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Models for paleodietary research: Three case-studies from arid and semi-arid environments in Northwest Argentina

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ABSTRACT

In this article, we present three case-studies of paleodietary reconstruction from Prehispanic agropastoralist societies located in the arid and semi-arid zones of North western Argentina. These three examples include the micro-region of Antofagasta de la Sierra, located in the *puna* of the Catamarca Province; the *puna* archaeological site of Río Doncellas; and the pre-*puna* archaeological site of Los Amarillos. These latter two sites are situated in the Jujuy Province. Here we present a quantitative approximation that provides a relative hierarchy of plant versus animal resource consumption. In so doing, we aim to overcome the uncertainty generated by previous studies on this theme. To this end, we employed the mixed Bayesian model FRUITS (Food Reconstruction Using Isotopic Transferred Signals), which utilises three different proxies – $\delta^{13}\text{C}_{\text{collagen}}$, $\delta^{13}\text{C}_{\text{apatite}}$ and $\delta^{15}\text{N}$. This model confirmed the importance of maize vis-à-vis other resources at Los Amarillos, its lesser relevance within the Antofagasta de la Sierra context, and its negligible presence at the Río Doncellas site. Likewise, within the resource hierarchy of the *puna* economy – *Solanum tuberosum* – a seemingly, marginal crop, in contrast to camelids, gained greater traction. In this manner, we can detect the different nutritional strategies employed by the Prehispanic agropastoralist economies of the region.

1. Introduction

During Pre-Hispanic times and across coeval periods, the existing ecological variability in North-western Argentina (NOA) would have presented a broad variety of economic possibilities. These varied economic life-ways would have resulted in different productive emphasis and the exploitation of certain resources to the detriment of others – for example, the cultivation of meso-thermal plants, such as maize, versus micro-thermal species, such as tubers and pseudo-cereals (Killian Galván, 2015). Likewise, cultivation choice could well have underpinned the social strategies employed in the distribution of these resources (Killian Galván, 2015).

One of the analysis proposed to establish the existence of different patterns of consumption in societies of the past, is that of stable isotope of carbon and nitrogen extracted from human remains. Thus, in this paper, the implications of isotope analysis towards the reliable reconstruction of human diet are examined. To this effect, three case-studies from arid and semi-arid regions with human isotope databases are presented. These are: the micro-region of Antofagasta de la Sierra, Catamarca; the archaeological site of Río Doncellas, Jujuy; and the archaeological site of Los Amarillos, Quebrada de Humahuaca, Jujuy (Fig. 1). These cases were selected because it allowed us to compare the

cereal production economy from areas where its cultivation might have been difficult. On this basis, this research discusses the role of cereal production in the societies of NOA macro-region.

In the case of Antofagasta de la Sierra (ANS), archaeological research in this micro-region allows us to propose – based on different lines of evidence – changes in economic strategies throughout the Late Holocene. In this respect, the consolidation of agro-pastoral groups is postulated, from ca. 2500 years BP. These groups progressively increased plant cultivation, leading from intensive to extensive strategies in agricultural production, a process that would have been further consolidated by the arrival of the Inca Empire to the region (Olivera, 1988). Stable isotope samples were obtained from 14 individuals from different agro-pastoral periods across the Late Holocene. Results, taking in account isotopic values of local and neighbouring resources, indicate that in most of cases, consumption of C_4 plant species such as maize (*Zea mays*) and amaranth (*Amaranthus caudatus*) was less important in relation to other resources, while meat resources from lower elevations within the *puna* eco-region were of a higher significance (Killian Galván et al., 2016a).

The Río Doncellas Archaeological Site (RD) is one of the best-known sites of the Late period (ca. 1000 CE–1450 CE) within the Argentinean Puna (Alfaro de Lanzone, 1988; Pérez and Killian Galván, 2011; Pérez

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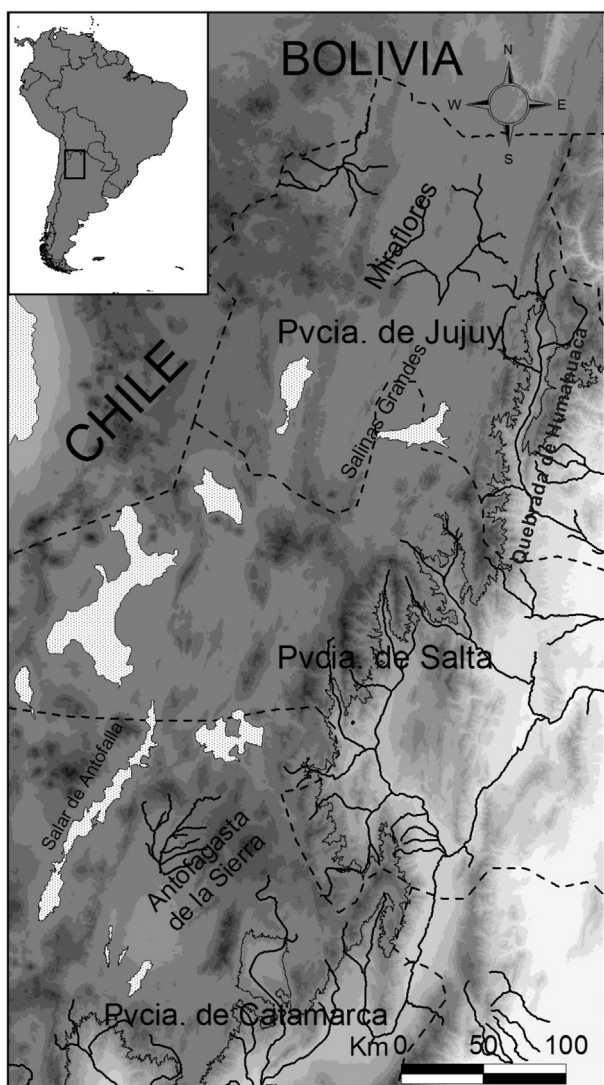


Fig. 1. Map of Puna and Pre-puna areas in Northwest Argentina (Catamarca Province and Jujuy Province), showing the location of the archaeological areas of research: Antofagasta de la Sierra, Miraflores (Archaeological site Río Doncellas) and Quebrada de Humahuaca (Archaeological site Los Amarillos).

de Micou, 1996). Based on research undertaken at the site between the decades of 1940 and 1970, it has been proposed that the population which occupied the area had camelid herding as their main economic activity, but also practiced extensive crop agriculture. From RD, 13 human individuals were sampled for stable isotopes analysis (Killian Galván et al., 2016b). The basis for paleodietary inference were the food resources – plant and fauna – found in the archaeological record, as well as modern comparative data from farms located in the study area (Abra Pampa, Cochinoca, Jujuy). The results indicate that maize (*Zea mays*) was less important than other plant resources within the diet. This contradicts the expectations generated from the macro-botanical evidence of the site, and the cultivation terraces that surround it. Similarly, camelids seemed to have been widely exploited; this was coherent with the modern importance of meat production within the region. These results allowed us to assert that cereal production did not predominate over other resources (Killian Galván et al., 2016b).

Finally, a sample of 20 adult human individuals from different sectors of the site of Los Amarillos, dating to the Regional Developments Period (ca. 1000 CE–1450 CE) and Inca Period (ca. 1430–1536 CE) were analysed. It has been postulated, that for late Prehispanic societies the daily food of these populations might have

been deficient, despite its availability due to an economic system based on the intensification of both meat and plant production. This has been suggested by the zooarchaeological analyzes and the bioarchaeological study of human skeletal series from different late sites of Quebrada de Humahuaca (Mercolli and Seldes, 2007; Seldes, 2007). Based on the data collected, researchers postulated that, despite the presumed greater availability of food resulting from agricultural (where maize stands out) and herding (camelid exploitation) intensification, the consumption of resources – particularly those of animal origin – could be unequal or inadequate (Mercolli and Seldes, 2007). In this case, our aim was to determine the predominant resources used in their diets, against the background of the regional plant and animal isotope (Killian Galván et al., 2016c). We also evaluated the internal variability of the sample, taking into consideration the location of the individuals in the site. The results indicate a balanced diet of meat resources located at levels below 3.900 m.a.s.l., and C_4 photosynthetic pathway plants (maize and amaranth). On the other hand, the consideration of the contextual data on the burials revealed little variability in dietary patterns (Killian Galván et al., 2016c).

All the samples, from across the three case-studies, were analysed using the same methodology: in all the cases, the interpretative methods employed were semi-quantitative and based on the comparison of human isotope values with pre-defined isotope ranges associated with types of diet. Thus, these studies have not fully quantitatively defined the importance of animal versus plant resources (Killian Galván et al., 2016a; Killian Galván et al., 2016b; Killian Galván et al., 2016c). Nevertheless, we build upon previous work in these three areas, by quantitatively reconstructing the diet of the population using the Bayesian mixing model FRUITS (Fernandes et al., 2014). Estimates generated by FRUITS include the relative calorie contribution from available food groups, levels of protein intake, and the relative protein contribution from each food group. Also, given the possibility of including a priori information as restrictions on the relative intake of macronutrients, the results thus rendered can be more realistic. Therefore, the aim of the present paper is to solve equifinality problems generated by an earlier methodology that did not consider the importance of macronutrient concentrations in each set of foods. We also differentiate between assemblages that exhibit similar isotopic signals, consequently establishing which set of resources supported the economy in each case: maize production, camelid exploitation or micro-thermal plant resources, such as high-altitude tubers.

2. Material and site description

2.1. Antofagasta de la Sierra (AS, Catamarca province)

Antofagasta de la Sierra (AS, Catamarca province) is in a typical Puna environment (Fig. 1, Table 1), with rainfall averaging 124 mm per year. The area presents a highly heterogeneous landscape, with three micro-environments and therefore different types of resources available: a) the basin bottom (3400–3550 m.a.s.l.) offers the best possibilities for agriculture with its open topography and water availability; b) the intermediate sectors (3550–3800 m.a.s.l.), which include the lower and middle sections of the Punilla River tributaries, with its availability of fodder, water and land suitable for agro-pastoral production, but of lesser extent and importance than the basin bottom, it also includes big extensions of shrubs; c) the high ravines (3800–4600 m.a.s.l.) including the narrow ravines of the middle and upper sections of the Punilla River tributaries, with permanent water and diverse fodder resources suitable for hunting and grazing activities (Olivera and Podestá, 1993).

The exploitation of all these areas, either in an articulated manner, or with a greater emphasis on one resource would have varied over time, and with it, presumably, the food consumption strategies employed (Olivera, 1992). For the Initial Period (ca. 3000–1700 years BP), an economic model that combined llama (*Lama glama*) pastoralism with agriculture has been suggested. In this model pastoralism was the main

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