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A Contribution to the Study of Diet of Formative Societies in Northwestern Argentina: Isotopic and Archaeological Evidence

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ABSTRACT The present paper is aimed at presenting and discussing currently available isotopic values ($\delta^{13}C$) of human samples dated to the Formative Period in the Santa María Valley, adjacent to the Yungas and Puna regions of northwestern Argentina. Results show that the expected tendency of increasingly positive C_4 isotopic values consistent with the hypothesis of maize agriculture consolidation during Formative times was only partially corroborated. A fuller understanding of this trend is limited by the scant number of samples as well as by the lack of local reference values. Notwithstanding, the revision of this evidence in light of relevant archaeobotanical data allows us to start building a more accurate reconstruction of the lifestyles of early agricultural societies settled in northwestern Argentina. Copyright © 2009 John Wiley & Sons, Ltd.

Key words: stable isotopes; $\delta^{13}C$; diet; northwestern Argentina; Formative Period

Introduction

In Mesoamerica and the Andes, debates about the process of domestication and the origins of agriculture have generally had maize as their main exponent, as this is considered to have been one of the principal staples of ancient American peoples (McClung de Tapia, 1992; Kroll, 1999; Oliszewski, 2004). Maize, as the most renowned example of C_4 type plants, is still considered to have been one of the leading staples of the American past. In northwestern Argentina, for example, evidence of cultivation and consumption of maize has been found in domestic and productive contexts of the first millennium AD (e.g. Cigliano *et al.*, 1972; González & Sempé, 1975; Pochettino & Scattolin, 1991; Miante Alzogaray & Cámara Hernández, 1996; Nuñez Regueiro, 1998; Oliszewski, 2004), as well as within some remarkable funerary deposits (e.g. Heredia, 1971). Yet, along with the relative 'abundance' of maize in the archaeological record is the scant representation of tubers and pseudo-cereals argued also to have been domesticated since the beginnings of food processing times (Fernández, 1969–1970; Tarragó, 1980; Korstanje & Würschmidt, 1999; Korstanje, 2005). Indeed, in northwestern Argentina, archaeobotanical studies have shown that the earliest production of food was probably centred on roots, tubers (e.g. potatoes, *ulluco*, *oca*, manioc), and pseudo-cereals (e.g. *quinoa*, amaranth, *cañiwa*) as well as other freeze- and drought-resistant

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crops (Albeck, 1993; Korstanje, 2005). In this sense, specific analyses on plant microfossils and crop-processing artefacts (e.g. milling stones) have widened our knowledge with regards to the range of edible plants consumed by pre-Hispanic societies, and forwarded discussions on the relative importance of maize in the diet of ancient Andean peoples. For example, although milling stones have traditionally been associated with the processing of maize, recent studies have proved that other starch-rich resources such as roots, stems, pods and seeds, both farmed and wild, were processed since very ancient times in different parts of northwestern Argentina (Babot, 2004; Korstanje, 2005). According to this, C_3 type plants (e.g. *quinoa*, beans, tubers) and a few belonging to the Crassulacean Acidic Metabolism (CAM) type (e.g. *tuna, pasacana*) are among the principal edible vegetal resources supposed to have constituted an essential part of the diets of ancient northwestern Argentina peoples (see also Burger & van der Merwe, 1990, for Peru). Yet, the observed disproportion in the available data does not necessarily reflect the preponderance or even the preference of maize over other crops by ancient populations, as this might as well be the result of a bias in the recovery of botanical samples. Certainly, while this situation could be linked to specific theoretical and methodological orientations in current archaeobotanical research, it is also enhanced by the naturally resistant characteristics of maize, which increase its chances of preservation and recovery relative to other crops (Burger & van der Merwe, 1990: 87; Korstanje, 2005). Recent research on local pre-Hispanic agricultural production revealed that the bottoms of valleys and low mountain slopes were chosen by the first farming villages to grow these crops (e.g. Albeck, 1993; Korstanje, 2005). Within these areas, the cultivation techniques employed were those of extensive non-irrigated agriculture or simple structures of irrigation canals (Albeck, 1993; Korstanje, 2005).

In general terms, then, currently available information and discussion about pre-Hispanic vegetal consumption has mostly been derived from indirect sources of evidence such as the study of agricultural technologies, as well as the recovery of macro- and micro-botanical remains. However, the development of isotopic analysis techniques has also contributed in fundamental ways to the study and reconstruction of past lifestyles. The interpretation of $\delta^{13}C$ values of human samples provides direct evidence for the consumption of specific types of food complementing other indirect sources of evidence (e.g. zooarchaeological and archaeobotanical data). These analyses allow us to make inferences about the relative proportion of vegetal resources with C_3, C_4 and CAM photosynthetic pathways in the diets by comparing archaeological samples against reference isotopic values for each plant group (Schoeninger & DeNiro, 1983; Hastorf & DeNiro, 1985; Ambrose & DeNiro, 1986; Burger & van der Merwe, 1990; Norr, 1995; Schoeninger, 1995; Ubelaker *et al.*, 1995; de France *et al.*, 1996; Larsen *et al.*, 1996). Direct evidence for the diversity and composition of ancient diets – such as that provided by isotopic analysis – is still incipient for most of northwestern Argentina. This lack of information is particularly pronounced in Santa Maria Valley's Formative[1] Period. In order to start reversing this situation, this article compiles and discusses currently available $\delta^{13}C$ isotopic evidence for human samples dated to different times in the Formative period in the southern Calchaquíes valleys, in relation to published data from the eastern Yungas forests and the highland Puna region of northwestern Argentina.

The sample: geographical and contextual information

According to the presence of distinct ecological environments, northwestern Argentina has been segmented into three major sub-areas: the Puna

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[1] In the social development of northwestern Argentina, the Formative Period (*ca.* 600 BC–900/1000 AD) has generally been characterised as a time of segmentary groups with little social hierarchy living in small agricultural-herding sedentary or semi-sedentary communities that, although mostly self-sufficient, were also involved in dynamic social interactions oriented towards the distribution and exchange of local products on a regional scale (Nuñez Regueiro, 1974; Tarragó, 1992; Tarragó & Scattolin, 1999; Olivera, 2001; Scattolin, 2006). The Formative Period is preceded by the Archaic – a period of experimental domestication (*ca.* 8000–1800 BC) – and followed by the Regional Developments or Late Period (*ca.* 1000–1436 AD), a time of highly hierarchical societies with clear-cut territorial boundaries maintained through the political control of other ecological areas, agglomerated settlements and warfare (e.g. Nielsen, 1996; Tarragó, 2000).

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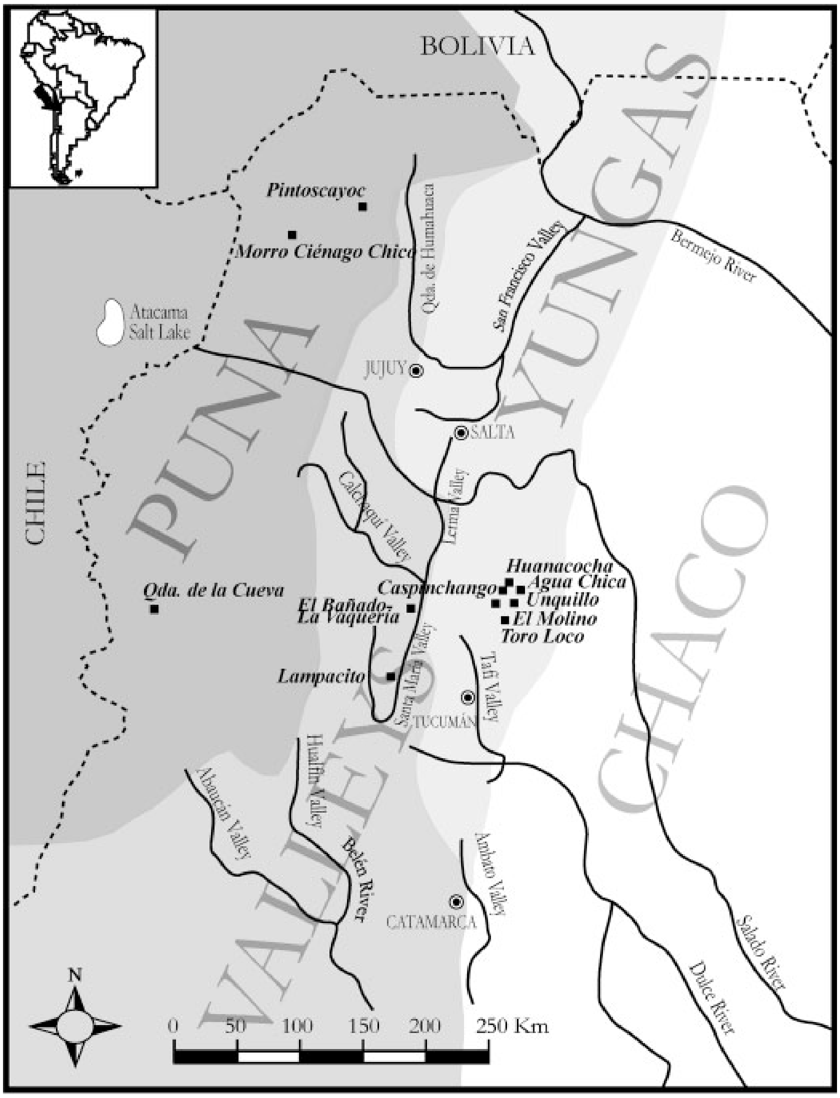

Figure 1. Map of northwestern Argentina showing the sites mentioned in the text.

(dry highlands), the Valles (temperate valleys and sierra) and the Yungas (the humid slopes on the eastern border of the Andes) (Figure 1). This particular geographical configuration is thought to have been of fundamental importance during pre-Hispanic times, as communities settled in different ecological environments were extensively involved in the circulation of people, objects and staples (e.g. Dillehay & Nuñez, 1988; Albeck, 1994; Lazzari, 2006), for which the comparison of samples coming from these areas may be significant.

Along with the very scant number of excavated Formative funerary deposits with detailed association records in the Santa María Valley (Scattolin *et al.*, 2005) to date, and as far as our knowledge allows us to discuss, only two human samples with known contextual provenance have provided δ^{13}C values worth discussing here. The first of these samples is from the locality of Lampacito (Figure 1). Here, the remains of an adult woman buried directly in the ground, with a complex grave-goods assemblage of 12 ceramic vessels of varied valley-like styles, stone beads, copper bracelets and rings, was recovered during a rescue excavation in 2003 (Scattolin *et al.*, 2005; Cortés, 2005). This burial was dated to 1446 ± 36 BP

(AA-59414) and the δ^{13}C isotopic value obtained through AMS dating procedures was −12.0‰ (Table 1).

The second sample comes from the nearby location of El Bañado-La Vaquería (Figure 1); it corresponds to an urn burial of a 5–6 year old child together with a newborn individual, a small Candelaria-type anthropomorphic vessel and a lithic bead (Tarragó & Scattolin, 1999; Cortés, 2005). The recovery was originally done by a team from the Universidad del Litoral in the 1960s, and later dated by AMS to 1375 ± 40 BP (Ua-20627) (Scattolin & Bugliani, 2005). The older individual's δ^{13}C isotopic signal obtained from one first permanent molar was −12.0‰ (Table 1). Given that the complete formation of this tooth expands for approximately eight years after birth (Scheuer & Black, 2000) – encompassing the expected breastfeeding, supplementary and weaning periods (Wright & Schwarcz, 1998) – the resultant isotopic signal is likely to represent an average value between the infant's own and his/her mother's diet.

Fortunately, several δ^{13}C values are available for the adjacent La Candelaria area in the Yungas region. These come from a sample of eight adult human remains originally excavated by Stig Ryden in 1936 and later studied by Adriana Muñoz and Natalia Fasth (Fasth, 2003). The human remains form part of a large sample of funerary urns recovered from the sites of Huanacocha, Toro Loco, Caspinchango, Unquillo, Agua Chica and El Molino at Candelaria (Figure 1; Rydén, 1936), which are currently curated at the Vorldskultur Museet of Gothenburg (Sweden). The AMS dates for these remains range from 1895 to 1120 BP and their δ^{13}C values vary between −9.1‰ and −13.0‰ (Fasth, 2003) (Table 1).

The third group of samples comes from the highland Puna region and belongs to four adult individuals and one subadult recovered at the sites of Pintoscayoc, Morro Ciénago Chico and Quebrada de la Cueva (Figure 1). These have been dated between 2900 and 1100 BP (Yacobaccio *et al.*, 1997; Olivera & Yacobaccio, 1999)[2] and their δ^{13}C values range from −17.9‰ to −12.6‰ (Table 1).

Table 1. Samples considered in the analysis

Context	Area	δ^{13}C (‰)	Human remains (age)	Sample type	Date (years BP)	References
Pintoscayoc (Pyoc1)	Septentrional Puna	−17.2	Subadult	—	±2900	Olivera & Yacobaccio (1999)
Morro Ciénago Chico (MCH1)	Septentrional Puna	−17.8	Adult	—	2750 ± 100 2460 ± 60	Yacobaccio *et al.* (1997); Olivera & Yacobaccio (1999)
Morro Ciénago Chico (MCH1)	Septentrional Puna	−17.9	Adult	—	2750 ± 100 2460 ± 60	Yacobaccio *et al.* (1997); Olivera & Yacobaccio (1999)
Quebrada de la Cueva-2 (QC2)	Meridional Puna	−13.1	Adult	—	1180 ± 60	Olivera & Yacobaccio (1999)
Quebrada de la Cueva-1 (QC1)	Meridional Puna	−12.6	Adult	—	1130 ± 60	Olivera & Yacobaccio (1999)
El Molino (Mol)	La Candelaria, Yungas	−9.5	Adult	Teeth	1895 ± 50	Fasth (2003)
Agua Chica (ACh)	La Candelaria, Yungas	−9.1	Adult	Bone	1740 ± 65	Fasth (2003)
Caspinchango (Cch)	La Candelaria, Yungas	−9.4	Adult	Bone	1615 ± 65	Fasth (2003)
Huanacocha (Hch)	La Candelaria, Yungas	−11.0	Adult	Bone	1455 ± 60	Fasth (2003)
Lampacito (Lam)	Santa María Valley	−12.0	Adult	Bone	1446 ± 36	Scattolin *et al.* (2005)
El Bañado-La Vaquería (BV)	Santa María Valley	−12.0	Subadult	Teeth	1375 ± 40	Scattolin & Bugliani (2005)
Toro Loco (TL1)	La Candelaria, Yungas	−9.8	Adult	Bone	1390 ± 65	Fasth (2003)
Toro Loco (TL2)	La Candelaria, Yungas	−11.0	Adult	Teeth	1380 ± 60	Fasth (2003)
Caspinchango (Cch)	La Candelaria. Yungas	−9.5	Adult	Bone	1280 ± 60	Fasth (2003)
Unquillo (Uq)	La Candelaria, Yungas	−13.0	Adult	Bone	1120 ± 55	Fasth (2003)

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[2] New isotopic data for this area was discussed by Yaccobacio and Olivera in the original Workshop giving rise to this Special Issue.

As a whole, the sample considered comprises a total of 15 $\delta^{13}C$ isotopic values ranging between −17.9‰ and −9.1‰ distributed over an 1800-year period, between 2900 and 1100 BP.

On the interpretation of $\delta^{13}C$ values: notes for their discussion

To date, many studies have been conducted around the world to estimate $\delta^{13}C$ values in modern and ancient edible plants. This line of research has underlined the multiplicity of factors that may induce variations in the isotopic signals of plants and animals, highlighting the importance of generating local reference values for the periods and areas under study. According to several researchers, the changes in the $^{13}C/^{12}C$ ratio in plants can occur as a result of climatic oscillations, intra- and inter-specific variations, between domesticated and wild species, and even between the organs of the same individual. Short-term changes within individuals or populations can also be the cause of variations, as can modifications in the relative environmental availability of CO_2 (Tieszen, 1991; Tieszen & Fagre, 1993; Heaton, 1999; Rubenstein & Hobson, 2004). Accordingly, researchers have warned about making any straightforward palaeodietary interpretation based on a small difference between isotopic values (i.e. of less than two points per thousand), since such divergence could be caused by environmental disparities in time and space as much as by an actual difference in the consumption of distinct food types (Heaton, 1999). To overcome these factors, the interpretation of isotopic values to infer ancient diets requires the pre-existence of reference values to be duly compared (Tieszen & Fagre, 1993; Heaton, 1999). Ideally, reference values must come from a similar ecological environment and preferably from known archaeological specimens. In this way, the effects of isotopic variation through time and space become minimised, allowing for a more accurate reading of the data.

With regards to the study region, extensive isotopic analyses have been carried out in the Puna, contrasting with the lack of reference values for the areas of Valleys and Yungas. Through exhaustive research, Fernández & Panarello (1999–2001) established several isotopic reference values for wild plant species from the Puna, which comprise the diets of *guanaco*, *vicuña*, *tojo* and *chozchori*. Between 5000 and 4000 m.a.s.l., guanacos and vicuñas fed on *Ephedra breana*, *Trifolium amabile*, *Poa juyensis*, *Tagetes multifora*, *Poa anua*, *Poa lilloi*, *Cotula mexicana*, *Bromus catharticus* and *Festuca orthophylla*, all of which follow a C_3 photosynthetic pathway. Within this area, the only C_4 species is *Muhlenbergia*, but it does not form part of the camelids' diet. The *tojo*, which inhabits areas of lower altitude (4000–3600 m.a.s.l.) feeds on *Nassauvia axillaris* and *Ephedra breana*, both following a C_3 pathway, as well as a C_4 species – *Sporobolus rigens* – which, together with *Pennisetum chilense*, can be found in localised pastures. At altitudes below 3500 m.a.s.l. – the *altiplano* proper – the *chozchori* nourishes on three CAM species of the *Maihueniopsis* genre (which synthesise following a C_4 pathway), together with C_3 plants such as *Gnaphalium lacteum*, *Senecio graveolens* and *Tarassa* sp. (Fernández & Panarello, 1999–2001: 64). The different proportions of C_3, C_4 and CAM plants is also corroborated by the enriched $\delta^{13}C$ values obtained from hair and bone collagen samples of each of the abovementioned species (Fernández & Panarello, 1999–2001: 66).

In this study, we have chosen to use Puna values as a reference, acknowledging the possibility of this hampering the strength of the interpretations that follow. For example, as reference $\delta^{13}C$ values for floral and faunal specimens exhibit a broad C_3 and C_4 isotopic variation (Table 2), the projection of our samples against such values may result in a different interpretation for each sample. This situation can be more easily observed graphically. In Figure 2 we have projected some of the values published by different researchers against a continuous scale where different ranges are delimited (dotted lines). Although these ranges form part of a continuum of variation, analytically they have been associated with a 'hypothetical' diet of 100% C_3 or C_4 foods (e.g. Hastorf, 1991, for plants). In this scenario, one of the main interpretative drawbacks arises when the sampled

Table 2. C_3 and C_4 isotopic reference values considered in the text

Reference	$\delta^{13}C$ (‰) and photosynthetic paths		Source	Geographical provenance	Modern/archaeological
	C_4	C_3			
Hastorf (1991)	−8.5 to −11.0	−22.0 to −28.0	Maize, tubers and *quinoa*	Central Andes, Upper Mantaro, Perú	Modern
Fernández *et al.* (1991) Fernández & Panarello (1999–2001)	−10.6 to −13.8	−21.6 to −29.1	Wild plants	Puna, NW Argentina (3600–3800 m.a.s.l.)	Modern
Korstanje (2005)	−11.3	—	Maize cob	Bolsón Valley, NW Argentina	Archaeological (Formative)
Fernández *et al.* (1991)	—	−25.8 to −26.8	Average of 4 samples of camelids	Puna, NW Argentina	Modern
Schoeninger & DeNiro (1983)	—	−20.2 to −20.6	*Llama* collagen	Perú	Modern
Fernández & Panarello (1994)	—	−18.0 to −20.6	*Guanaco* collagen	Puna, NW Argentina	Modern

values fall outside the expected ranges generated by the reference values. If we observe Figure 2A, the more ancient values from the Puna appear between the C_3 and C_4 ranges, and not within either. As a result, if the interpretation of these values were based on this reference only, they could be read as indicative of a 'mixed' diet with a balance of components C_3 and C_4 and possibly CAM and/or by herbivores consuming these resources (Pate, 1994). But in this same figure, should those values that fall outside the right extreme of the C_4 range be interpreted as inherently enriched in C_4 foods in relation to the adjacent ones? By contrast, if these values were interpreted with reference to the ranges proposed by Hastorf (1991) (Figure 2B), the more enriched values from the Yungas would become indicative of a 100% C_4 diet, while those immediately adjacent of mixed diets. The several factors generating variations between the reference and sampled values are also clear when comparing the ranges proposed for the C_3 patterns. The discrepancy in the specific provenance of the reference sample (i.e. plants, animals) is undoubtedly transferring its inherent variation into the interpretation of the samples. As the intake of animal resources will also be reflected in the $\delta^{13}C$ signal, its determination through isotopic analysis becomes more difficult as faunal diets can include other animals as well as plants with different photosynthetic pathways. However, for present purposes, camelid samples from the Puna region in northwestern Argentina will reflect a diet composed mainly of C_3 plants. Therefore, if these camelids were indeed part of the palaeodiets, the resultant isotopic values of the sampled individuals would exhibit more depleted values in relative terms. Yet, none of the sample values fall within any of the proposed C_3 ranges.

Having reviewed these scenarios, and in favour of providing one preliminary interpretation of the available data, we will only consider the reference values provided by Fernández *et al.* (1991) for plant samples. Also, in concordance with Heaton (1999), we will assume that whenever the difference between two isotopic values exceeds two points per thousand (2.0‰), the effects of any temporal and/or spatial variation between the reference and analysed samples can be expected to be minimised. In other words, any divergence

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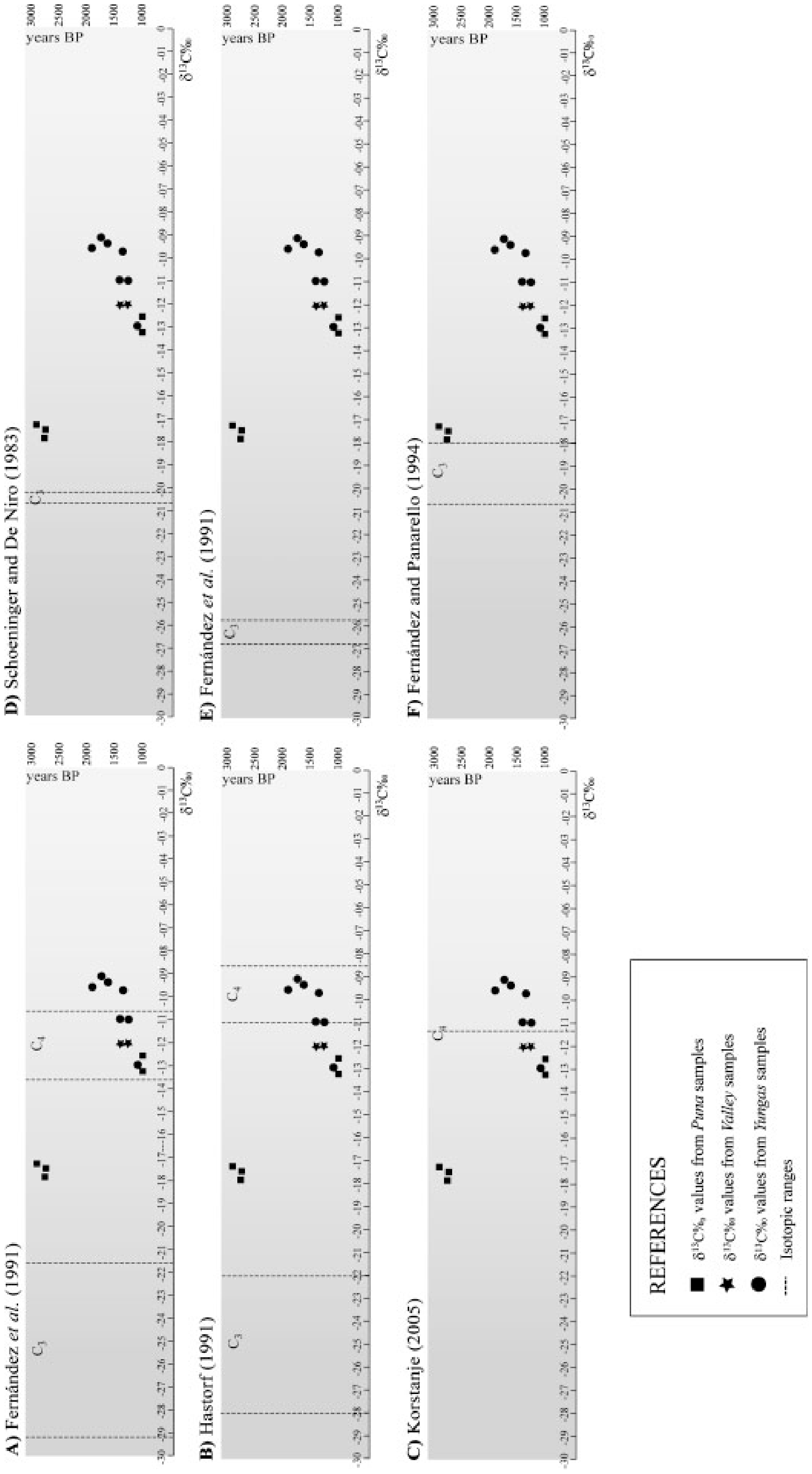

Figure 2. Samples plotted against C_3 and C_4 ranges as proposed by different researchers.

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Table 3. Distribution of the $\delta^{13}C_{COL}$ values in three analytical groups according to a 2‰ boundary

Chronology (years BP)	Region	Site	$\delta^{13}C_{COL}$ (−2.0‰)	$\delta^{13}C$ (‰)	$\delta^{13}C_{COL}$ (+2.0‰)
Group 1					
2750 ± 100 2460 ± 60	Puna	Morro Ciénago Chico	−15.9	−17.9	−19.9
2750 ± 100 2460 ± 60	Puna	Morro Ciénago Chico	−15.8	−17.8	−19.8
±2900	Puna	Pintoscayoc	−15.2	−17.2	−19.2
Group 2					
1180 ± 60	Puna	Quebrada de la Cueva2	−11.1	−13.1	−15.1
1120 ± 55	Yungas	Unquillo	−11.0	−13.0	−15.0
1130 ± 60	Puna	Quebrada de la Cueva1	−10.9	−12.9	−14.9
1375 ± 40	Valleys	El Bañado-La Vaquería	−10.0	−12.0	−14.0
1446 ± 36	Valleys	Lampacito	−10.0	−12.0	−14.0
1380 ± 60	Yungas	Toro Loco 2	−9.0	−11.0	−13.0
1455 ± 60	Yungas	Huanacocha	−9.0	−11.0	−13.0
Group 3					
1390 ± 65	Yungas	Toro Loco 1	−7.8	−9.8	−11.8
1280 ± 60	Yungas	Caspinchango 2	−7.5	−9.5	−11.5
1895 ± 50	Yungas	El Molino	−7.5	−9.5	−11.5
1615 ± 65	Yungas	Caspinchango 1	−7.4	−9.4	−11.4
1740 ± 65	Yungas	Agua Chica	−7.1	−9.1	−11.1

exceeding 2.0‰ will be interpreted as an effective difference in diet composition. By contrast, if the difference between values is smaller than 2.0‰, interpretations must be cautious as to what extent this might be the result of a variation between samples coming from different environments and/or chronological moments.

Discussion of the samples

Considering a 2.0‰ analytical boundary, the samples can initially be divided into three main groups (Table 3). From a diachronic perspective, a first and more evident temporal difference is observed between the diets of the most ancient individuals (from the Puna) and the most recent (from the Puna, Valleys and Yungas). This separation distinguishes Morro Ciénago Chico and Pintoscayoc, which group together around −17.0‰ (Figure 3) pointing towards a diet with a preponderance of C_3 plants (Olivera & Yacobaccio, 1999: 9), from the rest of the sample clustering around the C_4 range. At the opposite end of the chronological range a second group can be segmented between 1500 and 1000 BP. Within this group, a first cluster of isotopic values distributes between −11.0 and −12.0‰, corresponding to the sites of Huanacocha and Toro Loco2 (Yungas), and Lampacito and El Bañado-La Vaquería (Santa María Valley), both coincident with a diet of predominantly C_4 plants (maize) (Fernández *et al.*, 1991). Toro Loco 1 and Caspinchango 2 form a second cluster with values around −9.0‰, while a third is formed by the three individuals from Unquillo (Yungas) and Quebrada de la Cueva (Puna) with values of *ca.* −13.0‰, closer to the proposed boundary for C_4 plants according to Fernández *et al.* (1991). In between these two major groups, a third analytical temporal lapse between 2000 and 1500 BP comprises three individuals from La Candelaria with $\delta^{13}C$ values between −9.1 and −9.5‰ (Figure 3).

In general terms, it seems that the diets of the individuals from Agua Chica, Caspinchango 1 and El Molino – all from the Yungas and more ancient than 1600 BP – were different from those at Lampacito and El Bañado-La Vaquería from the Santa María Valley, as well as from the individuals buried at Quebrada de la Cueva (Puna) and Unquillo (Yungas), all these more recent than 1500 BP. By contrast, those individuals from Caspinchango 2 and Toro Loco 1 dated to later times join together within one isotopic group (i.e. with a difference of <1.0‰). In spite of their spatial and temporal overlap (1380 and 1390 BP), the two individuals from Toro Loco exhibit a non-negligible difference in their isotopic signals (−9.8 and −11.0‰, respectively). In effect, while

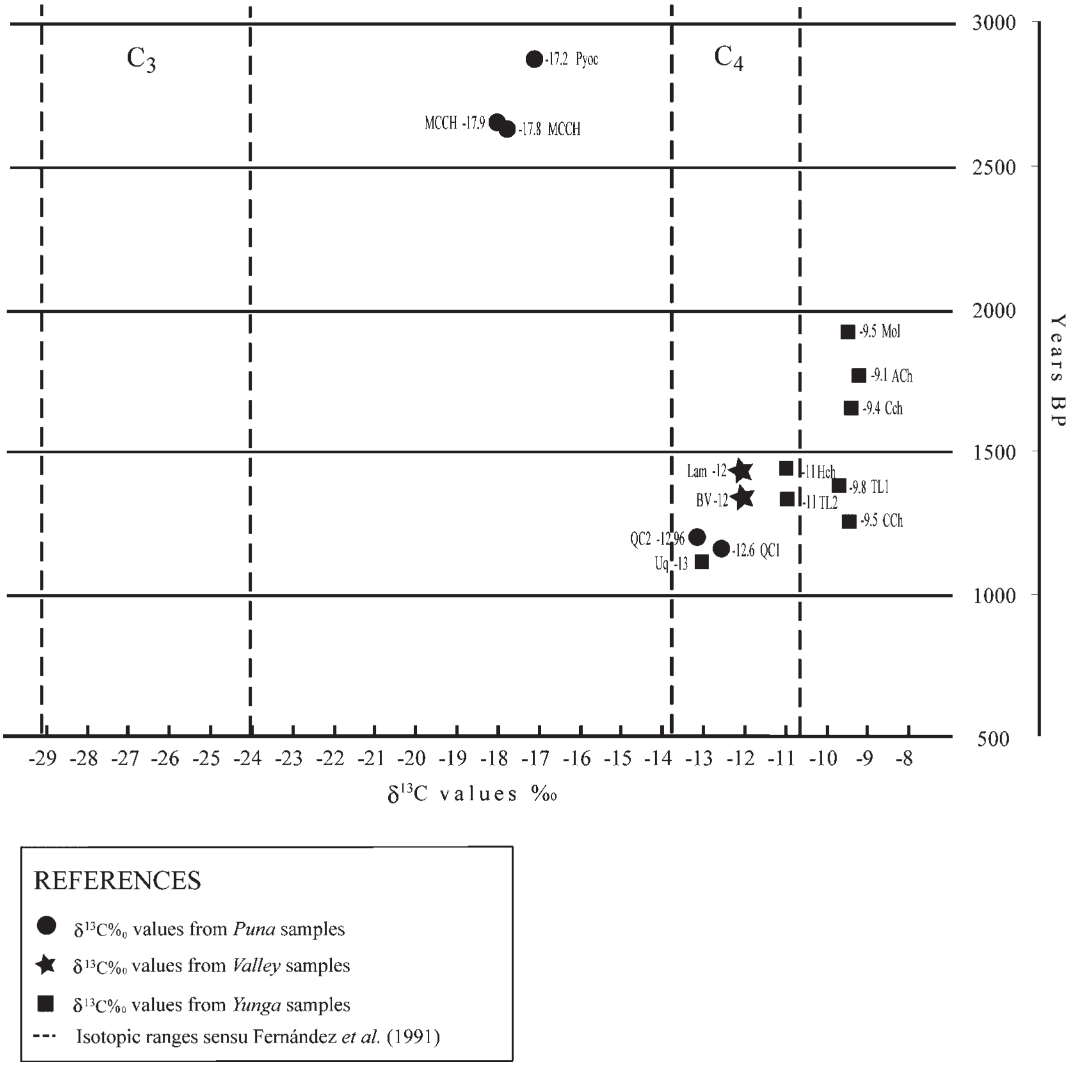

Figure 3. Temporal distribution of the samples against C_3 and C_4 ranges proposed by Fernández *et al.* (1991) for plants.

the sample Toro Loco 1 groups with Caspinchango 2, the sample Toro Loco 2 is more clearly associated with the individual from Huanacocha, both grouping towards the last values in the table. In this sense, and maybe because this is the region with the larger number of available isotopic data, La Candelaria represents an interesting case with regard to the distribution of isotopic values through time. Certainly, isotopic values become more depleted (from −9.0 to −13.0‰) over time. Yet, any interpretation of this tendency in terms of a modification in the diets of La Candelaria populations may be still unfounded given the meagre available sample.

Current research on early agriculture and archaeobotanical studies may offer some tools for a preliminary discussion of the data. As already mentioned, many authors have argued that tubers and pseudo-cereals were among the first products to be domesticated, while maize would not have acquired preponderance until agriculture was fully established perhaps towards the end of the Early Formative Period (*ca.* 600 AD) (Pearsall, 1992; Babot, 2004; Korstanje, 2005). According to this scenario, we would expect the samples to distance themselves from the C_4 ranges, getting closer to the C_3 ranges as we go back in time. The later samples (dated between 1100 and 1400 BP) from both the Valleys and the Yungas, as well as the three earliest ones (from 2500 to 3000 BP), seem to agree with this trend. Yet, those samples with dates lying within the 1500–2000 BP range show values that cluster around −9.0‰, thus moving away from the hypothesised tendency. This could be reflecting the fact that different populations would have followed diverse paths in the development of agriculture, that is, not adjusting to a unidirectional trend of decreasing C_3 and increasing C_4 values, but reflecting a more complex process of adoption and reliance on agriculture in northwestern Argentina. However, at this point, the lack of samples for the Yungas region dated between 2000 and 2500 BP hampers a more accurate interpretation of this process.

Conclusions

The analysis of samples from the Santa María Valley and adjacent Puna and Yungas areas of northwestern Argentina has shown that the expected tendency of increasingly positive C_4 isotopic values consistent with the assumed gradual consolidation of maize production techniques during Formative times was only partially corroborated. A more consistent verification of this trend is dependent upon the availability of a larger sample and local reference values. Data from the La Candelaria area could be showing a more complex and varied image of Formative times and the adoption of agriculture. Notwithstanding, considering the large chronological period and the small sample size, interpretations must be taken as preliminary and subject to further reconsideration in the light of new data. Future research will hopefully be centred upon enlarging the currently available sample as well as obtaining reference isotopic values for local fauna and flora, allowing a stronger interpretation of the observed tendencies.

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