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Radiocarbon dates and anthropogenic signal in the South-Central Andes (12,500–600 cal. years BP)

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ABSTRACT

This paper presents the analysis of the anthropogenic signal documented by four time-series in the highlands of the South-Central Andes (Puna of Argentina and North Chile) spanning the period between 12,500 and 600 cal years BP. Our goal is to extract demographic and occupational histories from temporal data. In this way, based upon the full radiocarbon dataset and the sites of provenance of the dates, we built the following time-series: the summed probability distribution of calibrated ages; the relative frequency of calibrated ages; the relative frequency of sites per unit of time; and the frequency of new sites per unit of time. For controlling the effects of site destruction on the anthropogenic signal, we used the exponential model as well as the volcanic empirical model of taphonomic bias. The four time-series coincide in showing a regional pattern with a phase of low and fluctuating demography of relative long term duration, followed by an growth phase well evident at 5000 cal BP in a context the economic intensification. The long-term demographic success of the hunter-gatherers in the highlands many millennia before the consolidation of food production exemplifies the flexibility of this mode of subsistence for achieving human adaptation to extreme selective environments as the Puna.

1. Introduction

The aim of this work is to study the anthropogenic signal documented by four time-series in the highlands of the South-Central Andes (Puna of Argentina and North Chile) spanning the period between 12,500 and 600 cal years BP, seeking to extract the demographic and occupational history of the area. Thus we pursue to document the anthropogenic signal on a broad spatial and temporal scale so as to discuss hypotheses related to past population dynamics. With this objective in mind we assessed possible sources of taphonomic bias as well as the resolution of the dates. In this way, by comparing different time series and taphonomic models our work seeks to contribute to the broader theoretical and methodological discussion that is currently taking place on the analysis of past demography (Surovell et al., 2009; Collard et al., 2010; Peros et al., 2010; Steele, 2010; Williams, 2012).

The space covered by this study comprises the so-called Puna of Argentina and the highlands of northern Chile, with an approximate area of 125,150 km^2 (Fig. 1). The Argentine side includes the Puna region, a high altitude environment over 3000 masl in the present-day provinces of Jujuy, Salta, and Catamarca. The Chilean side encompasses the Atacama basin and the upper and mid Loa regions, with spaces at over 2500 masl.

Consensus exists that the first human occupations of the study area were associated with a low demography and with a strategy of high residential mobility in an environment somewhat more humid than at present (Yacobaccio and Vilá, 2002; Yacobaccio and Morales, 2013). From the mid-Holocene on, large-scale aridization processes will have increased the ecological fragmentation of the south-Andean highlands, enlarging clearly localized patches with a greater supply of resources than the mean. In this way Núñez (1992) proposed that in the Atacama salt flat of north Chile an "archaeological silence" (absence of anthropogenic signal) is to be found during a part of the mid-Holocene, with human occupations restricted to "eco-refugia" (*sensu* Núñez, 1992). Towards the end of the mid-Holocene, in a patchy environment it has been suggested that the south-Andean hunter-gatherers reduced their residential mobility triggering processes of population aggregation (Aschero, 1994). In this way, it has been proposed that a context of high population density and larger local group sizes gave place to the

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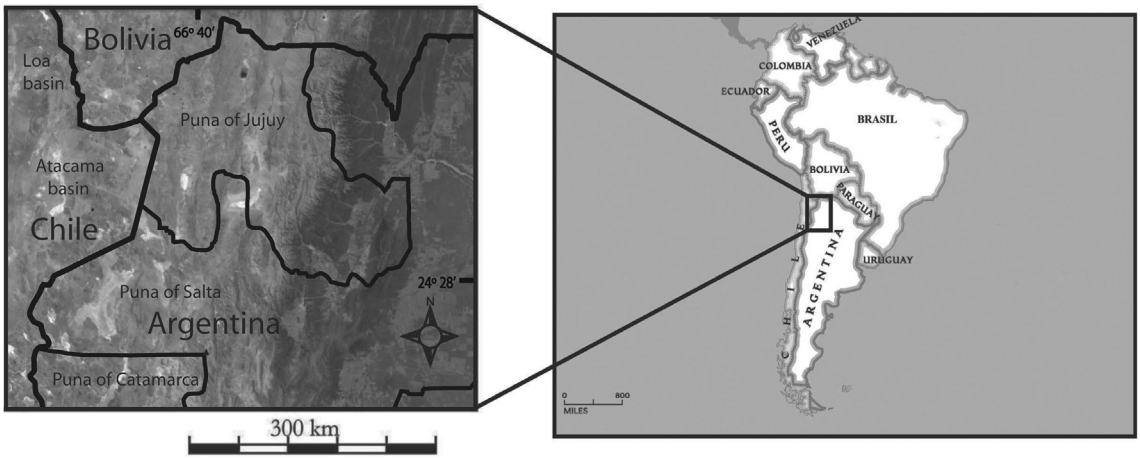

Fig. 1. Study area, the highlands of the Puna of Argentina (in the provinces of Catamarca, Salta and Jujuy) and North Chile (the Atacama basin and the Loa basin).

processes of camelid intensification and domestication, and to the increase of social complexity (Aschero, 1994; López and Restifo, 2012; Yacobaccio, 2001). In the same way it has been posited that the evolution of technological innovations was also related to population size increase (Muscio, 2012). Finally, the consolidation of productive economies during the late Holocene will also have been related to demographic growth (Albeck, 2001). Thus because the above mentioned questions are linked to demography the study of the anthropogenic signal on the scale undertaken here contributes to these issues. Indeed, Morales (2011) and Gayo et al. (2015) showed the utility of the analysis of radiocarbon dates series in order to document past demography in the Puna region.

2. Materials and methods

Currently, the study of archaeological time-series for discussing past demography and space use is a growing area of research (Rick, 1987; Shott, 1992; Collard et al., 2010; Steele, 2010). This demands to assess the possible sources of biases that affect the representation of a given sample of dates. Broadly, we can recognize natural and procedural sources of biases (Shott, 1992; Peros et al., 2010). The first includes those processes affecting the preservation of sites and which are technically named taphonomic biases (Surovell and Brantingham, 2007). The second source of biases comprehends a broad list of processes intervening in the recovering of the archaeological data. For instance the bias associated with the overdating of particular periods or regions and the sampling biases resulted from differences in the visibility or in the probabilities of discovery of sites. In this paper our methodology will focus mainly on taphonomic biases, limiting the analysis of the procedural biases to the assessment of the uncertainty of the radiocarbon dates. This obeys to the current availability of a number of sophisticated mathematical models for controlling taphonomic biases and the lack of similar tools for assessing procedural biases. In this vein, in order to increase the reliability of the archaeological inference, our methodology is aimed to analyze the anthropogenic signal by means of time-series of different nature built to discuss the discrepancies between the patterns they document.

2.1. Time–series

In this work we built time-series of calibrated years based on radiocarbon dates as well as sites-frequency and sites-occurrence data. These series are: 1) the summed probability distribution of calibrated ages; 2) relative frequency of calibrated ages; 3) relative frequency of sites per unit of time; and 4) frequency of new sites per unit of time. Each of these series provides singular information.

For series 1 and 2, the adopted analytical unit is the single radiocarbon dating of stratigraphic archaeological contexts. In this way we assume that the presence and frequency of radiocarbon events document the anthropogenic signal as well as its fluctuations in time and space (Rick, 1987). Other authors use other units, such as phases, components, or occupations, and averages of the calibrated dates (Prates et al., 2013; Shennan and Edinbourough, 2007; Buchanan et al., 2008; Steele and Politis, 2009; among others). By recognizing that instances of overlapping dates are always possible due to sampling biases, we used the other time-series (3 and 4) for which the unit of analysis is the dated site. These time-series alongside those built on the basis of the calibrated dates were used for comparison and control. Thus we seek to document the anthropogenic signal by alternative proxies in order to highlight potential discrepancies between them.

2.2. Radiocarbon distributions: summed probability and relative frequency of calibrated ages

As for the construction of time-based distributions, the first method we used is the summed probability of calibrated ages (Barrientos, 2009; Buchanan et al., 2008; Morales, 2011; Williams, 2012). To this end we employed the summed probability function with the calibration method of Oxcal 4.2 with the atmospheric curve of the southern hemisphere (ShCal13) (Bronk Ramsey and Lee, 2013). Because the number of sites or occupations throughout a period of time can be expected to co-vary positively with population size, changes in the distribution of the summed probability of calibrated dates from different sites or occupations serve as a proxy of population dynamics (Collard et al., 2010; Gamble et al., 2004; Shennan and Edinbourough, 2007).

In addition, we built the series of relative frequencies of calibrated dates (i.e. Steele, 2010). For this purpose we took the mid point of the two sigma calibrated range of each particular dating, so as to construct the distribution of dates along discrete time-intervals. The logic of this method is such that it relies on the frequency of calibrated dates. The temporal distributions were obtained working with 200 years intervals. The value of these intervals gives us a suitable scale to document anthropogenic signal patterns considering our sample size.

For discussing relevant archaeological patterns a critical issue is