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Zooming out from archaeological discontinuities: The meaning of mid-Holocene temporal troughs in South American deserts

Ramiro Barberena [a,*], César Méndez [b], María Eugenia de Porras [c]

[a] CONICET, Laboratorio de Paleocología Humana, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Cuyo, Padre Jorge Contreras 1300, Mendoza City 5500, Mendoza Province, Argentina
[b] Departamento de Antropología, Facultad de Ciencias Sociales, Universidad de Chile, Ignacio Carrera Pinto 1045, Ñuñoa, Santiago, Chile
[c] CEAZA (Centro de Estudios Avanzados en Zonas Áridas), La Serena, Chile

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ABSTRACT

Building on previous research at smaller scales, in this paper we assemble paleoecological data and archaeological time-series for deserts located in three latitudinal bands along the South American Arid Diagonal (16°–41°S, ~1,236,000 km^2 of area). Diverse proxies suggest the existence of arid and extremely arid conditions in large parts of these deserts. Working with a database composed of 914 archaeological dates falling between the first human presence in each region and 3000 years BP, which produce a minimum number of 578 occupational events, we identify a series of patterns at a macro-regional scale: a robust increase in the temporal signal at the beginning of the mid-Holocene (8000–7600 years BP) followed by two troughs (7600–7200, 6800–6400 years BP) during this period. The spatial scope of the data presented provides an opportunity for disentangling processes of spatial re-localization from actual changes in population size. We present a demographic hypothesis at a macro-regional scale, which suggests the existence of mid-Holocene population bottleneck(s). This hypothesis would account not only for the mid-Holocene troughs, but also for the posterior record of an intense and relatively rapid population growth (release) observed in many regions of the arid diagonal. These mid-Holocene events provide the context for independent trajectories of economic intensification based on different sets of resources -marine foods, camelids, and also probably wetland resources-, some of which lead to domestication processes. These cases occur in association with a tendency towards reduced residential mobility in regions that may have acted as refugia during arid periods of the mid-Holocene.

The analysis produces testable expectations for future research at different scales and for different research domains, including human DNA and morphometric evidence. We consider that these issues have a fecund comparative potential, since the analysis of the socio-demographic meaning of archaeological discontinuities in different continents shares a similar conceptual structure.

1. Introduction: building from the local to the continental

Archaeological discontinuities are a multi-layered phenomenon with demographic, informational, economic, technological, and taphonomic interacting dimensions. These levels are inextricably linked in historical processes. Assessing the behavioral, demographic, and evolutionary meaning of archaeological discontinuities is a highly complex endeavor permeated by issues of scale (Bailey, 2007; Holdaway and Wandsnider, 2006). The behavioral and demographic mechanisms invoked to explain discontinuities vary according to the temporal and spatial scale of patterns recorded in the data. Following 'time perspectivism' (Bailey, 2007), we consider that evidence at different scales can reveal the operation of diverse processes that can be hierarchically connected. Thus, zooming out the scale of analysis becomes a powerful tool for envisioning answers otherwise concealed at smaller scales, traditionally used in the archaeological research in South American deserts.

Archaeological radiocarbon databases provide a spatial-temporal proxy reflecting human rates of human discard of datable material (Rick, 1978; Williams, 2012). The use of summed probabilities of radiocarbon dates as a demographic proxy has grown in scope, methodological robustness, and theoretical insight (Bueno et al., 2013; Gamble et al., 2004; Shennan et al., 2013; Surovell et al., 2009; Williams et al., 2015). Some recent debate has focused on the validity of this line of enquiry based on system-

* Corresponding author.
E-mail addresses: ramidus28@gmail.com (R. Barberena), cmendezm@uchile.cl (C. Méndez).

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atic and random sources of bias that question the chain of connection between time-series and reconstruction of human demography (Bamforth and Grund, 2012; Contreras and Meadows, 2014; García Guraieb et al., 2015). Besides specific methodological responses (Timpson et al., 2014), we consider that this method provides a productive approach to explore structure in the data at a multiplicity of scales, helping to produce hypotheses that can be subjected to scrutiny from independent proxies, genomic analyses paramount among them (Gamble et al., 2004; Sundell et al., 2014; Wang et al., 2007).

In this paper we undertake an exploratory analysis of the temporal trajectories of human occupation in desert regions located along the South American Arid Diagonal (SAAD from now onwards). The goal is to explore the behavioral and demographic meaning of archaeological troughs and gaps in human signals recorded for the mid-Holocene (8000–5000 years BP). This period has received increasing attention in South American deserts, in particular regarding the presence of archaeological hiatuses, initially termed 'archaeological silence' by Núñez and Santoro (1988; see also Grosjean et al., 2007). This trough, which was first analyzed through settlement patterns and later on with radiocarbon datasets, was associated with the advent of global and local mid-Holocene climate changes (Anderson et al., 2007; Gil et al., 2005). Increasing arid conditions starting ca. 9000–8500 years BP recorded in diverse paleoclimatic archives in the Andes and nearby areas (Lamy et al., 1999, 2004; Latorre et al., 2003) have provided the frame for studying human responses to climatic change and resource degradation (Méndez et al., 2015; Neme and Gil, 2009). Volcanic eruptions have also been suggested to operate at local and regional scales (Durán et al., in press).

The analysis presented here is based on a compilation of radiocarbon databases recently published for the following regions (Fig. 1): (a) '*Low latitudes of the SAAD*' (16°–25°S), usually referred to as the South Central Andes, which include northern Chile, southern Peru and western Bolivia (Gayo et al., 2015; Grosjean et al., 2007; Marquet et al., 2012); (b) '*Mid latitudes of the SAAD*' (29°–35°S), integrating Cuyo region of Argentina and North Central Chile (Méndez, 2013; Méndez et al., 2015; Neme and Gil, 2009); and (c) '*High latitudes of the SAAD*' (35°–41°S), corresponding to northwestern Patagonia in Argentina and Southern Chile (Barberena et al., 2015; Campbell and Quiroz, 2015).

Enhanced aridity in already dry regions would increase environmental unpredictability and the associated costs of use of marginal lands (Mandryk, 1993). The most immediate response by mobile hunter-gatherers to increased risks would be spatial reorganization and/or relocation (Garvey, 2008; Méndez et al., 2015), which could lead to abandonment of regions in different spatial scales and for varying amounts of time. So far, working at local and regional levels, evidence of local abandonments and spatial re-locations has been presented for a number of desert regions along the Andes (Marquet et al., 2012; Neme and Gil, 2009; Núñez et al., 2002; Yacobaccio, 2013). While providing the basis for an assessment of the impact of climate change in local populations, this scale of analysis does not allow estimation of the overall demographic trajectories in the South American deserts and neighbor areas. The question in hand is whether the coincidence of multiple discontinuities in neighboring areas is evidence enough of a demographic decrease, which may display seemingly divergent local archaeological trajectories. Our core methodological suggestion is that, by augmenting the analytical scope, we can disentangle processes of spatial re-localization and/or reorganization of mobility from significant demographic changes at the level of metapopulations (i.e., significant increase or decrease in the numbers of people inhabiting a given unit of space). On this basis, we can then explore the behavioral and demographic basis of archaeological discontinuities.

2. South American Arid Diagonal: ecology and paleoecology

Large-scale patterns in the climate of southern South America are related to major atmospheric circulation patterns. The interaction of two large climatic systems that control precipitation patterns, the tropical easterlies and the southern westerlies, and the orographic (rain-shadow) effect of the Andes, results in the major climatic and biogeographic boundary of the SAAD, an arid NW-SE continuous area which extends from Peru to southern Argentina (Figs. 1 and 2) (Abraham de Vazquez et al., 2000; Bruniard, 1982; Villagrán and Hinojosa, 1997). The SAAD, which originated during the Pliocene (Villagrán and Hinojosa, 1997), has remained relatively stable since then, but global and regional climate change during the Late Quaternary has had important changes in the distribution of plants, animals, and human populations (Betancourt et al., 2000; Grosjean et al., 2003; Latorre et al., 2013; Marquet et al., 2012; Méndez et al., 2015).

The three latitudinal bands considered here present striking topographic, climatic, and ecological contrasts. In Fig. 2 we reproduce their main eco-physiographic properties. In Fig. 3 we present an overview of some settings. In the '*Low latitudes of the SAAD*' space is subdivided in: (a) coastal Atacama region, (b) inland Atacama region, and (c) Bolivian Altiplano region (Gayo et al., 2015). In the '*Mid latitudes of the SAAD*', space is stratified in: (a) Pacific coast, (b) western valleys, (c) West Andes, (d) East Andes, (e) Eastern foothills, (f) Eastern lowlands (Méndez et al., 2015). Finally, for the '*High latitudes of the SAAD*' space is subdivided in: (a) Pacific coast, (b) Valleys, and (c) Western Andes, (d) Eastern Andes, (e) Eastern steppes (Barberena et al., 2015; Campbell and Quiroz, 2015).

In Fig. 4 we present an overview of dominant climate trends since the late Pleistocene onwards for the three latitudinal bands considered. These tendencies are assessed in detail below.

2.1. Low latitudes of the SAAD (16°–25°S): South Central Andes of Chile, Peru, and Bolivia

After widespread humid conditions during the late Pleistocene-early Holocene (Betancourt et al., 2000; Latorre et al., 2002, 2003; Maldonado et al., 2005; Sylvestre et al., 1999), extreme arid conditions were established in the South Central Andes around 9500 years BP, peaking at 9000–7000 years BP (Betancourt et al., 2000; Grosjean et al., 2003; Latorre et al., 2003; Maldonado et al., 2005), although the timing of this arid phase varies from site to site. After this arid phase, still more extreme arid conditions characterized the mid-Holocene, but the onset of this environmental condition is a matter of discussion (Grosjean, 2001; Quade et al., 2008). On one hand, wetland and rodent midden-associated plant macro-remains records suggest that less arid conditions would have occurred since 8000–7000 years BP (Betancourt et al., 2000; Latorre et al., 2003; Rech et al., 2002). On the other hand, and in agreement with our view, lake sedimentary records and alluvial deposits from the Altiplano and the Salar de Atacama suggest that the arid phase would have lasted until 4000–3000 years BP, interrupted by a moist pulse around 6000–5000 years BP (Bobst et al., 2001; Grosjean, 2001; Grosjean et al., 2003). Pollen records from rodent middens at 21°S indicate the termination of the arid phase around 3300 years BP, supporting the second alternative (Maldonado and Uribe, 2015). During the late Holocene, highly variable environmental conditions at centennial-to-millennial scales occurred in the South Central Andes, but under less dry scenarios than those of the mid-Holocene. A series of moderate humid phases were recorded at 21°S in the highlands between 2400–720 years BP peaking at 2000 and 1000 years BP (Maldonado and Uribe, 2015), and in the lowlands at 2245–2230, 1615–1350, and

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