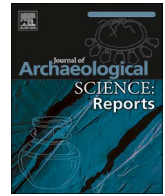




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## Exploring dietary trends in late Holocene populations from Northwest Argentina: Insights from new data on stable isotope analysis ( $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ )

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## ABSTRACT

In the territory of Jujuy province, northwest Argentina (NWA), a marked environmental diversity encouraged the emergence of a wide spectrum of subsistence strategies, during prehistoric times. This work explores the variability of human paleodiets from different environmental and temporal contexts of the province. Bone and tooth samples of 30 individuals from five archaeological sites were analysed: Til 20 (late Formative), Til 1, Yacoraité (Regional Developments and Inca), Til 43 (Hispanic-Indigenous) in Quebrada de Humahuaca, and Doncellas (Regional Developments and Inca) in Puna. The results of carbon and nitrogen isotopic analyses reveal a strong relevance of  $\text{C}_4$  resources and a balance between meat and plant components of the diet for Quebrada de Humahuaca. Late Formative site Til 20 exhibits more enriched  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values than Regional Developments and Inca sites, reflecting higher consumption of  $\text{C}_4$  resources and a greater relevance of meat component in diet or, alternatively, crop manuring practices. Hispanic-Indigenous samples exhibited intermediate isotopic values which indicate the consumption of  $\text{C}_4$  and  $\text{C}_3$  plant resources and enriched animal protein. In Puna,  $\delta^{15}\text{N}$  values show certain homogeneity around values that reflect a balance between meat and plant components in the diet. It is also observed in this region a great dispersion of the  $\delta^{13}\text{C}$  values for organic and mineral fractions, ranging from those reflecting high  $\text{C}_4$  resources intake to those where  $\text{C}_3$  resources have greater relevance.

## 1. Introduction

Dietary studies are of great importance in bioarchaeology, since they allow inquiring about the processes of social change and the diversity of behaviour, within the framework provided by the subsistence economies of each population. According to Wing and Brown (1979) subsistence economies involve complex interactions between cultural concepts of what organisms are edible, the potentials of the environment and the technological repertoire of food procurement and preparation. The diet of a community, in terms of items consumed and how they are distributed is closely linked to the used methods of farming, herding, and hunting. Therefore, advances in technology may allow a more efficient use of resources and enable to provide food to larger amounts of people.

Since inclusion of stable isotope analyses in archaeological

paleodietary studies (DeNiro and Epstein, 1978; Vogel and van der Merwe, 1977), isotopic techniques have merged with traditional sources of evidence and have demonstrated their potential by overcoming many of previous limitations. In general, inferences based on zooarchaeological and archaeobotanical records between others, were limited to the identification of alimentary resources without being able to determine the proportions consumed, or to make distinctions at the individual level. Moreover, these records usually represent a long period of time and therefore, many generations (Olivera and Yacobaccio, 1999; Tykot, 2004).

The main contribution of dietary stable isotopes studies was to allow a closer approximation to the actual food intake of the individuals with a temporal resolution that enables to know the variations within its lifetime. In this way isotopic studies have demonstrated the existence of a direct correlation between the chemical composition of the

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bone and the subsistence economies of the individuals in terms of variations in the proportions of foods consumed, according to its source (e.g. animal, plant), its geographical origin (e.g. terrestrial, marine, fluvial, different altitudinal levels) and the relative importance of domestication (e.g. hunting-gathering versus cultivation-herding) (Ambrose and Krigbaum, 2003).

### 1.1. Cultural developments in NWA

During prehistoric times, a marked environmental diversity, along with significant changes in social organization, propitiated the emergence of a wide spectrum of subsistence strategies among the inhabitants of the territory of Jujuy province, northwest Argentina (NWA). In the course of the first great lapse of occupation, the Archaic Period (ca. from 10000 to 3000/2700 BP), human populations lived in small groups and were characterized by a traditional nomadic pattern of behaviour, according to an economy based on hunting and gathering (Aschero, 2000).

Later, in the Formative Period (from ca. 2600 to 1100 BP), small sedentary or semi-sedentary communities were developed, mainly in Quebrada de Humahuaca. They were organized in dispersed villages at different altitudinal levels in locations with easy access to waterways, generally self-sufficient, based on productive economies. Food production differed markedly between regions. In Puna, it involved the herding of camelids, particularly llama (*Lama glama*), and the cultivation of a few microthermic andean plant C<sub>3</sub> species such as quinoa (*Chenopodium quinoa*), potato (*Solanum* spp.) and ulluco (*Ullucus tuberosus*) in favorable zones (Albeck, 2007). Corn (C<sub>4</sub>) cultivation was limited to highly localized microclimates, such as Casabindo - Doncellas region (Otonello and Krapovickas, 1973). In contrast with Puna, Quebrada de Humahuaca showed climatic conditions that allowed the adoption of agricultural extensive systems since this period, with corn being the predominant cultigen (Albeck, 2000; Lagiglia, 2001). From a socio-political perspective, they were largely egalitarian communities with low or non-centralized political authorities (González and Pérez, 1972; Nielsen, 2001; Olivera and Palma, 1997). However, these villages participated in social interactions aimed to the exchange and distribution of local products throughout the region (Tarragó, 1992; Olivera, 2001).

Between ca. 1100 and 600 BP (Late Period or Regional Developments), the populations of Quebrada de Humahuaca began to form agglomerated settlements, usually located in reliefs with difficult access. Highly hierarchical societies were developed, which kept clear territorial boundaries and exerted political control on other areas (Nielsen, 1996; Tarragó, 2000). These socio-political changes were accompanied by a process of agro-pastoral intensification that played a key role in the development of these societies. Archaeobotanical and zooarchaeological records revealed a great relevance of camelids' domestication associated with grazing practices (Nielsen, 2001; Raffino, 2007), complemented by the consumption of numerous plant resources (beans, gourds, peppers, roots, tubers, etc.). Corn (*Zea mays*) was the most important edible C<sub>4</sub> plant. Hunting practices were never abandoned, although they lost relevance to later times (Madero, 1993). According to the environmental and ecological conditions, the herding of camelids and hunting had greater emphasis on the Puna, while agriculture developed strongly in the Quebrada de Humahuaca, where it involved the construction of agricultural structures such as terraces or irrigation systems (Albeck, 1992; Lagiglia, 2001; Yacobaccio, 2001). Throughout this process, the expansion of commercial networks of both short and long distance continued. These exchange dynamics between regions and ecoregions (e.g. Puna, Quebradas and Yungas), where interaction and circulation of goods and alimentary resources took place, were intensified towards ca. 1000 B.P. and continued up to the end of the sixteenth century (Albeck, 1994, 2000; Nielsen, 2001).

From ca. 600 BP, the Inca imperial expansion process ended up incorporating the NOA within its domains, and thus became part of the

territory called Kollasuyu. Its main function was mining and agricultural production, the labor tribute and also to provide ceramic, textile, and lapidary works (González, 1978; Raffino, 1981; Williams, 2000; González and Tarragó, 2004). Although this situation changed notably certain material and socio-political aspects in the region, the fundamental cultural nucleus and language were maintained (Mendonça et al., 1997; Tarragó, 2000). Some of the strategies for expansion and domination towards the south had a great biocultural impact, such as those related to demographic relocation, in some cases through forced resettlement, the development of multi-ethnic administrative centres, preferential treatment of some ethnic groups and the elimination of populations. This occurred in the context of mining and agro-pastoral production intensification (D'Altroy et al., 1998; Lorandi, 1994). Besides its strategies aimed to obtain the peaceful surrender of the conquered peoples, the Inca imperial state exerted a powerful influence in the native societies of the NOA. It was also able to generate a variety of situations of tension and regional conflict in the different populations of the annexed territories, both by the imposition of new productive and distributive regimes and by the possibility of resistance by some local groups (D'Altroy, 1992; Williams, 2000).

By 1536 CE, Inca domination was in consolidation process at the time of the arrival of European contingents and the subsequent collapse of native societies (González and Pérez, 1972; Otonello and Lorandi, 1987). Although local populations may have had access to some European products at a first stage, their presence in funerary contexts does not reflect the existence of effective physical or biological contact with the invaders, but rather an introduction and diffusion mediated by pre-existing aboriginal structures of circulation and exchange. Only in a second lapse, the contact between native and European cultures was produced, characterized by the violent impact of the successive attempts of conquest and territorial penetration perpetrated by the Spaniards. This second stage culminated with the effective institutional imposition, both armed and religious, that led to the disarticulation of the beliefs, values and institutions of native societies (Mendonça et al., 1997).

### 1.2. Bioarchaeological studies in the region

From the bioarchaeological point of view, based on the available evidence for the study area (Bordach et al., 1999; Gheggi, 2012; Mendonça et al., 1991; Mendonça et al., 2002; Mercolli and Seldes, 2007; Merlo et al., 2005; Miranda, 2012; Nieva, 2001) and considering the above-mentioned socio-cultural processes occurred in the NWA, it is possible to outline expectations about the general trends in food for the temporal periods covered here. For times before 750 BP, some bioarchaeological indicators show a low incidence of nutritional stress, which can be interpreted as the result of adequate access to food resources and a strong relevance of carbohydrates, mainly obtained from maize.

In contrast, towards the second half of the Regional Developments period and later moments, the indicators of nutritional stress rise (Seldes, 2006, 2007). Particularly, it is observed an increase of the frequency of porotic hyperostosis, which is commonly associated with iron-deficiency anemia, derived either from iron-deficient diets, usually with low animal protein content, or from diets in which certain factors may inhibit iron assimilation, such as exaggerated dependence on maize (Aufderheide and Rodríguez-Martín, 2005; Cohen, 1989). Simultaneously, there is an increase in the manifestation of Harris lines and dental enamel hypoplasia, which can be related to severe deficiency events during the juvenile age, specifically of proteins, minerals and/or vitamins.

Taking into account the previously exposed zooarchaeological and archaeobotanical evidence, the bioarchaeological record would indicate that intensification in the production rate, both agricultural and pastoral, did not necessarily implied a higher level of consumption or nutritional improvements since the Formative Period onwards (Killian

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