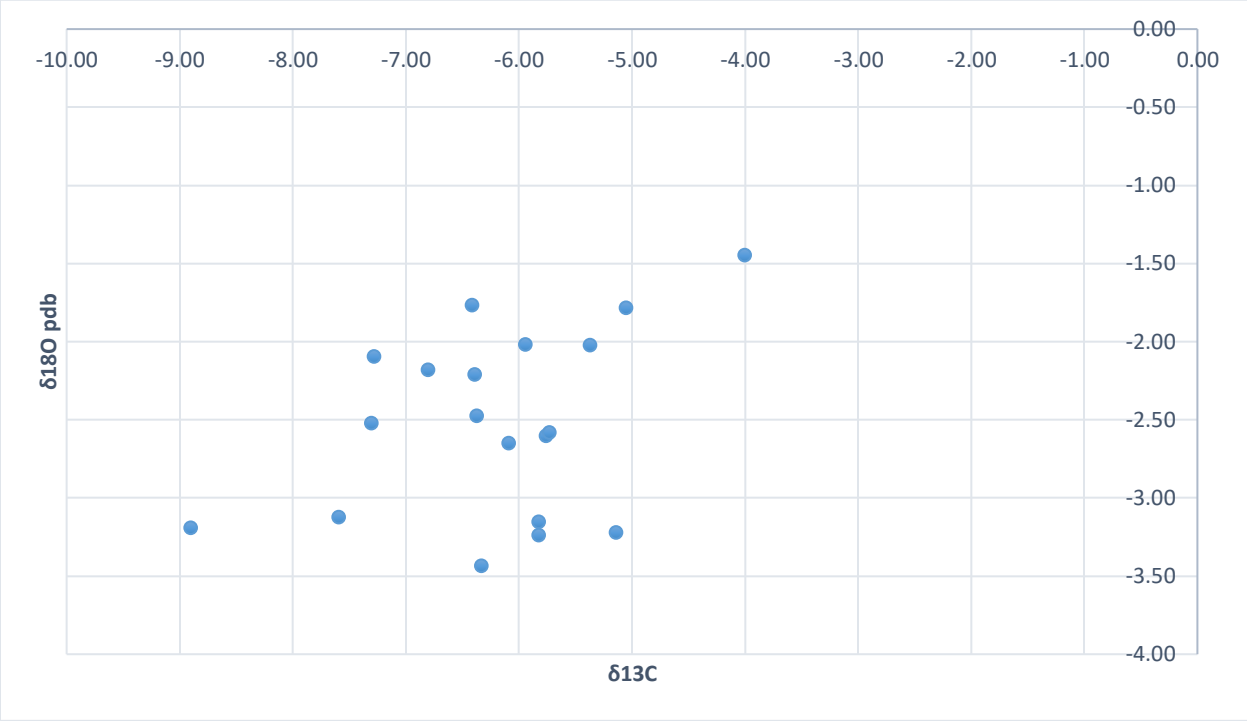


Fig 3. Scatter plot of δ13C values and δ18O pdb values.

Table 4 show the stable isotope results from apatite and collagen analysis of the bones from the individuals found. The highest $13C_{ap}$ value is -6.75 ‰ and the lowest is -10.17 ‰. The highest value is from Pool 7 MF, Mound 4, BU 1, Individual F. The individual value was 16-20 years old and a female. The lowest value is from Pool 7 MF, Mound 4, BU 1, Individual B. The individual is 35-40 years old and the sex is unknown. The highest $18O_{ap}$ pdb value 0.01 ‰ and the lowest value is -3.27 ‰. The highest value is from Pool 7 MF, Mound 4, BU1, Individual F. This individual was 16-20 years old and Female. The lowest value was from Pool 7 MF, Mound 1, BU2, Individual A. This individual was 16-20 years old and the sex is unknown. The highest $13C_{coll}$ value is -10.71 ‰ and the lowest is -14.58 ‰. The highest value is from MF4, Mound 1 North Structure, BU8, Individual A. This individual was 18-22 years old and possibly male. The lowest value is from Pool 7 MF, Mound 4, BU1, Individual B. This individual was 35-40 years old and the sex is unknown. The highest $15N_{coll}$ is 10.36 ‰ and the lowest is 8.25 ‰. The highest value is from Pool 7 MF, Mound 1, BU2, Individual A. This individual was 16-20 years old and the sex is unknown. The lowest value is from Pool 1, Structure 3, BU2. The individual was 18-22 years and possibly male.

Table 5 the % C4 in each individual's diet is shown again. In this case the comparison is between the %C4 as shown through the results from running the collagen samples to the %C4 shown through the results from running the apatite samples.

Table 4. Stable Isotope Results from Bone

Location	Mound	Burial/ Human cache	Individual	Age	Sex	Element	$\delta^{15}N_{coll\ AIR}$ (‰)	$\delta^{13}C_{coll\ VPDB}$ (‰)	$\delta^{13}C_{ap\ VPDB}$ (‰)	$\delta^{18}O_{ap\ VPDB}$ (‰)	$\delta^{18}O_{ap\ VSMOW}$ (‰)	$\Delta^{13}C_{ap\text{-}coll}$ (‰)
Pool 7 MF	4	1	A	Young Adult (18-24 years)	Male	LLM3 root	9.5	-12.2	-9.3	-2.6	28.2	2.9
Pool 7 MF	4	1	A	Young Adult (18-24 years)	Male	L humerus	9.2	-11.4	-8.5	-3.1	27.8	2.9
Pool 7 MF	4	1	B	Mid Adult (35-40 years)	?	LRP2 root	10.1	-14.6	-10.2	-2.4	28.5	4.4
Pool 7 MF	4	1	F	Adolescent (16-20 years)	Female	LLM1 root	10.0	-11.1	-6.8	0.0	30.9	4.3
Pool 7 MF	4	1	F	Adolescent (16-20 years)	Female	LLM3 root	10.2	-13.5	-8.8	-2.3	28.5	4.7
Pool 7 MF	1	2	A	Adolescent (16-20 years)	?	ULM1 root	10.4	-13.6	-9.7	-2.4	28.4	3.8
Pool 7 MF	1	2	A	Adolescent (16-20 years)	?	ULM3 root	10.3	-13.6	-8.7	-3.3	27.5	5.0
MF 4	1 North Str.	8	A	Young Adult (18-22 years)	Male?	ULP1 root	10.1	-10.7	-8.5	-2.6	28.2	2.2
Pool 1	Str. 3	2	-	Adolescent - Young Adult (18-22 years)	Male?	LRP1 root	8.3	-12.7	-9.8	-2.8	28.1	2.9
Pool 1	Str. 3	3	-	Young Adult (20-24 years)	Female?	Long bone	8.9	-13.8	-8.9	-2.9	27.9	4.9

Table 5. Stable Isotope Results from Bone cont.

Location	Mound	Burial/ Human cache	Individual	Age	Sex	Element	Collagen % yield	Wt % N coll	Wt % C coll	C:N	% C4coll (protein)	% C4ap (whole diet)
Pool 7 MF	4	1	A	Young Adult (18-24 years)	Male	LLM3 root	1.10	7.4	20.46	3.2	51.09	41.74
Pool 7 MF	4	1	A	Young Adult (18-24 years)	Male	L humerus	4.02	10.1	27.77	3.2	56.10	47.61
Pool 7 MF	4	1	B	Mid Adult (35-40 years)	?	LRP2 root	18.47	8.4	22.65	3.2	35.50	36.23
Pool 7 MF	4	1	F	Adolescent (16-20 years)	Female	LLM1 root	4.49	9.1	25.29	3.2	58.91	59.00
Pool 7 MF	4	1	F	Adolescent (16-20 years)	Female	LLM3 root	2.43	5.1	14.67	3.4	42.35	43.35
Pool 7 MF	1	2	A	Adolescent (16-20 years)	?	ULM1 root	7.73	10.5	28.52	3.2	42.23	39.11
Pool 7 MF	1	2	A	Adolescent (16-20 years)	?	ULM3 root	7.82	2.2	6.17	3.2	41.79	46.21
MF 4	1 North Str.	8	A	Young Adult (18-22 years)	Male?	ULP1 root	15.07	12.5	34.22	3.2	61.28	47.19
Pool 1	Str. 3	2	-	Adolescent - Young Adult (18-22 years)	Male?	LRP1 root	4.84	9.7	26.66	3.2	48.04	38.58
Pool 1	Str. 3	3	-	Young Adult (20-24 years)	Female?	Long bone	1.78	6.8	19.01	3.2	40.98	44.67

Percent C4 was calculated as follows: %C4 = ((-25 - (db - Δ))/-15) x 100, where -25 is the mean pure C3 end-member, db is the d13C value of bone collagen or apatite, Δ is the diet-apatite spacing (9.4‰ for non-ruminants and 13.5‰ for ruminants), and 15 is the difference in d13C between the C3 and C4 end

Discussion and Conclusion

Based off of the tooth apatite results the 13C values indicated that the diet of the individuals from the house mounds (Pool 7 MF and MF4) as well as the individuals from the Cara Blanca Pool 1 consisted mainly of C4 plants. This means that they all did in fact consume maize, making this the staple dietary plant source. The individual that seemed to consume the most maize was 3-4 years of age. This could possibly indicate the younger the individuals were the more maize based their diet was. This could also reveal the mother's diet because the tooth analyzed was a deciduous molar.

Dietary changes can be examined from infancy to adolescence for the individuals who had two teeth sampled. There does not appear to be much of a difference, except a slight decrease in maize consumption because the later teeth have lower 13C values. There were not many other significant differences amongst the individuals when it came to the 13C values. Therefore, not much can be determined when it comes to possible differences in status.

The 13C and 18O pdb values were not that much different when it came to the individuals from the house mounds (Pool 7 MF sites and MF4 site) and the individual from CB Pool 1. This could possibly mean that the status of the individual from CB Pool 1 was no different from the rest of the individuals that lived in the hinterlands of Yalbac. Since "carbon and oxygen isotopes in the same tissue reflect an individual's eating and drinking habits" (Freiwald 2011:67), having similar values would insinuate that the place the individuals lived in would have to have had similar foods and water supply. It made sense that the 18O pdb values were similar within the mounds where certain individuals were buried together because it showed that they lived in the same area so the water supply was not different for each individual.

The range of the 15N values on the other hand indicated that the individuals mainly consumed terrestrial animals as opposed to marine life. This could help visualize the type of environment the people living in the outskirts of Yalbac were exposed to. While there were bodies of water that were close to the house mounds that were excavated, the 15N values show that those bodies of water were not areas the people living within these households received their main source of animal protein from. When compared to a case study by White and Schwarcz this could be shown as an issue of social status. The samples that were analyzed within their research consisted of two samples that were obviously of higher status, based on the burial goods that were with their remains. The site that was excavated, called Lamanai, was a large ceremonial center and is known for having the longest continual occupation of any Lowland site in Belize (White and Schwarcz 1989). The 15N values revealed that there were in fact marine animals being consumed by the people within the regions, specifically those who were used as samples. Comparing the setting of this study to the site analyzed in this paper shows a great contrast. The site White and Schwarcz analyzed was known as a large ceremonial center whereas the sites analyzed within this paper were mainly in the hinterlands of a city center (Yalbac). This could go to show that people who live on the outskirts of a city or ceremonial centers are not on the social class as the people who live within them. This in turn could make their access to marine life limited. Interestingly enough the 15N values from the samples from CB Pool 1 also point more towards a diet consisting of terrestrial animals. This could point towards the people buried there perhaps being on the same social class as the people of the outskirts of Yalbac, despite their burial being within a possible ceremonial ground. This could even possibly be an example of a commoner being sacrificed as a opposed to choosing someone from a higher social status. This could even mean that there was no specific diet connected to spiritual practices for the individuals in or surrounding Yalbac.

Despite the information accrued from this analysis there is still more to study from the human remains excavated from these sites in order to fully answer the question of status and who the individuals were. Focusing on strontium analysis would add to the stories of individuals by showcasing the amount of mobility within the group excavated. This would help identify immigrants and also answer the question of whether the individuals in CB Pool 1 were from the region or possibly moved to Cara Blanca to participate in the ceremonial practices taking place there. Further research would help add layers to the stories of the individuals helping gain further understanding of the region during the time period and the how the society that was thriving in the area at the time was like.

Acknowledgements

This research would not have been possible without the help and guidance I have received throughout the process. This research was supported by Dr. Lisa Lucero. I am very grateful to Dr. Lisa Lucero for providing a field school, in turn, allowing access to the archaeological materials needed and for guidance in writing this paper. I would like to thank Dr. Stanley Ambrose for granting access to his lab and for helping analyze the results. I would also like to thank Shari Effert-Fanta at the Illinois State Geological Survey for running the samples and providing results. I am grateful Matt Fort for helping with the lab work and aiding in analyzing the results. I would like thank Timothy Xiong reviewing the manuscript. Finally, I am very grateful to Aimée Carbaugh for guiding me throughout the entire process, from lab work to reviewing the manuscript, as well as for compiling the results into the tables used within the paper.

References Cited

Ambrose, S. H.
1993 *Isotopic analysis of paleodiets: methodological and interpretive considerations.* Food and nutrition in history and anthropology (USA).

Ambrose, S. H.
1990 *Preparation and characterization of bone and tooth collagen for isotopic analysis.* Journal of archaeological science, 17(4), 431-451.

Ambrose, S. H., & Norr, L.
1993 *Experimental evidence for the relationship of the carbon isotope ratios of whole diet and dietary protein to those of bone collagen and carbonate.* In Prehistoric human bone (pp. 1-37). Springer Berlin Heidelberg.

Balasse et al.
2002. J. Arch. Sci (pages 917-932)

Buikstra, Jane E., and Douglas H. Ubelaker, eds.
1994 *Standards for Data Collection from Human Skeletal Remains*. Fayetteville, Arkansas.

Freiwald, C.
2011 *Maya migration networks: Reconstructing population movement in the Belize River valley during the Late and Terminal Classic* (Doctoral dissertation, UNIVERSITY OF WISCONSIN-MADISON).

Lee-Thorp, J. A., Sealy, J. C., & Van der Merwe, N. J.
1989 *Stable carbon isotope ratio differences between bone collagen and bone apatite, and*

their relationship to diet. Journal of archaeological science, 16(6), 585-599.

Lentz, D.

1991 *Maya Diets of the Rich and Poor: Paleoethnobotanical Evidence from Copan.* Latin American Antiquity, *2*(3), 269-287. doi:1.

Lucero et al.

2017 *Results of the 2016 Valley of Peace Archaeology Project: Cara Blanca Pool 1 Excavations and Yalbac Salvage Archaeology Program.* University of Illinois at Urbana Champaign, Urbana, Illinois, USA.

Pollard, Mark A. and Carl Heron

2008 *Archaeological Chemistry*. 2nd ed. RSC Publishing, Cambridge, UK.

White, C. D., & Schwarcz, H. P.

1989 *Ancient Maya diet: as inferred from isotopic and elemental analysis of human bone.* Journal of Archaeological Science, 16(5), 451-474.

White, C., Healy, P., & Schwarcz, H.

1993 *Intensive Agriculture, Social Status, and Maya Diet at Pacbitun, Belize.* Journal of Anthropological Research, 49(4), 347-375.