Journal of Archaeological Science: Reports xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Carbon and nitrogen isotopic ecology of Holocene camelids in the Southern Puna (Antofagasta de la Sierra, Catamarca, Argentina): Archaeological and environmental implications

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ARTICLE INFO

Keywords:
Camelids
Carbon stable isotopes
Nitrogen stable isotopes
Holocene
Puna

ABSTRACT

This article focuses on camelid isotope ecology from archaeological sites dating to the Holocene (*c.* 9800–420 BP) located in the Southern Argentine Puna. We present 92 carbon and nitrogen stable isotope values ($\delta^{13}C$ and $\delta^{15}N$) extracted from wild (*Vicugna vicugna* and *Lama guanicoe*) and domesticated (*L. glama*) camelid bone collagen. The samples come from the following archaeological sites: Quebrada Seca 3, Cueva Salamanca 1, Peñas de la Cruz 1.1, Casa Chávez Montículos 1 and 4, Bajo del Coypar II, Cueva Cacao 1A, Real Grande 1, and Real Grande 6, all of them located over 3300 masl in Antofagasta de la Sierra, Catamarca, Argentina. Mean carbon isotopic relationship ($\delta^{13}C$) was − 17.2‰, ranging from − 20.1‰ to − 11.6‰, and mean nitrogen isotopic relationship ($\delta^{15}N$) was 6.8‰, ranging from 3.4‰ to 10.8‰. We interpret these isotope values against the background of environmental and cultural changes that occurred throughout this period. Variations in $\delta^{13}C$ and $\delta^{15}N$ values were generally not structured per the availability of different pasture areas across varying altitude. Instead, there was an appreciable increase of some $\delta^{13}C$ values in domesticated camelids, suggesting the use of complementary forage in their diet. That aside, the isotope values do not differ significantly among the different camelid taxa. More generally, a noticeable increase in $\delta^{15}N$ values, and to a lesser extent in $\delta^{13}C$ values, was noted at around 8000 BP, coinciding with a palaeoclimatic phase of extreme regional aridity. Yet, no significant increase of $\delta^{13}C$ and $\delta^{15}N$ values was recorded during a later arid phase (1500 BP), and no significant variations were observed in isotope values during the arid and wet fluctuations (sub-phases) within each of the principal Holocene palaeoenvironmental phases recorded for the region. These results highlight the varying magnitude of past climatic changes and their differential impact, and emphasise the need to investigate further into the environmental aspects that produce variation in isotope data.

1. Introduction

The archaeofaunal record from North-Western Argentina, and generally from the South-Central Andes, shows that for thousands of years South American camelids were a key resource for the human populations of the region (Mengoni Goñalons, 2008; Mondini et al., 2013; Mondini and Elkin, 2014; Olivera and Grant, 2008; Yacobaccio, 2001). From the earliest human occupation (*c.* 10,000 BP) of the Antofagasta de la Sierra basin, in the Southern Argentine Puna, animal resources were obtained through hunting. In this scenario, wild camelids—vicuña (*Vicugna vicugna*) and guanaco (*Lama guanicoe*)—represented key species for the hunter-gatherers of the area (Mondini et al., 2013; Mondini and Elkin, 2014). Later, different populations across the Andean area experienced a series of processes that led human groups to undergo profound social and economic changes. In Antofagasta de la Sierra, these changes, possibly involving the local domestication of the llama (*Lama glama*) (Aschero et al., 2012; Elkin, 1996; Grant, 2014; Olivera and Elkin, 1994), date to the late Middle Holocene and the early Late Holocene (*c.* 4500–3000 BP), and culminated in the adoption of an agro-pastoralist way of life. From this moment onwards, hunting, herding and agriculture have played varied social and economic roles, with each enjoying greater or lesser importance through time (Olivera and Grant, 2008).

In this article, we present the results of carbon and nitrogen stable

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http://dx.doi.org/10.1016/j.jasrep.2017.05.045
Received 26 January 2017; Received in revised form 12 May 2017; Accepted 23 May 2017
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isotope analyses on camelid bone collagen from different archaeological sites in the Antofagasta de la Sierra region, with the aim of investigating the diet of these animals and, ultimately, the strategies employed in their exploitation by the prehispanic populations of the area. The archaeological occupations considered here date to the length of the Holocene (*c.* 9800–420 BP), although some periods, notably that from *c.* 6100–2100 BP, are not represented. Anyway, this broad temporal framework provides the necessary depth to consider not only the cultural changes occurring in the area, but also the environmental fluctuations that impacted on the Southern Puna after the Pleistocene. These fluctuations would have affected camelid ecology and, concomitantly, human decisions regarding their exploitation. Furthermore, the sites considered are located throughout the basin, ranging across all areas from the basin bottom (*c.* 3300 masl) to the high ravines (at over 4000 masl). This in turn allows us to assess variability in vegetation cover at different altitudes.

The faunal samples analysed here belong to wild camelids from hunter-gatherer contexts from the following archaeological sites: Quebrada Seca 3 (QS3), Cueva Salamanca 1 (CS1) and Peñas de la Cruz 1.1 (PCz1.1); while wild and domesticated camelid samples were obtained from agro-pastoralist levels at the following sites: Casa Chávez Montículos 1 and 4 (CChM1, CChM4), Bajo del Coypar II Sector 3 (BCII), Cueva Cacao 1A (CC1A), Real Grande 1 (RG1) and Real Grande 6 (RG6) (Fig. 1, Table 1) (Pintar, 2014a; Olivera and Grant, 2008; including bibliography therein). We present and discuss a total of 92 carbon and nitrogen stable isotopes extracted from camelid bone collagen. These isotope values were collected from a series of studies and research projects, the results of which—including some of the first samples from the high Andes in general to be reported for the chronological period considered—have only been partially presented in conferences and articles (Grant, 2017; Grant and Olivera, 2016; Mondini et al., 2010; Mondini and Panarello, 2014; Motta, 2013). Therefore, this is the first time that these values have been compared and interpreted altogether.

Based on these analyses, we explore here the diet and pasturage areas utilised by the different camelid species through space and time as suggested by these isotopes, and evaluate the importance of vegetation variability according to altitude, as well as environmental change throughout the Holocene. Given the results of previous studies in the Andean region (Fernández and Panarello, 1999–2001; López et al., 2013; Mengoni Goñalons, 2007; Yacobaccio et al., 2010; Samec et al., 2014; Szpak et al., 2014; among others), we proposed the hypothesis that isotope values varied according to the altitudinal location of feeding areas, as well as due to palaeoenvironmental change throughout the Holocene. This would result in less negative carbon values at lower altitudes and more positive nitrogen values for the drier palaeoenvironmental phases. Our data implies that the case is not as clear-cut. Indeed, many of our results, both on carbon and nitrogen values, did not develop as expected.

1.1. Environmental and palaeoenvironmental setting

Antofagasta de la Sierra is located between 25°50′ and 26°10′S and between 67°30′ and 67°10′W, at over 3000 masl. It is part of the Southern Argentine Puna, and environmentally belongs to the Salt Puna (Fig. 1). It is characterised by extreme aridity (arid Andean *puna* climate), with annual summer rainfalls ≤ 150 mm, including virtually no rain some years. Mean annual temperature is 9.5 °C, with substantial daily and seasonal amplitude, and low atmospheric pressure. The hydrological network is endorheic, fed by meagre precipitations, ice-melt (November to March), and subterranean aquifers (García Salemi, 1986; Olivera, 1992).

Phytogeographically, the lower part of this region belongs to the Puna Province of the Andean Domain, where the dominant vegetation is steppe shrub, with herbaceous, halophilic and samophilic steppe also present (Cabrera, 1976). Plants with a C_3 photosynthetic cycle are predominant, although C_4 and CAM plants are also found. In the High Andean Province, whose lower boundary varies between 3000 and 4000 masl across the region, C_4 plants are not commonly found (Fernández and Panarello, 1999–2001; Grant, 2016; Panarello and Mondini, 2015). Nevertheless, a recent study in Jujuy has found plants with this photosynthetic signature within this altitudinal range, and even at above 4000 masl (Samec et al., 2015).

In the Antofagasta de la Sierra basin, the lower and intermediate areas are dominated by *tolar* formations, composed principally of shrubs and with a low proportion of herbs. The *tolar* includes mainly C_3 (shrubs and grasses) and C_4 (mostly grasses) plant species. At a higher altitude—presently above *c.* 3900 masl—, the *pajonal* predominates, composed of pastures and a variety of herbaceous species which are all non-C_4 plants (Cabrera, 1976; Cabrera and Willink, 1980; Fernández and Panarello, 1999–2001; Haber, 1991; Olivera, 2006; among others). Both ecozones—*tolar* and *pajonal*—also include moor-like *vegas* associated to water streams. The archaeobotanical samples recovered from Holocene levels in Antofagasta de la Sierra sites are also mainly C_3, excepting a single CAM Cactaceae (*Trichocereus pasacana*, which grows in the Prepuna but may also grow in the Puna) dated after *c.* 7600 BP,

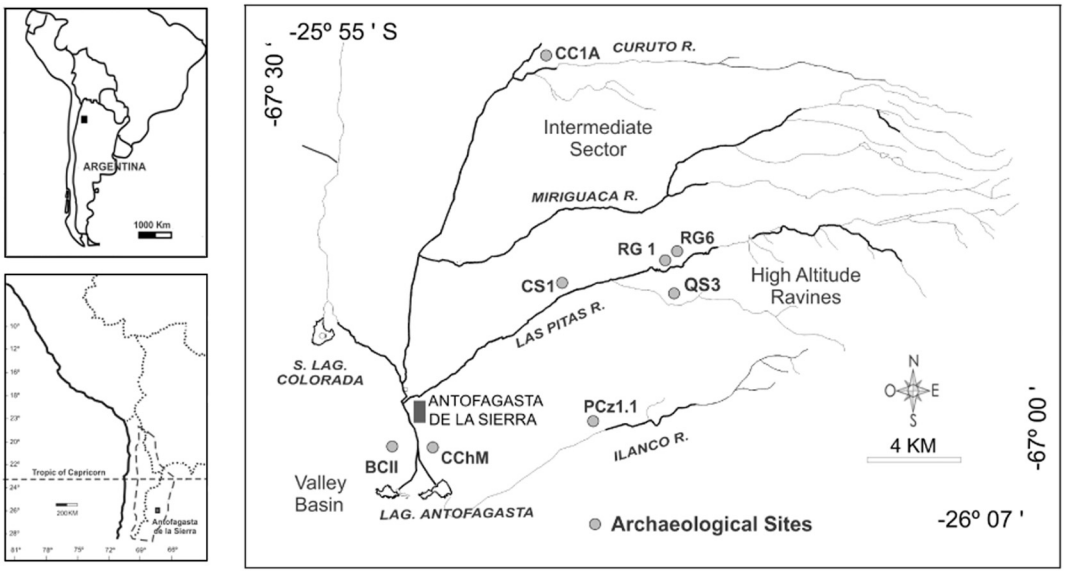

Fig. 1. Antofagasta de la Sierra and the archaeological sites considered in this study.

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