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Short-term variability of human diet at Basketmaker II Turkey Pen Ruins, Utah: Insights from bulk and single amino acid isotope analysis of hair

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ABSTRACT

Strands of human hair excavated from Basketmaker II Turkey Pen Ruins in Utah were examined using stable carbon and nitrogen isotope analysis and show that these individuals were heavily reliant on maize but their diet fluctuated over a period of months. Through serial bulk carbon and nitrogen analysis and serial single amino acid carbon isotope analysis of individual strands of hair, this study addresses the questions of how human diets at the site varied over a period of months and if domesticated turkeys (*Meleagris gallopavo*) were part of the diet during any point of the year. Hair carbon isotope values range from −9.2‰ to −12.4‰ with an average of −10.8 ± 1.2, and nitrogen isotope values range from 6.0‰ to 7.3‰ with an average of 6.6‰ ± 0.5. There was also variability in the single amino acid $\delta^{13}C$ values, with an overall pattern of terrestrial C_4 signatures of individual amino acids ($\delta^{13}C$ for leucine averaged −17.8‰ ± 1.7). $\Delta^{13}C_{valine\text{-}phenylalanine}$ values ranging from −1.6‰ to 2.6‰ also point strongly to a terrestrial diet. From the stable isotope data presented here, we suggest that BMII diet, while being heavily maize based, did vary during the year, and that turkeys were never a diet staple.

1. Introduction

There have been a number of archeological studies designed to better understand the introduction and use of domesticates such as maize, squash, beans and turkeys in the American Southwest (e.g. Coltrain and Janetski, 2013; Decker and Tieszen, 1989; Matson, 1991; Munro, 1994, 2006). Archeological evidence has shown that maize was present in the northern Southwest by 2200 BC (Huber, 2005; Huckell, 1996). By the Basketmaker II (BMII) period (~1000 BC–500 AD), there is also evidence of domesticated squash and turkeys, although beans do not appear in the archeological record until the Basketmaker III period (BMIII) (Decker and Tieszen, 1989; Kidder, 1924; Lipe, 1978; Matson, 1991; Spangler et al., 2010).

This study focuses on two questions using serial stable carbon, nitrogen, and serial single amino acid carbon isotope analyses of human hair from the BMII midden at Turkey Pen Ruins: 1) Was the relative proportion of maize to foraged material constant throughout the year, or were there periods of time (seasons) when these BMII individuals relied more heavily on foraged foods in their diet? 2) Multiple studies have shown that domesticated turkeys were fed maize during the BMII period (Aasen, 1984; Munro, 1994; Nott, 2010), and that humans from this period have carbon isotopic signatures that would be consistent with eating mainly maize, or eating meat from maize-fed turkey (Matson and Chisholm, 1991); within this established context, were the individuals from BMII Turkey Pen Ruins eating enough turkey on a regular or seasonal basis to contribute to their high maize-consumption isotopic signatures?

2. Background

2.1. Archeology of Turkey Pen Ruins on Cedar Mesa

In 1972, as part of the Cedar Mesa Project in southeastern Utah, R.G. Matson and William Lipe excavated a test pit in the BMII midden at the Turkey Pen site located in the neighboring Grand Gulch, in an alcove named for the "turkey pen" structure dating to a later Puebloan occupation (Fig. 1) (Matson, 2015b, Matson, 1991). Three columns were taken from the midden — two columns were excavated and sifted in situ to expose the central column between them (Matson, 1991). This central column was removed intact and examined stratum by stratum (Fig. 2) (Matson, 1991). Organic materials such as coprolites, hair, and feathers were well preserved by arid conditions at the site (Matson, 2015b, Matson, 1991). Radiocarbon analysis of numerous organic inclusions in the columns dated the BMII occupation of Turkey Pen Ruins to approximately 100 BC to AD 200 (Lipe et al., 2011; Matson, 2015b; Matson and Chisholm, 1991).

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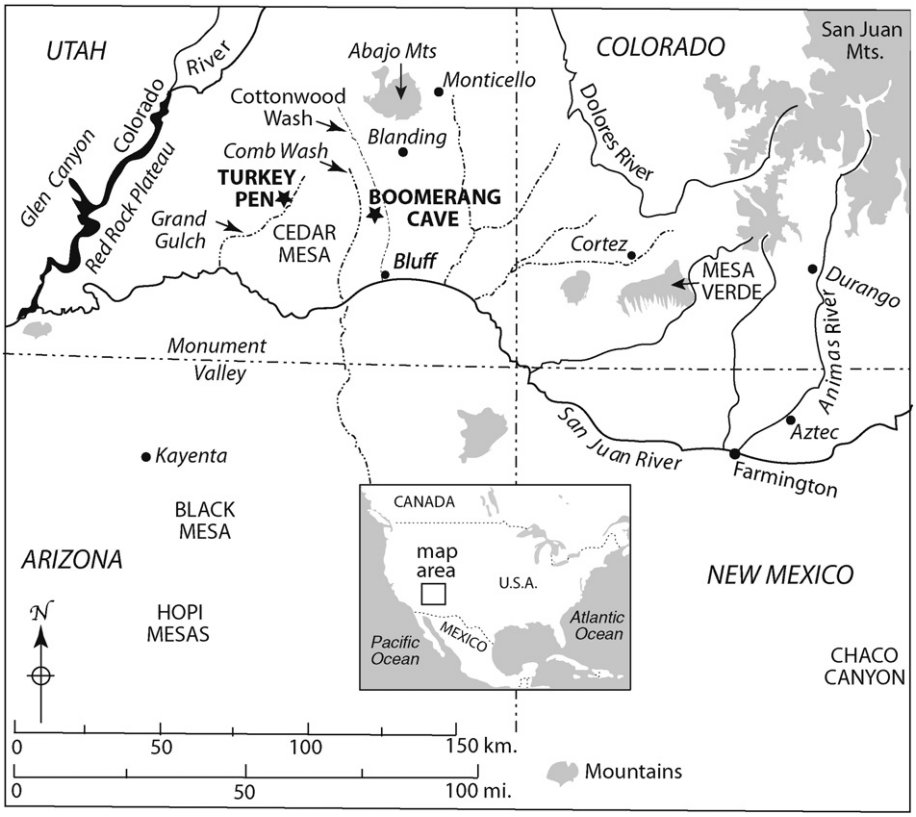

Fig. 1. Map of the Four Corners Region with Turkey Pen Ruins.

Maize (*Zea mays*) was a dietary staple at BMII Turkey Pen Ruins (Aasen, 1984; Matson, 1991, 2006; Matson and Chisholm, 1991). The BMII settlement pattern on Cedar Mesa is similar to those of later occupations and there is no evidence of a transition phase between a hunting and gathering tradition to a horticultural one (Matson, 1991). This evidence agrees with the human coprolite analysis, which found maize in a majority of the Turkey Pen coprolites (Aasen, 1984; Matson, 1991; Matson et al., 1988). Maize was also the greatest contributor to the macrofossil weight in most of the coprolites (Aasen, 1984; Matson et al., 1988). Coprolite and palynological analyses show that lesser contributors to the BMII diet include domesticated squash (*Cucurbita* sp.), pinion pine nuts (*Pinus*), ricegrass (*Stipa hymenoides*) chenopods and amaranth (Aasen, 1984; Matson and Chisholm, 1991). Isotopic analysis of human bone collagen from individuals excavated from the surrounding mesa resulted in similar conclusions being drawn, concurring with an overall high-maize consumption by Cedar Mesa BM II individuals (Chisholm and Matson, 1994; Matson and Chisholm, 1986, 1991).

Turkeys found in archeological contexts in the American Southwest have been identified as belonging to two mitochondrial haplogroups: one representing the local Merriam type (*Meleagris gallopavo merriami*) and the other one interpreted as a domesticate (Speller et al., 2010). This domesticate is more closely related to subspecies that are today found to the east of the Pueblo Southwest, *M. g. silvestris* or *M. g. intermedia* (Speller et al., 2010). Analysis of turkey coprolites from BMII Turkey Pen Ruins shows that the turkeys were fed maize (Aasen, 1984; Nott, 2010). The purpose of keeping domesticated turkeys is hypothesized to be for their feathers, which had ritual and economic value as ceremonial objects such as trimming on costumes or feather bundles and their use in feather blankets (Lipe et al., 2015; Munro, 1994, 2006). During the BMII period there is a lack of large assemblages of turkey bones with cut-marks or evidence of burning; this has been interpreted as indicating that turkeys were not a major source of food (Munro, 1994, 2006). Isotopic data from human bone collagen similarly suggests that the individuals from BMII mainly relied on plants and not meat for food (Chisholm and Matson, 1994; Coltrain and Janetski, 2013). Only one BMII study examining BMII human coprolites suggests that meat may have been a significant part of the diet in this region (Androy, 2003).

Seasonality of diet at Turkey Pen Ruins has only been briefly addressed. Aasen suggested that the use of the site was from the spring to the fall on the basis of pollen and macrofossil content of the coprolites, but the data was not conclusive (Aasen, 1984). This interpretation of seasonal use was supported by Androy's analysis of BMII coprolites from Boomerang Shelter (Fig. 1), which included a suggestion that meat might have been eaten in greater proportions during winter (Androy, 2003).

2.2. Stable carbon and nitrogen isotope analysis

Carbon and nitrogen isotope analyses can be used to create a useful bivariate data set for examining diets of past (and present) individuals (Lee-Thorp, 2008). Carbon isotope analysis compares the ratio of 1 ^{13}C to 1000 ^{12}C (expressed as $\delta^{13}C$ (‰) relative to an international standard), and can differentiate between proteins garnered from C_3 and C_4 plants (van der Merwe and Vogel, 1978). The differentiation between these plant types is possible because C_3 and C_4 plants utilize different photosynthetic pathways to incorporate atmospheric CO_2 (Lee-Thorp, 2008). C_4 plants are less likely to select for lighter atmospheric CO_2 containing ^{12}C, and so often have a higher $\delta^{13}C$ ratio compared to C_3 plants (Lee-Thorp, 2008). There is one other common photosynthetic pathway: crassulacean acid metabolism (CAM) which incorporates aspects of both C_3 and C_4 photosynthetic pathways such that CAM plants have differing $\delta^{13}C$ signatures depending on the climate (Ambrose and Norr, 1993). Of the plants used at BMII Turkey Pen Ruins, maize is C_4, squash, piñion pine, and Indian rice grass are C_3, and chenopods, yucca and amaranths are CAM plants (Coltrain and Janetski, 2013).

Nitrogen isotope analysis, comparing the ratio of 1 ^{15}N to 1000 ^{14}N (expressed $\delta^{15}N$ (‰) relative to an international standard), can reveal