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The Skiles Mummy: Care of a debilitated hunter-gatherer evidenced by coprolite studies and stable isotopic analysis of hair

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Abstract

The Skiles Mummy (SMM), a naturally mummified adult male from the late archaic period of Lower Pecos Canyonlands of South Texas, represents a unique case of care. SMM is an exceptional mummy within this region due to both the retention of a full head of hair, and having a diagnosed case of megacolon, a complication commonly associated with Chagas disease caused by *Trypanosoma cruzi*. Stable isotopic analysis of his hair is consistent with a diet incorporating of C₄/CAM plants with some C₃ plants, freshwater resources, and higher trophic level animals. However, the segments of hair most proximal to the scalp exhibited elevated $\delta^{15}\text{N}$ values. Data from previous research indicate starvation and malnutrition can cause $\delta^{15}\text{N}$ values to rise. The presence of large fecal boluses in the digestive tract suggest peristalsis ceased in the last four to five months of life, and this, together with results from coprolite

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analysis, indicate he would not have been able to adequately absorb protein and nutrients during this time. His condition would have rendered him immobile. Following Tilley's index of care, someone would have had to bring him food resources, as well as attending to his daily needs.

Keywords: Chagas disease, Megacolon, Coprolite studies, Stable isotopes, Bioarchaeology of care

1. Introduction

Reinhard (2017) asserts that rigorous studies of archaeological parasitism must include extensive research into all aspects of lifestyle of the related culture. He states that parasitological data lose archaeological relevance when presented as infections isolated from archaeological context, and urges a holistic, anthropological approach to understanding the cultural and physical environment in which a prehistoric individual lived. Archaeological details are often derived from ancillary studies in fields such as palynology, zooarchaeology, archaeoentomology and archaeobotany, and well-preserved mummy remains, particularly where cultural background is known, can prove a particularly rewarding focus for such interdisciplinary research.

In this report, we present a case study demonstrating the value of multiple lines of evidence in evaluating the onset and severity of pathology represented in a mummy from the Lower Pecos Canyonlands of Texas and dating to the Late Archaic Period. The intestinal pathology of this individual has been linked to *Trypanosoma cruzi*, a parasite that provokes Chagas disease (Reinhard et al., 2003; Reinhard and Araujo, 2015). Through coprolite (botanical) and stable isotopic analysis, we document dietary intake over the last months of life, and infer provisioning of food and other forms of care to this individual.

The Lower Pecos Canyonlands include the confluences of the Rio Pecos and Devils River with the Rio Grande (Rio Bravo) of Texas, USA and Coahuila, Mexico (Shafer, 2013a). The archaeology of the Lower Pecos is noteworthy due to quality of preservation of archaic hunter-gatherer remains and an archaeological record that dates many millennia to Paleoamerican times (Shafer, 2013a). To our knowledge, no other region has such a comparable hunter-gatherer record. Details of preservation include remarkable rock art (Boyd, 2013; Boyd and Cox, 2016; Kirkland and Newcomb, 1996; Shafer, 2013b, c), portable

art (Shafer, 1975, 2013b, 2013c; Turpin, 1996), dietary plants (Bryant and Reinhard, 2012; Riley, 2008, 2010), animal foods (Reinhard et al., 2007; Lord, 1984), hallucinogens and medicines (Boyd and Dering, 1996), tools (Shafer, 1986, 2013b, 2013c), portable art associated with women (Mock, 2013); woven art (McGregor, 2013), cooking features (Black and Thorns, 2014; Koenig, 2012), activity areas (Shafer, 1986), and coprolites (Bryant and Reinhard, 2012; Riley, 2008; 2010; Reinhard and Bryant, 2008). Cultural connections have been established through rock art analysis. Prehistoric rock art motifs and designs are similar to those of modern Huichol and Nahua peoples (Boyd and Cox, 2016). This suggests the potential for a broad continuum of mythology from ancient to modern times in this region.

Up to 150 mummified bundle burials have been noted in rock shelters in the area (Turpin et al., 1986). One mummy has been especially well studied. This individual, known as the Skiles Mummy or SMM, died about 1200 years ago. The first detailed physical anthropological analysis of these remains, including x-rays and facial reconstruction, was conducted in the 1980s by Turpin et al. (1986), showing this mummy to be an adult male, 35–45 years old at death. He was interred in a small rockshelter in the rimrock of the Rio Grande Canyon, overlooking the canyon and river. The opening to the shelter is constricted and provided a protected interment for SMM. Dressed in a rabbit fur cape and a necklace of stone and bone ornaments, with a deer hide strap encircling his lower torso, SMM's body was bound in a flexed position after death. Several layers of matting were wrapped around the corpse to create the burial bundle, with tightly woven mats closest to the body and coarsely woven mats making up the outer layers. The bundle was then finished by tying a length of animal hair rope around the final layer of matting. Within the shelter, SMM was buried in a pit. This type of interment is typical for the Late Archaic in the Lower Pecos Canyonlands, while the furnishings are not as elaborate as some burials, SMM's burial includes furnishings not found in all burials (Turpin et al., 1986).

The deer hide artifact wrapped around SMM's abdomen posed an enigma for the original researchers (Turpin et al., 1986). In a second analysis by Reinhard et al., (2003), its utilitarian nature was defined. They wrote, "The rope is 1 cm wide and is painted red on both sides. It is now in many fragments. However, our examination of the

fragments reveals only two cut ends, so it is probable that the rope was one long piece when it was used. Now it is in 17 segments ranging from 7 to 70 cm in length. The total length of the segments is 756 cm. When the mummy was found, the strap was found wrapped around the lower torso” (Reinhard et al., 2003: 167). Therefore, in form and context the rope appears to have had a role in girdling the lower body of SMM.

Morphologically speaking, aside from his teeth, SMM’s skeletal remains reflect good health. SMM did exhibit extensive dental pathologies present on both maxillary and mandibular arcades, including caries, several abscessed teeth, worn molars, widespread inflammation and extensive antemortem tooth loss (Turpin et al., 1986). These types of dental pathologies are not characteristic of prehistoric hunter-gatherer populations, which typically present with well-worn teeth and little decay. However, pathologies similar to SMM’s and other burials from the Lower Pecos are consistent with a reliance on plants high in carbohydrates, like succulents, and repetitive chewing of fibrous tissues found in sotol and lechuguilla (Danielson and Reinhard, 1998; Marks et al., 1985; Turpin et al., 1986; Winkler, 1982).

SMM offers a unique set of circumstances allowing for multiple lines of analysis to be executed. First, as a naturally desiccated individual enveloped in a bundle burial, he retains a full head of hair. Only a handful of other naturally desiccated individuals from the Lower Pecos had hair present when recovered (e.g., Martin, 1933). Secondly, SMM presents with a very large desiccated fecal mass, which encompasses the majority of what would have been the gastrointestinal tract. The enlargement of the colon was diagnosed as case of megacolon, which was most likely a complication of Chagas disease (Reinhard et al., 2003). The preservation of both the hair and fecal matter enable botanical analysis and reconstruction of short-term paleodiet through stable isotopic analysis to be performed. These analyses provide evidence of not only alteration in diet during the last few months of SMM’s life, illustrating a diet inconsistent with the region and his own previous diet, but also support that SMM was being cared for and provisioned by other individuals in his community.

2. Evidence for disease, methods, and results

2.1. Evidence for disease: megacolon

Reinhard et al. (2003) diagnosed SMM with a case of megacolon after analyzing the weight and volume of the large intestine. Megacolon results from disruption of the migrating motor complex activity in the large intestine, resulting in the cessation of peristalsis. As this occurs, partly digested food fills the intestine, causing the colon diameter to enlarge as muscular strength and tone is lost (Reinhard et al., 2003). This case of megacolon in SMM is believed to result from Chagas disease (Reinhard et al., 2003). Chagas disease, provoked by *Trypanosoma cruzi*, was endemic to the region; a discussion of pathoecology of Chagas in the Lower Pecos can be found in Reinhard and Araujo (2015).

Turpin et al. (1986) did not recognize this pathology during their initial study of SMM, although they noted the large coprolite mass. In Reinhard et al. (2003):167 reexamination of SMM, they wrote, “The large intestine is nearly complete. The appearance of this organ is consistent with megacolon. There are ten segments of the colon that are preserved today. Most segments exhibit a grossly enlarged diameter. The average diameter of the large intestine was 6 cm. There are 112.9 cm of the large intestine, compacted with partially digested food, which are “mummified”. The reason the intestine “mummified” is due to the fact that it was filled with compacted food remains that desiccated and retained the form of the colon. Of the colon segments that could be weighed, 1170 g of feces were present. The total volume of the preserved large intestine was 3710 cm³”.

In addition to the colon contents, the small intestine and stomach contents pooled to one side of the mummy and desiccated. Therefore, the total contents of the digestive tract are much larger than the measurable colon sections. To provide an idea the size of this mass, consider that the volume of a basketball is 5000 cm³. The measurable mass of the colon was close to 75% of the basketball size. SMM was 168–170 cm in stature, or about 7 cm shorter than the average American male in modern times. The mass of the food in the digestive tracts would have caused distension. Fig. 1 provides an idea of the distension caused by this massive bolus in the SMM individual.

Fig. 1. The Skiles Mummy as displayed in 2016. The dark gray objects in the abdomen, wrapped by deer hide straps, are the colon segments completely filled with digesta.

2.2. Methods and results

Two approaches are used for establishing diet in the unique case of SMM. These analytic methods consist of coprolite studies, assessing both macro- and microbotanicals and macrofauna, and stable isotopic analysis of SMM's hair.

2.2.1. Coprolite analysis and results

Recent reviews (Reinhard, 2017; Camacho et al., 2018) emphasize that quantitative methods must be used in coprolite analysis. The most suitable method for quantification today is based on the Callen method, developed 60 years ago (Camacho et al., 2018) and based on rehydration of coprolites in trisodium phosphate. In this method, which has long been the standard for recovering all types of evidence from coprolites, the microscopic remains present in the coprolite are separated from macroscopic remains by rehydration and screening. During the last two decades, the Callen method has been modified by adding known amounts of exotic spores or pollen to samples to allow

Fig. 2. Colon segment analyzed in 2016. All sections of the colon were coated with shellac decades ago. Therefore, to recover material for analysis, a sample had to be removed from the interior. The shellac permeated the samples to an unexpected degree. However, this old method preserved the material well, although probably added weight to the coprolites.

for the quantification of all types of microfossils in terms of items per gram of coprolite (an innovation from the field of palynology). The Callen method used in the study of SMM's coprolites is detailed by Camacho et al. (2018).

The food remains within this extremely distended colon were first analyzed by Riskind and are cited by Turpin et al. (1986):306–308. Grass pollen, grass seeds, prickly pear seeds and fiber from agave were present in the initial analysis of macroremains. The most common animal remains were insect remains from grasshoppers or crickets. The bones of small fish, snake, bat, recently hatched bird, white-footed mouse and pocket gopher represented consumption of vertebrates.

Two of us, Teixeira-Santos and Reinhard, visited the mummy in 2016 and sampled a total of five grams of the coprolite bolus for dietary study (Figs. 1 and 2), and determined the results were generally consistent with those described by Riskind featured in Turpin et al. (1986). Riskind noted 250 grasshoppers pieces were recovered, 80% of which were mandibles (Turpin et al., 1986). In our analysis, one hundred and sixty-five grasshopper fragments were observed,

including 87 mandibles, 65 leg fragments and 23 miscellaneous thorax pieces. Therefore, 33 grasshopper fragments were recovered per gram of sample.

There were some botanical differences. No grass seeds were found. The pollen data also differed from those found by Riskind. Wind pollinated plants, such as ragweed, were more common than grass in these new samples. Traces of prickly pear were present. The results indicate variation in plant foods between the two samples, but that grasshoppers were a consistent part of the diet. The megacolon distention must have taken some time to develop and it is likely that the food accumulated over some weeks. The replacement of grass pollen by ragweed pollen may suggest the accumulation of food occurred over a period of time long enough to overlap a change in environmental plant composition, or it could be due to dietary shift that reflects a shift in plant availability.

2.2.2. Hair analysis and results

Stable isotope signatures in hair allow a fine-grained level of dietary analysis and identification of a general pattern of resource use (DeNiro and Epstein, 1978; O'Connell, 2001; Reece and Campbell, 2009; Sharp, 2007). Although many factors affect hair growth rates, the variation in growth rate is primarily related to nutrition, one to two centimeters of hair generally corresponds to one to two months of growth and therefore to one to two months of food intake (Knudson et al., 2007; Macko et al., 1999; Petzke et al., 2005; Robbins, 2002; Sandford and Kissling, 1993; Sponheimer et al., 2003; Valkvoic, 1988). This means that stable carbon and nitrogen isotope analyses of hair are capable of producing a detailed picture of diet that may span weeks and months to years (O'Connell, 2001; Williams and Katzenberg, 2011; Knudson et al., 2007; Sponheimer et al., 2003).

Stable isotopic analysis of SMM's hair was performed by Verostick (2013). The hair sample analyzed was approximately 17 cm in length, which can be equated to roughly 17 months of growth. While the sample was taken cautiously and as close to the scalp as possible, there were some obstacles in sampling; the most significant being a shellac coating on the hair, placed in the 1930s when SMM was originally found. The 17 cm hair sample was segmented into 1 cm portions for

Isotope Ratio Mass Spectrometry (IRMS) testing, sample 17M being most proximal to the scalp and 1M the most distal portion. The samples were processed via a modified procedure based on Petzke et al. (2005). Also, it should be noted that while hair can grow daily, this growth does not reflect the most recent dietary intake; growth reflecting dietary intake is usually not apparent till a week to two weeks later. Procedure and information on sample preparation protocols and analysis can be found in the supplementary section.

Overall, the stable isotopic values from the hair segments are generally consistent with what is typically found in the region, a diet base mainly of C_4 /CAM plants with some C_3 plants, freshwater resources, and higher trophic level animals (Table 1 and Fig. 3). The isotopic data also show shifts and variability that can be interpreted to reflect seasonal changes in diet. The high $\delta^{15}N$ values found in SMM's hair indicate a year-round usage of higher trophic level protein sources ($\delta^{15}N \bar{x} = 12.6 \pm 0.5\text{‰}$). However, nitrogen values over 12‰ are not common among prehistoric humans in Texas, even in coastal areas. This value is exceeded by only 7 of 163 cases of prehistoric humans reported by Hard and Katzenberg (2011) in Central / Coastal Texas.

Table 1 Stable carbon and nitrogen isotopic data from SMM hair segments (17M most proximal, 1 M, 2M most distal).

Sample number	δC value	δN value
1 M, 2M	-13.4 12.1	
3M	-13.3	12.1
4M	-13.9	12.3
5M	-14.8	12.3
6M	-14.4	12.3
7M	-14.5	12.4
8M	-14.3	12.6
9M	-13.2	12.7
10M	-12.8	12.7
11M	-12	12.6
12M	-12.1	12.4
13M	-12.6	12.5
14M	-13.1	13
15M	-13.2	12.8
16M	-13.6	13.1
17M	-13.4	12.9

Fig. 3. $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values of SMM's hair segments. Box indicates months prior to death, the dashed line represents the nitrogen values, and the solid gray line represents the carbon values.

3. Discussion of results

3.1. Implications of diet in the Lower Pecos

Over several decades, numerous paleonutritionists have studied and reconstructed Lower Pecos diet through coprolite analysis. The analyses of hundreds of samples provide comparative data to assess whether or not the foods provided to SMM are outside the normal range for the population. The most important of these foods are grasshoppers. The presence and absence of grasshoppers have been derived from several studies in Table 2. The data show that grasshoppers are in general rare foods. Although caches of grasshoppers without legs have been found in the region (Turpin et al., 1986), they are rarely found in coprolites. Edwards (1990:95–96) summarizes the Hinds Cave data collected by Williams-Dean, Stock, Reinhard and herself. She notes that out of all the Hinds Cave coprolites, just one contains grasshopper remains. At Conejo Shelter, Bryant (1974a) found grasshoppers in four of 43 coprolites. However, unlike SMM, grasshoppers were not the dominant food, but rather appear to be supplements

Table 2 Coprolite studies within the Lower Pecos region, listing the number of samples in each study including grasshoppers.

Analyst	N=/site	Date range	Number of coprolites w/grasshoppers
Stock (1983)	29/Hinds cave	8778 B.P.-9460 B.P. and 9032 B.P.-9464 B.P. calibrated	0
Stock (1983)	26/Hinds cave	7436 B.P.-7790 B.P. 8020 B.P.-8514 B.P., 8045 B.P.-8508 B.P. calibrated	0
Williams-Dean (1978)	100/Hinds cave	6409 B.P.-6727 B.P. and 6495 B.P.-6896 B.P. calibrated	1
Edwards (1990)	7/Hinds cave	6409 B.P.-6727 B.P. and 6495 B.P.-6896 B.P. calibrated	0
Edwards (1990)	33/Hinds cave	ca. 2300-1300 B.P.	0
Reinhard et al. (2007)	23/Hinds cave	Late Archaic, 3150 to 1300 B.P.	0
Bryant (1974a)	43/ Conejo Shelter	2800 to 1500 B.P.	4
Sobolik (1988)	38/Baker Cave	1100 B.P.	0
Fry (in Sobolik, 2008)	32/Frightful Cave	9500 to 1700 B.P.	0

to a diet that included a wide range of foods including small mammals, yucca, prickly pear, wild onion, and reptiles. The grasshoppers were most often eaten with the following combinations: 1) small mammals and yucca/agave/sotol, 2) prickly pear pad, wild onion, bark, small mammals and yucca/agave/ sotol, 3) goosefoot seeds and prickly pear fruit, 4) prickly pear fruit, reptiles, and yucca/agave/sotol. The SMM mummy is unique in having a nearly exclusive reliance on grasshoppers.

In comparison to Late Archaic coprolite data, the pollen spectrum of SMM is unlike the majority of coprolite samples previously published by Reinhard et al. (2008). The SMM grass concentration was 715 pollen grains per gram. This value is quite low for Late Archaic samples, which have an average concentration of 57,271 pollen grains per gram with counts ranging from 500 to 659,410 grains per gram (Reinhard et al., 2008). Also, most samples reported by Reinhard et al. (2008) have more taxa represented, with 8.5 taxa per coprolite compared to the number of taxa represented in SMM (n=6). The low grass counts and low taxon diversity observed in the SMM samples are not unknown in Late Archaic samples, but they are rare. The high percentage of grass pollen reported by Riskind and the relative absence

of grass pollen found by Teixeira-Santos and Reinhard in the recent study suggests the components of the fecal sample from SMM reflect variation of foods ingested, or pollen inhaled by SMM over the period of time since the cessation of peristalsis and death.

Additionally, phytolith analyses of coprolites are another component of understanding diet in the Lower Pecos Canyonlands (Bryant, 1974a, 1974b; Bryant and Williams-Dean, 1975). Danielson and Reinhard (1998) quantified the amount of phytoliths in coprolites for the Late Archaic period. They found ten to twenty percent of the volume of coprolites was composed of calcium oxalate phytoliths from desert succulents. Teixeira-Santos and Reinhard noted the number of phytoliths in SMM was much lower than expected for Late Archaic samples. Therefore, the small amount of succulent phytoliths, combined with low fiber content, makes the SMM sample inconsistent with the hundreds of Lower Pecos coprolites analyzed to date.

Reviewing the coprolite data for the Lower Pecos, Riley determined that there were three major seasonal “menus” (Riley, 2008, 2012). The first focused on prickly pear pads in late spring when preferable foods were unavailable. The second focused on baked agave (lechuguilla) in the cool season. Prickly pear tunas (fruit) were the basis of the third menu in summer. From this perspective, the SMM focus on grasshoppers is, again, unusual, as are the low number of succulent phytoliths.

3.2. Interpretations from coprolite studies

A high fiber diet is typical of Lower Pecos hunter-gatherers. Dietary fiber in the form of seeds, stems, and epidermis compose the majority of coprolites of hunter-gatherers in the region. The fiber is largely derived from desert succulents. The coprolite data, as summarized and analyzed by Riley (2012) clearly shows the universal importance of desert succulents in the diet.

However, the SMM coprolite stands out as a unique sample that is not dominated by plant fiber from succulents. The normal large amount of fiber from agave, yucca, sotol and prickly pear would have rapidly filled his non-functioning intestinal tract. His community may have perceived this issue, resulting in the collection of small rodents and insects as an alternative source of nutrition for SMM. Despite this, even though SMM’s diet in his last months was anomalous for

the Lower Pecos region, he was still likely consuming more dietary fiber than more modern diets, such as that seen in the case of “Mr. K” (see Section 4 below).

3.3. Interpretations from stable isotopic data

Of particular interest to the topic of care are the hair segments most proximal to the scalp, which represent the several months prior to death (samples 14M to 17 M). The data from these four segments, highlighted in Fig. 3, show increased $\delta^{15}\text{N}$ values ($\bar{x}=13 \pm 0.13\text{‰}$) that do not fit with the other data from SMM’s hair ($\bar{x}=12.4 \pm 0.2\text{‰}$), or from within other possible resources of the Lower Pecos region. As noted above, nitrogen values over 12‰ are not common among pre-historic humans in Texas, even in coastal areas where estuarine and marine resources are available (Hard and Katzenberg, 2011). Other reported values of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ for the Lower Pecos region come from Conejo Shelter and Skyline Shelter (Table 3) (Bousman and Quigg, 2006; Huebner, 1991), while only consisting of a small sample size, they are mostly consistent with values found in the SMM data. Additionally, there are several reported values from Seminole Sink (Turpin, 1988), but the bone collagen was analyzed only for $\delta^{13}\text{C}$.

While there is not a definitive way to interpret this section of the data, three possible explanations for the higher nitrogen values near time of death can be offered. Values this high could reflect a substantial contribution of freshwater fish to the diet, one of the few animal resources having a high nitrogen value in the Lower Pecos region. The mean of the $\delta^{15}\text{N}$ values from the SMM samples ($\delta^{15}\text{N } \bar{x}=12.6 \pm 0.5\text{‰}$) is higher than most recorded values, except for one individual from Conejo Shelter with a very enriched $\delta^{15}\text{N}$ value of 16.6‰, while all

Table 3 Stable isotopic values from other studies in the Lower Pecos region (Bousman and Quigg, 2006; Huebner, 1991).

Site	Time Period	$\delta\text{C}_{\text{collagen}}$	$\delta\text{C}_{\text{apatite}}$	$\delta\text{N}_{\text{collagen}}$
Conejo Shelter	Late Archaic	−12.6	−8.6	10.2
Conejo Shelter	Late Archaic	−12.6	−7.3	12.6
Conejo Shelter	Late Archaic	−12.6	−7.6	10.5
Conejo Shelter	Late Archaic	−14.6	−7.7	16.6
Skyline Shelter	Late Archaic	−15.7	−7.8	5.3

other reported values are 12.6‰ (for one individual) or lower (Table 3)(Huebner, 1991). Some fish bones were recovered in the coprolite studies, which supports the isotopic data. There has been some internal debate by researchers, who believed the high number of grasshopper remains evident in SMMs coprolite drove the observed $\delta^{15}\text{N}$ values. The $\delta^{15}\text{N}$ values for grasshoppers are, however, minimal ($0.8 \pm 2.4\text{‰}$, $n=3$) (DeNiro and Epstein, 1981).

These enriched values in portions of hair closer to time of death may also be a reflection of the seasonal availability of resources. Due to the changing values over the length of the hair, it becomes apparent that many types of resources were consumed. The variability in the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values point towards flexibility in the protein resources of the diet rather than emphasis on any one resource. While seasonal variability is seen throughout the length of SMM's hair, the last four segments (14M to 17 M) are anomalous to the previous data in SMM's hair, as well as higher than any other recorded $\delta^{15}\text{N}$ values (except one) in the region.

The third possible scenario, and the more plausible one, is that the high nitrogen values seen in the last months of life may not result from resource intake, but are rather an artifact of malnutrition. Due to the lack of peristalsis in the digestive track and the presence of large fecal boluses, SMM would have not been able to adequately absorb protein and nutrients. The differences between $\delta^{15}\text{N}$ values in segments closer to time of death are likely attributed to the illness or disease that caused SMM to retain such copious amounts of fecal matter in his intestines. The $\delta^{15}\text{N}$ values are enriched 0.3‰ to 1‰ from previous values in the months before time of death. Changes in $\delta^{13}\text{C}$ values are also quite variable, with enrichment from .4‰ to 1.4‰ from the previous months.

Multiple isotopic hair studies in forensic contexts note prolonged starvation results in a significantly higher $\delta^{15}\text{N}$ values than seen with normal changes in diet, these studies show an increase in $\delta^{15}\text{N}$ value on average of 0.5‰ during malnutrition episodes (Mekota et al., 2006, 2009; Neuberger et al., 2013). In starvation episodes, the body use stores of glycogen from liver and muscle in order to function properly. It is hypothesized the enriched $\delta^{15}\text{N}$ values are a result of gluconeogenesis, where the body makes glycogen from non-carbohydrate sources from within the body (Mekota et al., 2009). Essentially the elevated $\delta^{15}\text{N}$ values are resultant from the body consuming or

metabolizing its own tissue, which are already enriched in $\delta^{15}\text{N}$ relative to diet. This is similar to the elevated $\delta^{15}\text{N}$ observed in weaning and breastfeeding studies.

Since the $\delta^{15}\text{N}$ values in the last segments of hair are higher than expected for the region, and higher than the majority of what has been demonstrated in other isotopic testing, the values being affected by means other than consumed resources seems most likely. It can be reasoned the high $\delta^{15}\text{N}$ values SMM demonstrated in the isotopic data during his last months of life is the result of SMM's inability to process proteins and absorb other nutrients properly through his digestive tract. Though SMM was consuming grasshoppers, as evidenced in the coprolite analysis, these resources lack the ability to increase the nitrogen values to such an enriched value. Despite consuming various foods, we know that SMM was unable to benefit from these resources, because they remained unprocessed in his digestive tract. Hormones and nerve regulators essentially control the digestive process, but in cases of megacolon, the nerves may be damaged and do not send proper signals to the digestive tract. Simply put, megacolon prevents the digestive juices from mixing with food and descending into the rest of the GI system to be absorbed. Carbohydrate rich foods, such as succulents or processed plant foods, do not have to go through the digestive tract to be broken down, but start their breakdown in the mouth with amylase, making their absorption into the body much easier once they have passed into the stomach. However, based on the coprolite data, SMM was not consuming succulents or many processed plant foods. If the increased $\delta^{15}\text{N}$ values are a reflection of malnutrition, they could also represent the time when SMM's digestive track stopped fully functioning. SMM could potentially have lived 4 to 5 months without peristalsis or a fully functioning digestive tract.

4. Illustrating the impacts of megacolon: the case of "Mr. K"

The pain and debilitation arising from megacolon may not be readily appreciated by most people. In order to provide such an understanding, the following vignette of the health impacts of megacolon is taken from a case study by Geib and Jones (1902), in which they detailed the pathology of a "Mr. K", who died at the end of a long struggle

Fig. 4. Image of Mr. K's colon.

with constipation. Their description well matches our observations of SMM. Geib and Jones note:

“During these periods of costiveness, he [Mr. K] could not eat full meals and do a good day's work... The evacuation of his bowels made him very weak, and he was greatly troubled with gas so that he had to lie on his right side to relieve himself... His abdomen was greatly distended so that the liver and stomach crowded up to the diaphragm and the floating ribs were visibly pushed out. The colon, on palpation, seemed to be as large as a six-inch stovepipe. From the head of the sigmoid flexure to the rectum, the bowel seemed to be nearly perfectly straight and hard. On digital examination, the rectum was found filled with a mass of fecal matter so hard that no impression could be made on it.” (Geib and Jones, 1902:1305)

Olive oil and enemas were used to soften fecal matter, with up to eight gallons of feces being liberated. However, the debilitating constipation returned and the patient expired.

“The autopsy showed the abdomen greatly distended with gas and fecal matter. On making an incision along the linea alba, the tension was sufficient to tear the flesh apart; the omentum was very thin and the colon was brought at once into view. The position of the colon was shown in the photograph, save that the extra loop overlaid the normal colon. The splenic flexure, transverse colon and descending portion of the extra loop were very much thickened, containing much more muscular fiber than normal. The parts most distended were the splenic flexure, the transverse and descending portion of the extra loop, but the whole colon was much larger than normal (Geib and Jones, 1902:1305).”

It is instructive to compare the photograph of the colon presented by Geib and Jones (1902) (Fig. 4) from the autopsy with those of the SMM colon casts (Fig. 1) illustrated by Reinhard et al. (2003). The images are remarkably similar and this suggests that the pathology suffered by SMM was similar to that of Mr. K. While the case of Mr. K is dated, there are not many other correlates for megacolon cases without modern medical intervention

5. Discussion: disease impact and care response

Referring to the bioarchaeology of care approach (Tilley 2017), and applying features of the Index of Care (Tilley and Cameron, 2014), there are multiple lines of evidence, which aid in understanding the care SMM received.

5.1. Document, diagnose, and describe the pathology and lifeways

As noted above, megacolon is a painful and limiting condition in terms of ability to participate in active daily living, much less procurement of vital necessities such as food or water. SMM has a clear case of megacolon. In clinical settings, megacolon is diagnosed based on the physical characteristics observed of the bowel or colon, usually based on the dilation of the colon to a certain diameter, ranging from

6 to 10 cm or larger (Cuda et al., 2018). The average diameter found in SMM's large intestine is 6 cm. When taking into consideration this is also desiccated material, SMM fits well within the diagnostic criteria.

Acquired megacolon is either idiopathic or a secondary complication, it can result from a several conditions including ulcerative colitis, Crohn's colitis, disorders of the enteric nervous system, as well as Hirschsprung's disease (O'Dwyer et al., 2015), and of course Chagas Disease. Similar megacolon pathology has been described in recent cases of Chagasic megacolon (Flórez et al., 2010). We know that SMM's megacolon is the result of Chagas Disease, based on PCR analysis on tissue samples (Barth and Kundrotas, 2011). However, whatever its etiology, megacolon is caused by the same impetus: the degeneration of the myenteric plexus, or the major nerve supply that controls motility in the gastrointestinal tract. Although the case of Mr. K provides us some information with the impact of megacolon, at this time there are not any studies assessing the impact of the pathology on quality of life (Cuda et al., 2018).

Due to symptoms resulting from SMM's health condition, which would have included constipation, abdominal bloating and tenderness, abdominal distention and abdominal pain, it is unlikely he was able to care for himself or was very mobile in his last months. While at first his disease would primarily affect the gastrointestinal system and metabolic functions, the persistence of the condition would have several further effects in the immune system, cognitive/mental functions, and the cardiovascular and respiratory systems. As megacolon persists, the body is unable to receive adequate nutrients. The stable isotopic data posits SMM lived with lack of peristalsis for several months. While he may have been mobile at the beginning of this timeframe, it is very likely that he would have required assistance in at least the last two months, if not more, due to the additional symptoms of megacolon. The vignette of Mr. K's experience aids in recognizing the types of issues SMM would have likely had to deal with.

Additionally, complications or symptoms associated with the chronic phase of Chagas disease include megaesophagus and cardiomyopathy (Flórez et al., 2010; Rassi et al., 2010). Megaesophagus refers to a generalized enlargement of the esophagus, which features decreased to absent motility. Cardiomyopathy affects the muscles of

the heart, making it hard for the heart to deliver blood to the body. Symptoms associated with cardiomyopathy include breathlessness, swollen legs and feet and a bloated abdomen.

5.2. Estimating disability and constructing a model of care

While in the first stages of dealing with megacolon, SMM would have been able to perform some essential activities (basic tasks of daily living such as personal and toilet hygiene, and function mobility), as the ailment progressed his ability to perform many essential activities such as those listed would have been greatly constrained. ‘Instrumental activities’ (context driven social and economic tasks such as hunting and gathering, cooking meals, and interaction with other community members) which are not fundamental for functioning in everyday life, but are necessary for an individual to function independently in a community, would have been the first activities to be affected as SMM’s condition worsened overtime.

As SMM’s condition deteriorated, he would have gone from needing care in the form of “accommodation of difference” to care in the form of “direct support”, the latter including many of the constants of care proposed by Tilley et al. (2017). These constants of care would include provisioning of food. Due to both the pathological condition of his teeth and his constipation, a special diet was required, water, potentially help with drinking or eating, shelter and bedding, monitoring of health status, and management of hygiene.

The distention of the abdomen would have been debilitating. Reinhard and colleagues note that a deer hide strap was wrapped about the abdomen like a girdle to support the mass of digesta that impinged on the sacrum and iliac crests, with the use of this strap being different to, and separate from, the strapping used to bundle the burial. This distention of the abdomen would affect mobility not just within the community, but in basic activities, like getting up and down.

The Lower Pecos features canyonlands and uplands with plains and plateaus bisected by steep ravines. The people living here were highly mobile hunting and foraging groups, with a small group economy, and subsistence focused on riverine sources, game animals, and a variety of local flora from nuts and persimmons to succulents. As his disease progressed, SMM would have not been able to hunt

or gather, much less trek up and down the terrain of the Lower Pecos. This indicates someone else had to bring him food and water, though access to water would be dependent on where the camp site was located, and respond to the other daily needs identified above. Due to the nature of this highly mobile group, some accommodations to SMM's impeded mobility were likely made, such as providing him a fixed resting place, potentially minimizing the movement of the group as his condition progressed, and providing aid in transportation between camp sites.

Additionally, foods consumed by SMM may have had to be crushed or otherwise processed. Since SMM retained only his 3rd maxillary molars, he was likely not able to masticate his own food. Riskind inferred that plant food was prepared for him by crushing in stone mortars (Turpin et al., 1986); however, processing food is something SMM may have been capable of doing himself. It is very likely SMM was receiving care from others on a daily basis during the last few months of life.

5.3. *Interpretation of care*

SMM's burial style is consistent with time and regional location, suggesting social acceptance and community inclusion at the time of his death. This is likely because the pathology would have not affected him severely but for the several months prior to death. Working under the assumption SMM was a well-integrated and productive member of his community when he contracted this disease; there are several other considerations that should be made. While it is clear SMM was cared for in his last months, whether this care was an automatic response or not by his community is unknown. It is also not clear if care was a community effort or on the individual level. Likewise, it is also unknown if the care would have continued had SMM lived for a longer time period. The affect this illness would have had on the community is also hard to gauge. The vignette of Mr. K aids in understanding what SMM might have experienced, and the notes of Geib and Jones (1902) are useful in thinking how the community might react.

6. Conclusion

Dietary data from coprolite analyses can be compared to stable isotope data from SMM's hair, and together these data provide a picture of SMM's dietary intake and nutritional status in the weeks and months prior to his death. Using these lines of evidence, along with what is known of the clinical impacts of megacolon, and the context of the region cultural and physical environmental context, we can make inferences about the perceived care SMM was receiving. SMM was reliant on his small mobile community for care, which included food provisioning for around two to three months before he died, and aid in daily living activities. This case study gives insight into social behaviors related to disability and care, particularly when thinking of the treatment of an individual within the community, and the community's response to an ill community member's needs.

The use of stable isotopic and coprolite analysis within the contexts of the bioarchaeology of care can enrich studies seeking to understand different aspects of community involvement in care, such as the awareness and recognition of the community that a member needs care, and the care the community is willing to give to an individual. While these studies can only be implemented in certain circumstances, such as the case of mummified remains, they offer a perspective that otherwise would not be detected.

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Appendix A. Supplementary data

Supplementary material follows the References.

References

- Barth, E., Kundrotas, L., 2011. Megacolon from Chagas disease in an ancient Texan. *Gastroenterology* 141 (1), 403.
- Black, S.L., Thorns, A.V., 2014. Hunter-gatherer earth ovens in the archaeological record: fundamental concepts. *Am. Antiq.* 79 (2), 204–226.

- Bousman, C.B., Quigg, M., 2006. Stable carbon isotopes from archaic human remains in the Chihuahuan Desert and Central Texas. *Plains Anthropol.* 51, 123-139.
- Boyd, C.E., 2013. *Rock Art of the Lower Pecos* (No. 8). Texas A&M University Press.
- Boyd, C.E., Cox, K., 2016. *The White Shaman Mural: An Enduring Creation Narrative in the Rock Art of the Lower Pecos*. University of Texas Press.
- Boyd, C.E., Dering, J.P., 1996. Medicinal and hallucinogenic plants identified in the sediments and pictographs of the Lower Pecos, Texas Archaic. *Antiquity* 70 (268), 256-275.
- Bryant, V.M., 1974a. Prehistoric diet in southwest Texas: the coprolite evidence. *Am. Antiq.* 39, 407-420.
- Bryant, V.M., 1974b. The role of coprolite analysis in archaeology. *Bull. Texas Archeol. Soc.* 74, 1-28.
- Bryant, V.M., Reinhard, K.J., 2012. Coprolites and archaeology: the missing links in understanding human health. In: In: Hunt, A. (Ed.), *Vertebrate Coprolites*. New Mexico Museum of Natural History and Science Bulletin 51. pp. 379-387.
- Bryant, V.M., Williams-Dean, G., 1975. The coprolites of man. *Sci. Am.* 232 (1), 100-109.
- Camacho, M., Araújo, A., Morrow, J.J., Reinhard, K.J., 2018. Recovering parasites from mummies and coprolites: establishing an epidemiological approach. *Parasit. Vectors* 11 (1), 248-265.
- Cuda, T., Gunnarsson, R., de Costa, A., 2018. Symptoms and diagnostic criteria of acquired Megacolon – a systematic literature review. *BMC Gastroenterol.* 18, 25-34.
- Danielson, D.R., Reinhard, K.J., 1998. Human dental microwear caused by calcium oxalate phytoliths in prehistoric diet of the Lower Pecos Region, Texas. *Am. J. Phys. Anthropol.* 107, 297-304.
- DeNiro, M.J., Epstein, S., 1978. Influence of diet on the distribution of carbon isotopes in animals. *Geochim. Cosmochim. Acta* 42, 495-506.
- DeNiro, M.J., Epstein, S., 1981. Influence of diet on the distribution of nitrogen isotopes in animals. *Geochim. Cosmochim. Acta* 45 (3), 341-351.
- Edwards, S.K., 1990. *Investigations of Late Archaic Coprolites: Pollen and Macrofossil Remains From Hinds Cave (41VV456), Val Verde County, Texas*. Doctoral Dissertation. Department of Anthropology. Texas A&M University, College Station, Texas.
- Flórez, O., Esper, J., Higuera, S., Barraza, M.F., Cabrera, H.B., Mantilla, J.C., Rugeles, C.I.G., 2010. Chagasic megacolon associated with *Trypanosoma cruzi* I in a Colombian patient. *Parasitol. Res.* 107 (2), 439-442.
- Geib, D., Jones, J.D., 1902. Unprecedented case of constipation. *J. Am. Med. Assoc.* 38 (20), 1304-1305.
- Hard, R.J., Katzenberg, M.A., 2011. A stable isotope study of hunter-gatherer-fisher diet, mobility, and intensification on the Texas gulf Coastal plain. *Am. Antiq.* 76 (4), 709-751.
- Huebner, J.A., 1991. Cactus for dinner, again! An isotopic analysis of late archaic diet in the Lower Pecos region of Texas. *Papers on Lower Pecos prehistory*.

- In: In: Solveig, A. (Ed.), Turpin 8. Texas Archeological Research Laboratory, University of Texas at Austin, pp. 175–190.
- Kirkland, F., Newcomb, W.W., 1996. *The Rock Art of Texas Indians*. University of Texas Press.
- Knudson, K.J., Aufderheide, A.E., Buikstra, J.E., 2007. Seasonality and paleodiet in the Chiribaya polity of southern Peru. *J. Archaeol. Sci.* 34, 451–462.
- Koenig, C.W., 2012. *Burned Rock Middens, Settlement Patterns, and Bias in the Lower Pecos Canyonlands of Texas*. Masters Thesis. Department of Anthropology. Texas State University-San Marcos, San Marcos, Texas.
- Lord, K.J., 1984. *The Zooarchaeology of Hinds Cave (41 VV 456)*. Doctoral dissertation. Department of Anthropology. The University of Texas Austin, Austin, Texas.
- Macko, S.A., Bada, J., Ambler, R.P., Eglinton, G., Sykes, B., Griffiths, J.B., 1999. Documenting the diet in ancient human populations through stable isotope analysis of hair - discussion. *Philos. Trans. R. Soc. Lond. Ser. B-Biol. Sci.* 354, 75–76.
- Marks, M.K., Rose, J.C., Buie, E.L., 1985. Bioarcheology of seminole sink. In: Turpin, S.A. (Ed.), *Seminole Sink: Excavation of a Vertical Shaft Tomb*. Research Report 93. The University of Texas at Austin, Texas Archaeological Survey.
- Martin, G.C., 1933. *Archaeological Exploration of the Shumla Caves: Report of the George C. Martin Expedition*. Witte Memorial Museum, San Antonio.
- McGregor, R., 2013. Basketry and other perishable arts. In: Shafer, H. (Ed.), *Painters in Prehistory: Archaeology and Art of the Lower Pecos Canyonlands*. Trinity University Press, San Antonio, pp. 153–170.
- Mekota, A.M., Grupe, G., Cuntz, U., Ufer, S., 2006. Serial analysis of stable nitrogen and carbon isotopes in hair: monitoring starvation and recovery phases of patients suffering from Anorexia Nervosa. *Rapid Commun. Mass Spectrom.* 20, 1604–1610.
- Mekota, A.M., Grupe, G., Ufer, S., Cuntz, U., 2009. Identifying starvation episodes using stable isotopes in hair. *Rechtsmedizin* 19, 431–440.
- Mock, S.B., 2013. Painted pebbles: Lower Pecos women take charge. In: Shafer, H. (Ed.), *Painters in Prehistory: Archaeology and Art of the Lower Pecos Canyonlands*. San Antonio. Trinity University Press, pp. 223–240.
- Neuberger, F.M., Jopp, E., Graw, M., Püschel, K., Grupe, G., 2013. Signs of malnutrition and starvation- reconstruction of nutritional life histories by serial isotopic analyses of hair. *Forensic Sci. Int.* 226, 22–32.
- O'Connell, T., 2001. Isotopic comparison of hair, nail and bone: modern analyses. *J. Archaeol. Sci.* 28, 1247–1255.
- O'Dwyer, R.H., Acosta, A., Camilleri, M., Burton, D., Busciglio, I., Bharucha, A.E., 2015. Clinical features and colonic motor disturbances in chronic megacolon in adults. *Dig. Dis. Sci.* 60 (8), 2398–2407.
- Petzke, K.J., Boeing, H., Metges, C.C., Klaus, S., 2005. Carbon and nitrogen stable isotopic composition of hair protein and amino acids can be used as biomarkers for animal-derived dietary protein intake in humans. *J. Nutr.* 135, 1515–1520.

- Rassi Jr, A., Rassi, A., Marin-Neto, J.A., 2010. Chagas disease. *Lancet* 375 (9723), 1388–1402.
- Reece, J.B., Campbell, N.A., 2009. *Biology*. Pearson Benjamin Cummings, San Francisco.
- Reinhard, K.J., 2017. Reestablishing rigor in archaeological parasitology. *Int. J. Paleopathol.* 19, 124–134.
- Reinhard, K.J., Araujo, A., 2015. Prehistoric earth oven facilities and the pathoecology of chagas disease in the Lower Pecos Canyonlands. *J. Archaeol. Sci.* 53, 227–234.
- Reinhard, K.J., Bryant, V.M., 2008. Pathoecology and the future of coprolite studies. In: Stodder, A.W.M. (Ed.), *Reanalysis and Reinterpretation in Southwestern Bioarchaeology*. Arizona State University Press, Tempe.
- Reinhard, K.J., Fink, T.M., Skiles, J., 2003. A case of megacolon in Rio Grande Valley as a possible case of Chagas disease. *Memorias do Instituto do Oswaldo Cruz* 98, 165–172.
- Reinhard, K.J., Szuter, C., Ambler, J.R., 2007. Hunter-gatherer use of small animal food resources. *Int. J. Osteoarchaeol.* 17, 416–428.
- Reinhard, K.J., Chaves, S.A.M., Iñiguez, A.M., 2008. Chloroplast aDNA in prehistoric Texas coprolites: evidence of contamination, medicine, and diet. *J. Archaeol. Sci.* 35, 1748–1755.
- Riley, T., 2008. Diet and seasonality in the Lower pecos: evaluating coprolite data sets with cluster analysis. *J. Archaeol. Sci.* 35, 2726–2741.
- Riley, T., 2012. Assessing diet and seasonality in the Lower Pecos Canyonlands: an evaluation of coprolite specimens as records of individual dietary decisions. *J. Archaeol. Sci.* 39, 145.
- Robbins, C.R., 2002. *Chemical and Physical Behavior of Human Hair*, 4th ed. Springer, New York.
- Sandford, M.K., Kissling, G.E., 1993. Chemical analyses of human hair: anthropological applications. In: Sandford, M.K. (Ed.), *Investigations of Ancient Human Tissue: Chemical Analyses in Anthropology*. Gordon and Breach, Philadelphia, pp. 131–166.
- Shafer, H.J., 1975. Clay Figurines from the Lower Pecos region, Texas. *Am. Antiq.* 40 (2), 148–158.
- Shafer, H.J., 1986. *Ancient Texans: Rock Art and Lifeways Along the Lower Pecos*. San Antonio Museum Association; Texas Monthly Press.
- Shafer, H.J. (Ed.), 2013. *Painters in Prehistory: Archaeology and Art of the Lower Pecos Canyonlands*. Trinity University Press, San Antonio.
- Shafer, H.J., 2013b. Cultural and stylistic through time in the lower Pecos. In: Shafer, H.J. (Ed.), *Painters in Prehistory: Archaeology and Art of the Lower Pecos Canyonlands*. Trinity University Press, San Antonio, pp. 59–91.
- Shafer, H.J., 2013c. Culture and lifeways of native peoples in the Lower Pecos. In: Shafer, H.J. (Ed.), *Painters in Prehistory: Archaeology and Art of the Lower Pecos Canyonlands*. Trinity University Press, San Antonio, pp. 93–138.
- Sharp, Z., 2007. *Principles of Stable Isotope Geochemistry*. Pearson/Prentice Hall, Upper Saddle River.
- Sobolik, K.D., 1988. Diet change in the Lower Pecos: analysis of baker cave coprolites. *Bull. Texas Archeol. Soc.* 59, 111–127.

- Sobolik, K.D., 2008. Nutritional constraints and mobility patterns in the Northern Chihuahuan Desert. In: Reitz, E.J., Scarry, C.M., Scudder, S.J. (Eds.), *Case Studies in Environmental Archaeology*, 2nd ed. Springer, NY, pp. 211–234.
- Sponheimer, M., Roeder, B., Robinson, T., Ehleringer, J., Ayliffe, L., Shipley, L., Dearing, D., Cerling, T., Lopez, E., Passey, B., 2003. An experimental study of carbon-isotope fractionation between diet, hair, and feces of mammalian herbivores. *Can. J. Zool.* 81, 871–876.
- Stock, J.A., 1983. The Prehistoric Diet of Hinds Cave: (41 VV 456), Val Verde County, Texas : The Coprolite Evidence. Master's Thesis. Department of Anthropology. Texas A&M University, College Station, Texas.
- Tilley, L., Cameron, T., 2014. Introducing the Index of Care: a web-based application supporting archaeological research into health-related care. *Int. J. Paleopathol.* 6, 5–9.
- Tilley, L., 2017. Showing that they cared: an introduction to thinking, theory and practice in the bioarchaeology of care. In: Tilley, L., Schrenk, A. (Eds.), *New Developments in the Bioarchaeology of Care*. Bioarchaeology and Social Theor. Springer, pp. 11–43.
- Turpin, S.A., 1988. Cultural implications of seminole sink. In: Turpin, S.A. (Ed.), *Seminole Sink: Excavation of a Vertical Shaft Tomb, Val Verde County, Texas*, Research Report 93. Texas Archaeological Survey. The University of Texas at Austin, pp. 119–141.
- Turpin, S.A., 1996. Painting on bones and other unusual media in the lower and transpecos region of Texas and Coahuila. *Plains Anthropol.* 41 (157), 261–272.
- Turpin, S.A., Hennenberg, M., Riskind, D.H., 1986. Late archaic mortuary practices of the Lower Pecos River region, southwest Texas. *Plains Anthropol.* 31 (114), 295–315.
- Valkovic, V., 1988. Human hair. *Fundamentals and Methods for Measurement of Elemental Composition*, vol. I CRC Press, Boca Raton.
- Verostick, K.A., 2013. Using Prehistoric Mummy Hair and Stable Isotopes to Understand Paleodiet and Seasonality: a Case Study in the Lower Pecos of South Texas. Master's Thesis. Department of Anthropology. The University of Texas at San Antonio, San Antonio, Texas.
- Williams, J.S., Katzenberg, M.A., 2011. Seasonal fluctuations in diet and death during the late horizon: a stable isotopic analysis of hair and nail from the Central Coast of Peru. *J. Archaeol. Sci.* 39, 41–57.
- Williams-Dean, G.J., 1978. Ethnobotany and Cultural Ecology of Prehistoric Man in Southwest Texas. Doctoral dissertation. Department of Anthropology. Texas A&M, College Station, Texas.
- Winkler, B.A., 1982. Wild Plant Foods of the Desert Gatherers of West Texas, New Mexico and Northern Mexico: Some Nutritional Values. Master's Thesis. Department of Anthropology. University of Texas at Austin, Austin.

Supplement

Summary of protocols and interpretation isotopic sampling of hair.

The 17cm hair sample was segmented into 1cm portion for IRMS testing, and was processed via a modified procedure based on Petzke et al. (2005). To aid in removal of the shellac, an acetone step was added. All preparation steps were performed at the Paleo-Research Laboratory at the Center for Archaeological research at the University of Texas San Antonio (CAR-UTSA). IRMS testing was done at the Colorado Plateau Stable Isotope Laboratory at Northern Arizona University (CPSIL-NAU). Samples were analyzed using a Thermo-Electron Delta V Advantage Isotope Ratio Mass Spectrometer configured through the CONFLO III using a Carlo Erba NC2100 elemental analyzer. Both carbon and nitrogen isotopic compositions were obtained during a single run. $\delta^{13}\text{C}$ values are reported in per mil relative to the Vienna Pee Dee belemnite standard and $\delta^{15}\text{N}$ values are reported relative to AIR. Based on replicative analysis, the CPSIL has an uncertainty of $\leq 0.10\text{‰}$ for $\delta^{13}\text{C}$, $\leq 0.20\text{‰}$ for $\delta^{15}\text{N}$. The SMM hair samples had atomic C/N ratios between 3.4 and 3.6, all within the acceptable range. The commonly accepted values range from 2.9 to 3.8 for uncontaminated hair samples (O'Connell and Hedges, 1999; Williams and Katzenberg, 2011). $\delta^{15}\text{N}$ values are enriched $\approx 3\text{--}4\text{‰}$ in hair relative to diet, while $\delta^{13}\text{C}$ values are enriched $\approx 3\text{--}3.5\text{‰}$ in hair relative to diet (Bousman and Quigg, 2006; White et al., 2009; Williams and Katzenberg, 2011).

Supplemental Table 1– Results from IRMS Analysis on Hair Segments from SMM.

Sample #	δ Carbon (‰)	δ Nitrogen (‰)	%C	%N	C/N
1M,2M	-13.4	12.1	42.5	14.4	3.46
3M	-13.3	12.1	44.8	15.3	3.42
4M	-13.9	12.3	44.5	15.3	3.40
5M	-14.8	12.3	45.7	15.8	3.38
6M	-14.4	12.3	46.0	15.9	3.37
7M	-14.5	12.4	44.3	15.2	3.39
8M	-14.3	12.6	44.8	15.4	3.39
9M	-13.2	12.7	45.9	15.7	3.40
10M	-12.8	12.7	44.0	14.7	3.49
11M	-12.0	12.6	42.5	13.9	3.58
12M	-12.1	12.4	42.9	14.5	3.46
13M	-12.6	12.5	39.8	12.9	3.60
14M	-13.1	13.0	43.1	14.5	3.47
15M	-13.2	12.8	45.3	15.7	3.37
16M	-13.6	13.1	45.0	15.5	3.38
17M	-13.4	12.9	44.9	15.5	3.38

References

O'Connell, T.C., Hedges, R.E., 1999. Investigations into the effect of diet on modern human hair isotopic values. *Am. J. Phys. Anthropol.* 108, 409-425.

White, C.D., Nelson, A.J., Longstaffe, F.J., Grupe, G., Jung, A., 2009. Landscape bioarchaeology at Pacatnamu, Peru: inferring Mobility from $[\delta]^{13}\text{C}$ and $[\delta]^{15}\text{N}$ values of hair. *J. Archaeol. Sci.* 36, 1527-1537.