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Landscape bioarchaeology at Pacatnamu, Peru: inferring mobility from $\delta^{13}C$ and $\delta^{15}N$ values of hair

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ABSTRACT

Stable carbon- and nitrogen-isotope ratios were measured for segments along the shafts of hair from eight individuals from the site of Pacatnamu, located in the Jequetepeque Valley on the north coast of Peru. All are from known grave contexts dating from Moche (ca. 450–750 A.D.) to Lambayeque periods (ca. 900–1100 A.D.). The mean $\delta^{13}C$ and $\delta^{15}N$ values of hair segments from individuals are comparable to those of bone, and demonstrate increased consumption of marine resources in the Lambayeque times relative to the Moche period.

Sequential analyses of the hair, however, reveal that intra-individual dietary variation occurring over periods of months is even greater than that between cultural periods. The frequency, timing and amplitude of these shifts are not what would be expected of seasonal differences. Instead, they more likely indicate geographic relocations resulting from short-term travel between regions with different food resources, for example, the coast and the highlands. Adult males exhibit more dramatic shifts than the children and there is no evident patterning in the residence place of individuals close to the time of death. There are several possible reasons for this variability. First, as previously proposed, Pacatnamu may have been a pilgrimage site. Second, there may have been coastal-highland movement, indicating complex utilization of the landscape, possibly including the verticality thought to characterize many ancient Peruvian exchange systems. Finally, Pacatnamu may have functioned as an administrative center for a large geographic area. Thus, the reason for these geographic relocations may have been religious, economic or administrative in nature.

1. Introduction

Isotopic paleodiet reconstruction in the Andes to date has been used to examine: relationships between maize consumption and cultural development/processes (Burger and van der Merwe, 1990; Ericson et al., 1989; Hastorf and Johannessen, 1993; Olivera and Yacobaccio, 1995; Sandness Bruwelheide, 1995; Tieszen et al., 1992; Tomczak, 2003; Tykot and Staller, 2002; Verano and DeNiro, 1993; Williams and Katzenberg, 2004; Williams, 2005), status and gender differences (Hastorf, 1991; Hastorf and Johannessen, 1993; Ubelaker et al., 1995), animal husbandry practices (Finucane et al., 2006), and the presence of "foreigners" in some contexts (Andrushko et al., in press; Aufderheide et al., 1994; Baraybar, 1999; Verano and DeNiro, 1993). Many of these studies have demonstrated a dietary difference between coastal and highland sites. In this study, we present isotopic data from the bone and hair of ancient humans from the coastal site of Pacatnamu (Fig. 1).

Although bone is the tissue most often used for isotopic analysis of ancient humans because it is most commonly preserved, it can only provide an averaged picture of food consumption over roughly a 10-year period (Manolagas, 2000) because it is a metabolically active tissue that constantly remodels. The rare presence of hair in an archaeological population provides an opportunity to add more detail to the long-term homogenized isotopic record provided by bone. The use of hair to reconstruct short-term dietary shifts occurring during the most recent part of an individual's life is possible because ancient hair is generally thought to preserve its original isotopic compositions (Lubec et al., 1986; Macko et al., 1999; Robbins, 2002; Roy et al., 2005), and because hair grows quickly from its roots in a linear sequence and does not maintain its metabolic activity by regenerating the cells it lays down (O'Connell et al., 2001). Therefore, the sequential analysis of hair segments allows the testing of a wide variety of hypotheses related to short-term dietary change. Furthermore, the original biogenic signal of

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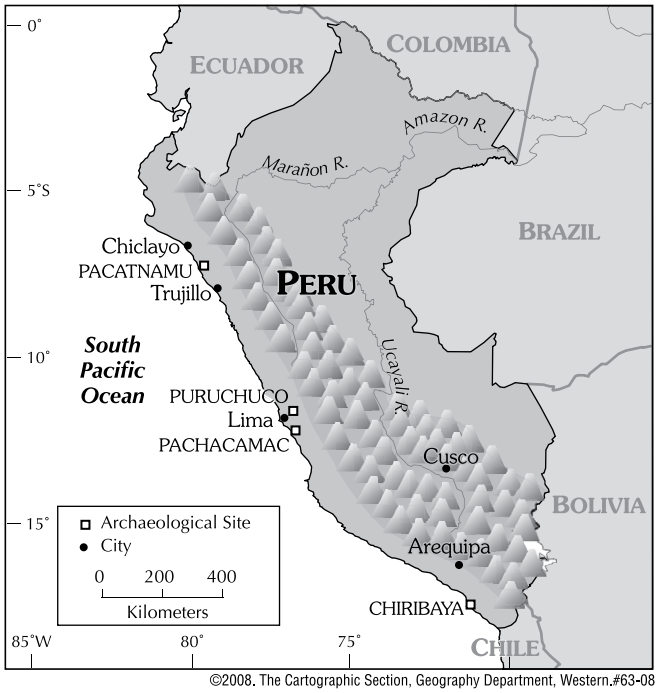

Fig. 1. Map showing the location of Pacatnamu.

carbon and nitrogen in hair keratin is generally quite resistant to atmospheric and cosmetic contamination (O'Connell and Hedges, 1999), as well as diagenesis (Kempson et al., 2003).

We compare the consistency of our values with the isotopic bone collagen data from surface remains left from looting (and subject to diagenesis) with bone collagen from excavated primary contexts published by Verano and DeNiro (1993). The isotopic data for human hair from this site are then tested for comparability to isotopic data for human bone, and sequential analysis of hair segments is used to augment the long-term and culturally diachronic dietary data derived from bone with short-term dietary data from hair. The reconstruction of behaviours producing short-term records such as seasonality, short-term movements between the coast and the highlands, or recent permanent relocations of individuals from different environments are important for understanding the function of the site.

Pacatnamu is a large urban archaeological site located in the Jequetepeque Valley on the North Coast of Peru. Archaeological excavation has revealed a sequence of occupations there, ranging from Moche (ca. 350AD) to Lambayeque (also referred to as Sican – ca. 1370 AD) times (Donnan, 1997; Hecker and Hecker, 1995). Opinions of the primary function of the site and whether it had a local or regional (or inter-regional) focus have differed. Those who argued for the wider focus also believed that it was a major pilgrimage center. Uhbelodde-Doering (1959) was the first to suggest a pilgrimage function based on the wide diversity among the ceramic jars he excavated. He hypothesized that people came from distant sites to celebrate or engage in ritual, and/or to be buried there because it was a holy place. A variation of this theme was expressed by Keatinge (1977), whose analysis of artifacts (particularly textiles) led him to conclude that Pacatnamu may represent a "perfect example of a cult center" (1977: 242) that functioned as part of a network of coastal religious centers including the central coast site of Pachacamac (Keatinge, 1982). Kosok (1965) supported an inter-regional role for the site, but felt that its primary function was the control of irrigation. Donnan (1986, 1997) rejected the pilgrimage model because exotic artifacts were not found in his excavations: rather, the majority of ceramics recovered were simple, utilitarian objects. He did, however, feel that Pacatnamu "undoubtedly served as a focus of ceremonial activity and political power for the population of the lower Jequetepeque Valley" (Donnan, 1986: 23). Boynter (1998) echoed this conclusion in his analysis of Pacatnamu textiles arguing that the site conformed to a model of a "Regal-Ritual City" (1998:187) wherein the exercise of power by the ruling elite relied on the ritualized expression of ideology. In this latter view, Pacatnamu was a ceremonial/administrative center with a local focus.

The differing hypotheses for the function of the site provide a useful opportunity for investigating population mobility. If the primary focus were local, then short-term dietary shifts found in the hair of individuals buried there should be minimal, and only reflect possible cyclical seasonal dietary changes. However, if the primary focus were regional or inter-regional in scale, then there may be more irregular and extreme dietary shifts that reflect movement through different environmental zones.

2. Theoretical considerations

2.1. Stable isotope analysis

The stable isotopes of carbon and nitrogen are expressed in per mil (‰) as δ-values:

$$\delta = \left[\left(R_{\text{sample}}/R_{\text{standard}}\right) - 1\right]1000$$

Carbon-isotope ratios are measured relative to the Vienna PDB (VPDB) standard (Coplen, 1994) and the nitrogen-isotope standard (AIR, Hoefs, 1997) is purified atmospheric nitrogen calibrated using IAEA-N1 (.4‰) and IAEA-N2 (+20.3‰). These isotopic ratios are useful for reconstructing diet because there is variability in the isotopic compositions of foods that are incorporated into the tissues of consumers.

Differences in the way plants use atmospheric ^{13}C during photosynthesis create the most basic level of variation in $\delta^{13}C$ values. C_3 plants are those that discriminate most against ^{13}C during photosynthesis and have the lowest or most negative $\delta^{13}C$ values (average of −26.5‰; O'Leary, 1988; Smith and Epstein, 1971). Plants in Peru are dominantly C_3 (DeNiro and Hastorf, 1985; Tieszen and Chapman, 1992) and include most wild plants and grasses, vegetable cultigens, nuts and fruits. C_4 plants incorporate more ^{13}C during photosynthesis and have higher or more positive $\delta^{13}C$ values (average of −12.5[13]; O'Leary, 1988; Smith and Epstein, 1971). In Peru there are a few C_4 species in the natural environment (e.g. *Amaranthus deflexus*, *Cynodon dactylon*, *Distichlis spicata* [Tieszen and Chapman, 1992]) but maize is the only major C_4 cultivar. A separate category of mainly cacti and succulents is constituted by CAM (Crassulacean acid metabolism) plants. These plants have flexible photosynthetic pathways and a range of $\delta^{13}C$ values (−27 to −12‰) that overlaps with C_3 and C_4 plants. CAM plants are part of modern Peruvian diets particularly in locations 2520 m above sea level where they have a mean value identical to that of C_4 plants (-12.5 ± 1.1‰, Tieszen and Chapman, 1992), and may have been included in ancient diets as well. The $\delta^{13}C$ values of most coastal CAM plants would be indistinguishable from the natural background of C_3 plants.

This basic configuration of expected isotopic compositions in ancient Peruvian plant foods is complicated by several other factors. Modern plants have $\delta^{13}C$ values that are 1.5‰ lower than pre-industrial plants because the burning of ^{12}C-rich fossil fuel has altered the isotopic composition of carbon dioxide in the