International Journal of Osteoarchaeology
Int. J. Osteoarchaeol. **19**: 266–280 (2009)
Published online in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/oa.1053

An Approach to Pre-Hispanic Diets in the Pampas during the Early/Middle Holocene

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ABSTRACT The purpose of this paper is to contribute to dietary studies of Early-Middle Holocene Pampean hunter-gatherers, and to evaluate the intra-group dietary differences. Results from stable carbon isotope analysis of the organic and inorganic fractions of bone from 26 human remains from the sites Arroyo Seco 2 (Interserrana area) and Monte Hermoso 1 (Atlantic coast) are presented and discussed. Isotopic values from archaeofauna – including megafauna and current fauna – are also reported. $\delta^{13}C_{COL}$ isotopic values on human remains from these sites suggest the existence of different diets in Early-Middle Holocene groups, including individuals consuming mainly marine resources, individuals with a terrestrial diet based on C_3 plants and/or the intake of C_3-consuming herbivores, and finally, individuals with a mixed diet. $\delta^{13}C_{COL}$ data from human remains are consistent with the isotopic results obtained for the most abundant faunal remains at the sites (guanaco, Pampean deer, and seal). Apatite analysis was carried out on 22 individuals from AS2. The apatite results suggest C_4 plants or marine food consumption or a combination of both. Copyright © 2009 John Wiley & Sons, Ltd.

Key words: isotopic analysis; hunter-gatherers; Pampean region; Arroyo Seco 2; Early-Middle Holocene

Introduction

The present paper contributes to the dietary study of Early-Mid Holocene Pampean hunter-gatherers by means of stable isotopic analysis, and evaluates intra-group dietary differences in resource consumption, namely marine or terrestrial animals and plants. For this purpose, results of $\delta^{13}C$ studies performed on organic and inorganic fractions from human remains are presented. Isotopic data from fauna, such as mid-size terrestrial herbivores, marine mammals and extinct mega-mammals, are also summarised.

The analysed samples of human bone remains come from the Arroyo Seco 2 (AS2) site, located in the Interserrana area of the East Pampean region and dated to Early-Middle Holocene times. Additionally, for comparison, isotopic data are also included for results obtained from human remains from the Monte Hermoso 1 (MH1) site, on the Atlantic coast of the Pampean region (see Bayón *et al.*, 2007). The faunal database is from three different sites: Arroyo Seco 2, La Olla 1 and 2 on the Atlantic coast (adjacent to the MH1 site), and Campo Laborde in the Pampean plain (151 km north of AS2) (Figure 1). These sites relate to a period between the end of the

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Received 20 *October* 2008
Accepted 28 *October* 2008

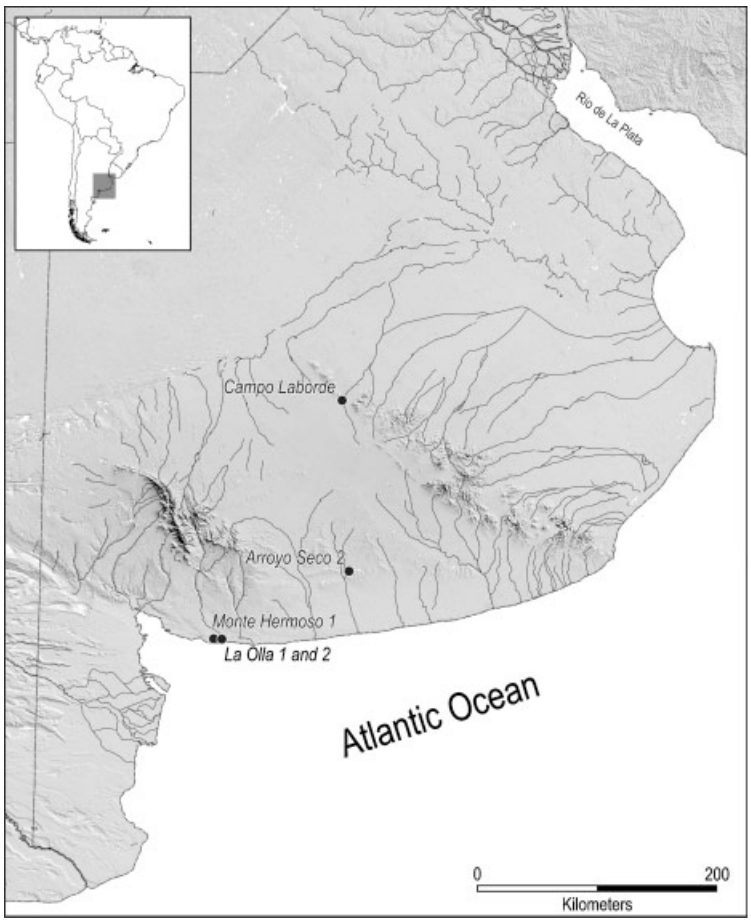

Figure 1. Map showing the location of the study area and sites.

Pleistocene and the Mid-Holocene. Isotopic data from both Campo Laborde and La Olla 1 and 2 have already been presented in recent papers (Bayón *et al.*, 2007; Politis & Messineo, 2008)

A consensus exists regarding the consumption of terrestrial herbivores among grassland Pampean hunter-gatherer groups, namely guanaco, Pampean deer and, in early times, Pleistocene megamammals, as well as plants and marine resources such as seals (e.g. Politis & Salemme, 1989; Mazzanti & Quintana, 2001; Berón, 2003; Martínez & Gutierrez, 2004; Bonomo, 2005). However, the importance of these resources in the prehistoric diet is currently under debate due to their uneven preservation in the archaeological record. Hence, research has focused primarily on archaeofaunal remains because of their greater representation, thus creating an incomplete picture that emphasises the protein portion of diet. Furthermore, plant remains are poorly represented and their consumption has been inferred only through the presence of grinding stone tools. As these materials seem to appear more frequently in the Late Holocene, it is concluded that most plant consumption occurred during this period. Specifically, consumption of fruit trees from the Espinal phytogeographical province has been suggested (Politis, 1984; Crivelli *et al.*, 1987–1988; Martínez, 1999; Politis & Madrid, 2001; Berón, 2003). Marine food has been identified mainly through the presence of associated seal bones found at just a few Pampean sites, like La Olla 1 and 2 (Bayón & Politis, 1996; Johnson *et al.*, 2000) and Alfar (Bonomo & Leon, 2007).

On the other hand, it has been proposed that the mobility of the eastern Pampean hunter-

DOI: 10.1002/oa

gatherers from the south of the Rio Salado Depression included the complementary exploitation of different resources from the coast, hills and grassland plains (Politis *et al.*, 2003; Bonomo, 2005; Bayón *et al.*, 2007). This idea has been discussed based on various evidence such as lithic raw material provenance, faunal remains, and more recently isotopic analyses (Barrientos, 1997; Politis & Barrientos, 1999; Flegenheimer *et al.*, 2002). Summing up, subsistence reconstructions have been so far based either on the study of faunal assemblages or lithic artefacts (i.e. grinding tools). In this context, chemical studies represent the first approach allowing an analysis at the scale of the individual.

Since the 1990s, the use of different stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) has gained relevance in subsistence studies of the Pampean region. These analyses have attempted to contribute to the debate on the diet of Pampean hunter-gatherers, complementing conventional approaches and shedding light on the exploitation of different environments. By means of traditional floral and faunal studies, and pathologies and dental wear studies performed in the region, it was possible to ascertain the possible diet components, but not individual quantities or proportions (Ambrose, 1998). Chemical studies of organic tissues have surpassed these limitations by yielding percentage ranges in which each diet component was consumed. As an example, we may cite the work of Barrientos (1997), who studied the diet of individuals from Arroyo Seco 2 and relied upon $\delta^{13}C_{COL}$ values of bone fragments to discriminate the contribution of terrestrial and marine resources to the diet of ancient populations. He concluded that their diet included the consumption of terrestrial foods with an occasional contribution of marine elements. Later, Politis & Barrientos (1999) presented new carbon and nitrogen isotope studies of human and faunal remains from AS2, Laguna Tres Reyes (Interserrana area), and Túmulo de Malacara (Atlantic coast). These first studies did not utilise isotopic analysis performed on the inorganic bone fraction, leaving the participation of plants in the diet mainly unexplored. Flegenheimer *et al.* (2002) cross-referenced information from lithic raw materials with isotopic analyses to determine the exploitation of different resources and to infer the mobility patterns of Late Holocene hunter-gatherers. The samples they studied came from El Guanaco site (county of San Cayetano), some 13 km from the coast. The data have shown the predominance of terrestrial over marine foods.

Murgo & Aldazabal (2007) made use of these analyses to characterise the diet of the Rio Salado Depression human populations, based on samples from La Salada, Laguna Sotelo and La Colorada. The results have been interpreted as showing a predominant consumption of terrestrial foods. Within the same area, Scabuzzo & González de Bonaveri (2007) recently discussed plant consumption through time in the La Guillerma locality. They utilised $\delta^{13}C$ data from the organic and inorganic phases of human bone, in conjunction with isotopic data from the regional fauna and flora. It was concluded that a larger plant intake – especially of the C_3 type – took place in early periods, while in later periods the diet involved the consumption of the aquatic rodent coypu (*Myocastor coypus*) and freshwater fish. Another example is the paper of Loponte & Acosta (2007), who used this type of study to observe the participation of plants with type C_3 or C_4 photosynthesis, and terrestrial and marine foods in the diet of pre-Hispanic groups in the Paraná Delta. Likewise, the authors attempted to identify the incorporation of corn (maize) in these populations. Martínez *et al.* (2006, 2009) employed $\delta^{13}C$ and $\delta^{15}N$ isotopes from organic and inorganic bone fractions to describe the diet composition, including marine food incorporation, in individuals from sites of the lower Río Colorado valley, to the south of the Pampean region. The authors conclude that their diets were characterised by the consumption of terrestrial foods with some incidence of freshwater resources, although variation in the incorporation of plant and animal food was observed among the samples.

In the context summarised above, the data from AS2 is crucial because abundant and well-dated samples are available. Moreover, along with MH1, both are among the very few Early Holocene sites with human remains in the whole Pampean region. This provides an excellent opportunity to explore the diet of ancient Pampean populations through isotopic analysis, taking into account at the same time variables

DOI: 10.1002/oa

such as the sex and age of the individuals and the distance to marine resources.

The Arroyo Seco 2 site

Arroyo Seco 2 (AS2) presents exceptional evidence for the study of the early peopling of the Pampean region (Fidalgo *et al.*, 1986; Gutierrez, 2004; Politis *et al.*, 2008). This multi-component, open-air site is located on a low ridge of loess between a small stream, the Arroyo Seco Creek, and a lagoon. The site is nowadays about 50 km north of the Atlantic coast (Figure 1). During Late Pleistocene times (*ca*. 12,000 to 11,000 years BP) the distance was greater, probably a few tens of kilometres more, due to the lower sea level, while in the interval 8000 to 4500 BP the distance was about the same as today.

AS2 has an early component containing a lithic assemblage composed of unifacial, marginally retouched tools associated with bone remains of guanaco (camelid), Pampean deer, and nine extinct megafaunal taxa: *Paleolama*, *Equus*, *Hippidion*, *Toxodon*, *Megatherium*, *Eutatus*, *Glossotherium*, *Macrauchenia* and *Glyptodon* (Politis, 1984; Fidalgo *et al.*, 1986; Gutierrez, 2004). At least three extinct genus found in this early component show evidence of human exploitation: *Equus*, *Hippidion* and *Megatherium* (see discussion in Gutierrez, 2004). The lower component of AS2 is interpreted to be the result of several human occupations at the end of the Pleistocene without a clear vertical resolution. The span of ^{14}C ages on megafauna bones is interpreted to be the result of two main factors: different occupation events, and differential bone contamination due to diagenetic processes. Three additional factors, possibly of a secondary nature, might also be involved: non-cultural mixing of bones due to biological and geomorphological processes; cultural factors such as the human graves; and discrepancies between labs in the pretreatment of the dated samples.

In the late 1980s and early 1990s, three radiocarbon ages from bone collagen of extinct horse (*Equus neogeus*) and giant ground sloth (*Megatherium americanum*) yielded Early Holocene ages: 8890 ± 90 BP (TO-1504), 8470 ± 240 BP (LP-53) and 7320 ± 50 BP (TO-1506) (Politis & Beukens, 1991; Politis *et al.*, 1995). However, 11 new Accelerator Mass Spectrometry (AMS) dating ages on megafauna bones from AS2 run at different laboratories yielded an age range between 10,500 ± 90 and 12,240 ± 110 BP (Politis *et al.*, 2008; Steele & Politis, 2008). Among these, three new results were particularly significant as they were obtained on the same *Megatherium americanum* bone sample previously dated to 7320 ± 50 BP. These new results do not confirm the Early Holocene age of the sample, placing it at the end of the Pleistocene: 12,200 ± 170 BP (CAMS-58182), 12,155 ± 70 BP (OXA-10387) and 11,770 ± 120 BP (AA-62514) (Politis & Steele, 2008). Therefore, the 7320 BP age should now be rejected, and the age of 8470 BP previously obtained on a separate specimen of *Megatherium* at the site must be considered suspect. The age of 8890 BP from *Equus* was not replicated either. Three dates from separate bone samples of American horse also gave Late Pleistocene ages: 11,320 ± 110 BP (AA-39365) for *Hippidion* sp, and 11,250 ± 105 BP (AA-7965) and 11,000 ± 100 BP (OXA-4590) for *Equus neogeus*. The revision of all megafauna bone dates from AS2 led to the conclusion that the dated assemblages contain at least five extinct species and at least three different events: one involving *Megatherium* at *ca*. 12,100 BP, a second with *Toxodon* at *ca*. 11,750 BP, and a third involving *Equus* and *Hippidion* at *ca*. 11,200 BP (Politis & Steele, 2008). As a consequence, the new group of radiocarbon ages from AS2 does not appear to support the Holocene faunal survival at the site, as was proposed previously.

Besides this early component, the site contains one of the best records of the transition between the Early and Mid-Holocene in the Pampas. To date, 44 human skeletons have been uncovered, with 21 dates from *ca*. 7800 to 4500 years BP (Politis *et al.*, 2008). An overlying level of unifacial quartzite tools and triangular bifacial stemless projectile points associated with guanaco, Pampean deer and rhea remains are probably related to the burials, which occur as both single-individual and multi-individual burials of adults and children (Figure 2). The earliest level of inhumation is represented by four burials (AS24, AS31, AS36 and AS39) of skeletons with bifacial triangular stemless projectile points within the

DOI: 10.1002/oa

Figure 2. Burials of Arroyo Seco 2.

bodies (Figures 3 and 4) and dated to between 7800 and 7615 years BP. A secondary burial with a similar chronology (*ca*. 7600 BP), which is the earliest burial of this type in the whole region, was also recovered at the site (Scabuzzo & Politis, 2007). With the exception of three graves of children (AS11, AS12 and AS13) dating to between *ca*. 4800 and 4500 BP, all the other skeletons are concentrated in the interval 7800 to 6300 BP (Table 3). Grave goods consisting of marine shell beads and necklaces of canid canines and powdered red ochre were recorded for 12 skeletons, indicating an early and complex funerary treatment of the dead. Moreover, the abundance of canid canines in a funerary context and the absence of other skeletal parts of canids in the site suggests that this animal would have had a strong symbolic connotation to mediate the relationship between humans and supernatural spirits or beings. The span of dates from the burials of AS2, both primary and secondary, suggests the use of the site – not continuously but redundantly – for inhumation purposes for about 3000 years during the Early-Middle Holocene.

Stable isotope analysis

Stable isotope analysis of bone is a well-established method of studying ancient human diet, with many publications on the principles, analytical methods, and means of interpretation (e.g. Tykot, 2006), so that we only emphasise here the methods used to produce the isotope data in this study. Carbon isotope values distinguish between C_3 and C_4 plants in the terrestrial food web, while nitrogen values can indicate marine resource exploitation, terrestrial climate and trophic level. Stable isotope ratios of carbon in bone apatite also represent diet, as long as adsorbed and diagenetic carbonate is removed prior to analysis. It appears that $\delta^{13}C_{COL}$ values

DOI: 10.1002/oa

Figure 3. Arroyo Seco 2 skeleton with two bifacial triangular stemless projectile points.

represent mostly dietary protein, while those from apatite reflect the whole diet (Ambrose & Norr, 1993). Both reflect long-term diets for adults, while elevated metabolism and growth rates of juveniles may result in more rapid collagen and apatite turnover; in all cases, isotope data from human bones represent the average diet over at least several years.

At the Laboratory for Archaeological Science at the University of South Florida, collagen was extracted by slow dissolution of the mineral component in dilute hydrochloric acid, neutralisation of humic acids with sodium hydroxide, and separation of fatty residues with a 2:1:0.8 chloroform, methanol and water mixture. In addition to visual assessment of the solid samples throughout processing, the resulting collagen pseudomorphs were dried and percentage yields calculated in order to evaluate preservation. Duplicate samples were subsequently run in continuous flow mode on a Finnigan MAT Delta Plus mass spectrometer connected to a CHN analyser, and %C, %N, and C:N ratios were recorded.

Bone apatite was extracted from cleaned bone by drilling a powdered sample, dissolving the organic phase in Clorox, and removing diagenetic and adsorbed carbonate contaminants with 1 M buffered acetic acid. Weight percentage yields at each stage were also recorded in order to identify any highly contaminated samples. Bone apatite samples were then analysed on a Finnigan MAT Delta Plus mass spectrometer using a Kiel III device which produced CO_2 gas through reaction with 100% phosphoric acid.

Isotope ratios are reported using the delta notation in parts per thousand or per mil, relative to the PDB (Peedee Formation, South Carolina, *Belemnitella americana* marine fossil limestone) standard in the case of carbon, and to AIR (atmospheric N_2) in the case of nitrogen. Precision is about $\pm$ 0.1 for carbon and $\pm$ 0.2 for nitrogen isotope results.

Results and discussion

With the aim of interpreting the isotopic results from the human remains, it is necessary to have an isotopic characterisation of the potential resources available in the lifetime of these people. Among these, two groups are distinguished: Pleistocene fauna and extant fauna.

Isotopic information for mega-mammals

The first set of isotopic information comes from different extinct animals, including giant ground sloth (*Megatherium americanum*), ground sloth (*Glossotherium robustum*), toxodont (*Toxodon platensis*) and extinct horse (*Equus neogeus* and *Hippidion* sp.) from the earliest levels of AS2 (*ca.* 12,100–10,500 BP) and Campo Laborde (*ca.* 7800–8100 BP; see discussion in Politis & Messineo, 2008). There are now 11 $\delta^{13}C_{COL}$ isotopic results for both sites. It is noteworthy that all $\delta^{13}C_{COL}$ values obtained are those informed by the radiocarbon dating laboratories jointly with the

DOI: 10.1002/oa

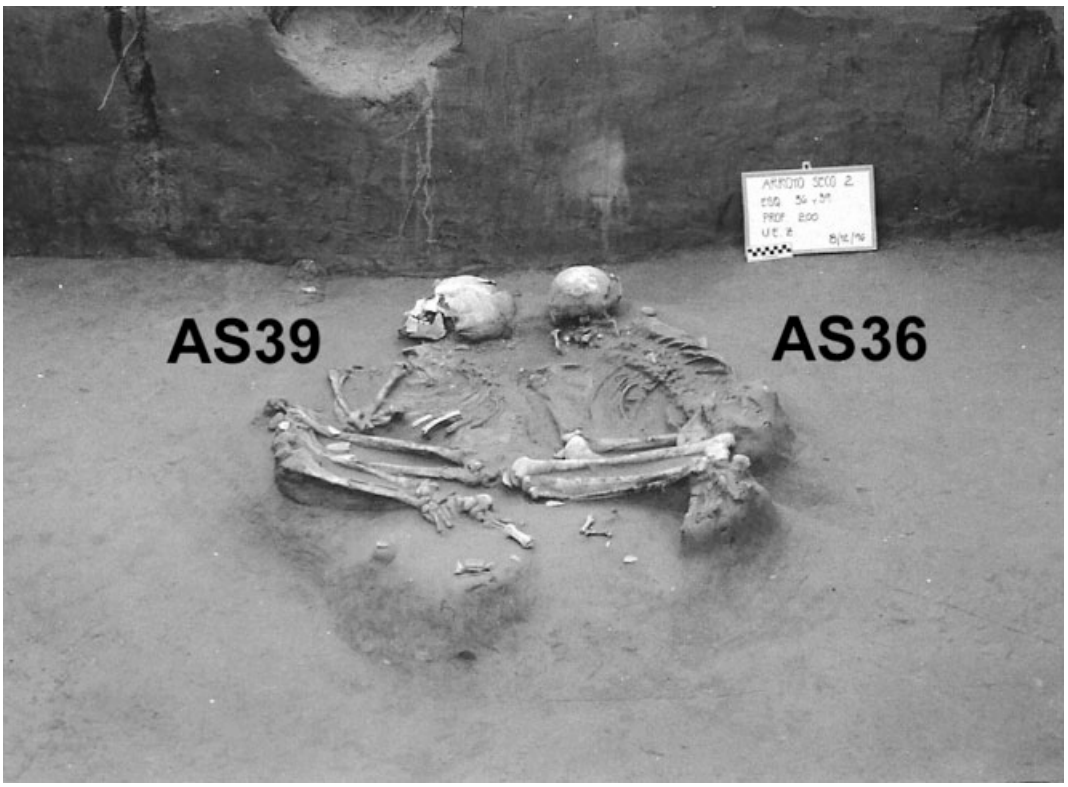

Figure 4. Arroyo Seco 2 burial 27.

reported ^{14}C dates. Two $\delta^{13}C_{AP}$ values were obtained from extinct mega-mammals, one from the AS2 site and another from the Campo Laborde site. Meanwhile, the four $\delta^{15}N$ analyses performed so far were done on toxodont and giant ground sloth found at AS2 (Table 1).

At the AS2 site, six $\delta^{13}C_{COL}$ values have been obtained so far, which were performed on different species: giant ground sloth, ground sloth and extinct horse (*Megatherium americanum*, *Glossotherium robustum*, *Equus neogeus*, *Hippidion* sp.). Six isotopic results with a range between −19.5‰ and −23.5‰ and a mean of −20.6‰ were obtained for these four species. These values indicate that the diet of these mega-mammals mostly consisted of plants following the C_3

Table 1. Isotopic information from extinct animals

Site	Species	$\delta^{13}C_{COL}$	$\delta^{13}C_{AP}$	$\delta^{15}N$	^{14}C Dates (yrs BP)	Lab no.	Source
AS2	*Megatherium americanum*	−23.5			11770 ± 120	AA-62514	Steele & Politis (2008)
AS2	*Megatherium americanum*	−19.7		5.2	12155 ± 70	OXA-10387	Steele & Politis (2008)
AS2	*Megatherium americanum*	−19.5		5.2	12170 ± 55	OXA-15871	Steele & Politis (2008)
AS2	*Hippidion* sp	−20.8			11320 ± 110	AA-39365	Steele & Politis (2008)
AS2	*Equus neogeus*	−20.1	−9.2		11000 ± 100	OXA-4590	Steele & Politis (2008)
AS2	*Glossotherium robustum*	−20.3			10500 ± 90	AA-9049	Steele & Politis (2008)
AS2	*Toxodon platensis*?	−15.3		5.7	12070 ± 140	OXA-9243	Steele & Politis (2008)
AS2	*Toxodon platensis*?	−15.3		5.7	11730 ± 70	OXA-9242	Steele & Politis (2008)
AS2	*Toxodon platensis*	−16.5			11590 ± 90	AA-7964	Steele & Politis (2008)
CL	*Megatherium americanum*	−18.9	−4.7		7750 ± 250	AA-55117	Politis & Messineo (2008)
CL	*Megatherium americanum*	−18.7			8080 ± 200	AA-55118	Politis & Messineo (2008)

DOI: 10.1002/oa

photosynthetic path (Larsen, 1997; Bocherens, 2000; Drucker & Henry-Gambier, 2005). Likewise, a value of −9.2‰ for $\delta^{13}C_{AP}$ was obtained from the horse remains. It is interesting to observe that the apatite value shows that the extinct horse diet included C_4 plants in moderate amounts. Two 5.2‰ $\delta^{15}N$ values were also obtained from the giant ground sloth samples.

Three additional $\delta^{13}C_{COL}$ values have also been obtained, one from a toxodont and two from an unidentified mega-mammal dated to the same age (most probably a toxodont) found at AS2. The average is −15.7‰, with a range between −15.3‰ and −16.5‰, indicating enrichment in comparison with the *Glossotherium*, *Megatherium*, *Equus* and *Hippidion* sp. samples from the same site. Two 5.7‰ $\delta^{15}N$ values were also obtained from the unidentified mega-mammal (probably a toxodont) sample. In summary, both the $\delta^{13}C$ and $\delta^{15}N$ values suggest that the diet of the toxodonts recovered from the AS2 site included a greater consumption of C_4 plants, which would explain the enriched $\delta^{13}C$ values. It is important to point out that until recently it was supposed that these types of plants were nonexistent in the area. The data obtained refute this, supporting their presence since the Late Pleistocene at least.

Two $\delta^{13}C_{COL}$ values have been obtained from the *Megatherium* remains found at Campo Laborde. These values present a range between −18.7‰ and −18.9‰ and an average value of −18.8‰, thus indicating that the diet of the *Megatherium* was preponderantly based on C_3 plants. However, a recently obtained $\delta^{13}C_{AP}$ value of −7.4‰ would indicate the incorporation of C_4 plants in this mega-mammal diet (Tykot, 2006). The $\delta^{13}C_{COL}$ values of the Campo Laborde *Megatherium* specimens show differences of 1.8‰ with those obtained from AS2 for *Glossotherium*, *Megatherium*, *Hippidion* sp and *Equus* (mean = −20.6‰). These differences could be related to a temporal variation in the availability of plants, since both samples present a difference of approximately 3000 years. It could also be related to spatial variation in plant distribution in the Pampas, since the sites are 151 km apart. This issue is still under study.

Terrestrial and marine resources

For the Early and Mid-Holocene fauna there are a total of 13 isotopic results from terrestrial and marine resources from the Arroyo Seco 2, La Olla 1 and La Olla 2 sites; $\delta^{13}C$ values performed on both bone fractions and $\delta^{15}N$ values are available for the following terrestrial taxa: canid, guanaco, Pampean deer, and rhea (Table 2). The $\delta^{13}C_{COL}$ values of the medium-sized herbivores, guanaco and Pampean deer, show a range between −19.4‰ and −23.3‰ with a mean of −21.3‰. These values, together with the 5.9‰ $\delta^{15}N$ value obtained for the Pampean deer, indicate a diet based predominantly on C_3 plants (Pate, 1994; van der Merwe *et al.*, 2000). However, a recent $\delta^{13}C_{AP}$ result yielded a value of −6.8‰, thus showing the consumption of C_4 plants (van der Merwe *et al.*, 2000). Besides,

Table 2. Isotopic values for terrestrial and marine resources

	Site	Species	$\Delta\delta^{13}C_{COL}$	$\delta^{13}C_{AP}$	$\delta^{15}N$	^{14}C dates (yrs BP)	Lab no.	Source
Terrestrial resources	AS2	*Canidae*	−13.5			6495 ± 95	AA-7967	This study
	AS2	*L. guanicoe*	−19.8	−6.8		7540 ± 80	AA-24052	This study
	AS2	*L. guanicoe*	−23.3			8390 ± 410	AA-52613	This study
	AS2	*O. bezoarticus*	−19.4		5.9			This study
	AS2	*R. americana*		−8.1				This study
Marine resources	LO1	*Otariidae*	−13.7			7315 ± 55	AA-7972	Bayón *et al.* (2007)
	LO2	*Otariidae*	−12.3			7400 ± 95	AA-19292	
	LO	*Otariidae*	−12.0		21.1			
	LO	*Otariidae*	−11.5		21.1			

DOI: 10.1002/oa

$\delta^{13}C$ values of −13.7‰ from canid remains are available for the same site. These values, more enriched than those obtained from the terrestrial herbivores, are expected for carnivores (Ambrose, 1993; Tykot, 2006).

For marine fauna, six values of $\delta^{13}C_{COL}$ and $\delta^{15}N$ from Otariidae obtained at the coast sites of La Olla 1 and La Olla 2 are available; $\delta^{13}C_{COL}$ analysis on these samples yielded values between −11.5‰ and −13.7‰, with a mean of −12.6‰. Those enriched in ^{13}C and high $\delta^{15}N$ values are expected for marine fauna (see Table 2).

Isotopic analysis of human remains

In the case of humans, $\delta^{13}C$ values performed on the organic bone fraction are available; it is worth noting that as in the case of faunal results, 17 $\delta^{13}C$ values have been provided by the radiocarbon dating laboratories jointly with the reported dates, and 12 have been processed at the Laboratory for Archaeological Science at the University of South Florida. Up to now, 29 $\delta^{13}C_{COL}$ values for the individuals from AS2 and two values for the MH1 site are available. When grouping individuals from both sites, the range of values is between −12.4 and −19.6‰ (Table 3).

This broad range of values indicates that the diets of Early-Middle Holocene individuals were varied. The study included individuals ($n = 3$) whose diets were based on the consumption of marine foods – these individuals were from MH1 and AS36 from Arroyo Seco 2. They are represented by the most enriched $\delta^{13}C_{COL}$

Table 3. Human samples with isotopic information

Sample	$\delta^{13}C$ (col)	$\delta^{13}C$ (ap)	$\Delta\delta^{13}C$	$\delta^{15}N$	C:N	Sex	Age	Radiocarbon dates (BP)
AS1	−17.2	−9.6	7.6	12.7	2.9	M	Young adult	
AS2	−17.3	−8.6	8.7	12.3	3.0	F	Children	
AS3	−18.3	−8.9	9.4			Indet.	Infant	6300 ± 70
AS4	−17.2			11.7		F	Young adult	
AS5	−19.0	−9.1	9.9			F	Young adult	
AS6	−17.3			11.8		Indet.	Adolescent	
AS7	−18.3	−8.8	9.5			F	Young adult	7043 ± 82
AS8	−16.3	−7.2	9.1	12.6	3.0	Indet.	Adolescent	
AS12	−17.8					Indet.	Infant	4487 ± 45
AS13	−19.6					Indet.	Infant	4793 ± 69
AS14	−17.0	−10.1	6.9			M	Adult	6838 ± 73
AS15	−17.7			12.6		F	Young adult	7000 ± 80; 6970 ± 60; 6880 ± 90
AS16	−18.7			12.7		Indet.	Infant	
AS19	−17.4	−10.4	7.0			M	Middle adult	6860 ± 60
AS20		−12.5				M	Middle adult	
AS21	−18.5					Indet.	Indet.	6908 ± 76
AS22	−17.9	−11.0	6.9	11.4		M	Old adult	
AS23		−10.9				M	Young adult	
AS24	−17.6	−11.1	6.5			M	Young adult	7800 ± 115
AS25	−17.6	−10.0	7.6	11.3		M	Middle adult	
AS26	−19.6	−9.6	10.0			F	Young adult	7580 ± 50
AS27		−10.1				Indet.	Children	
AS30	−17.2			11.4		Indet.	Indet.	
AS31	−17.3	−11.0	6.3			M	Old adult	7615 ± 90
AS32	−18.4	−9.9	8.5			F	Old adult	7685 ± 95
AS34		−8.4				Indet.	Infant	
AS36	−12.4	−10.6	1.8			M	Young adult	7805 ± 85
AS38	−18.2					M	Old adult	6823 ± 69
AS39	−19.6	−10.7	8.9	11.7		F	Adolescent	
AS40	−17.1	−10.7	6.4			F	Old adult	6940 ± 75
AS41	−16.2	−10.7	5.5	10.1		F	Old adult	
MH1-1*	−13.6					Indet.	Adult	6606 ± 79
MH1-2*	−13.2					Indet.	Adult	7866 ± 75

* *Source*: Bayón *et al.* (2007).

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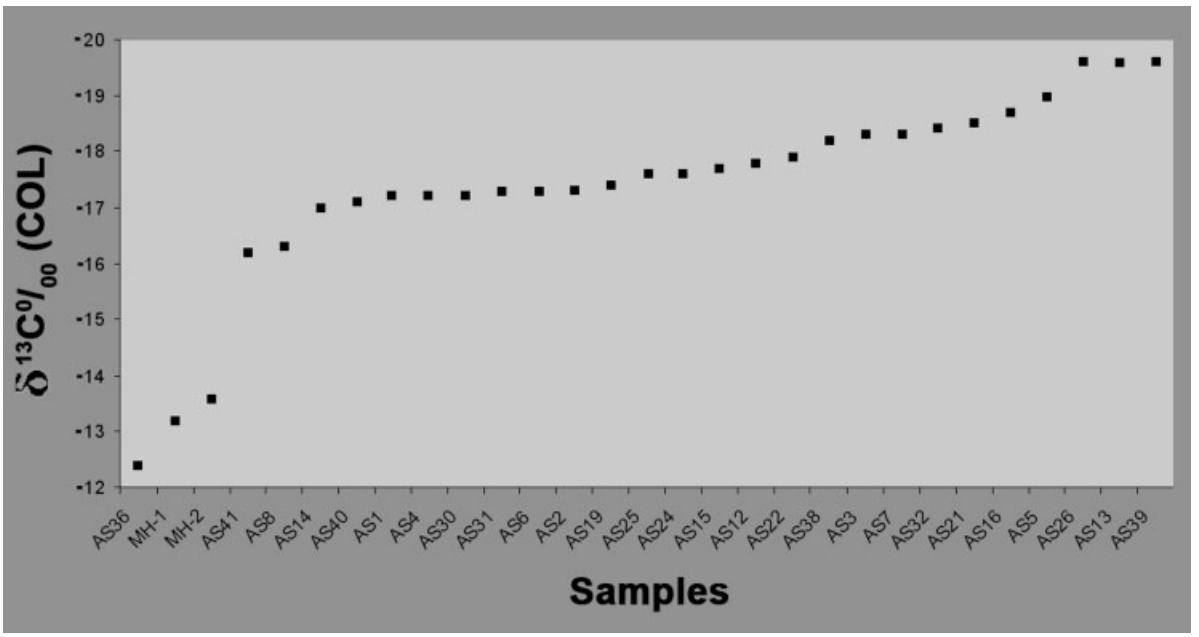

Figure 5. $\delta^{13}C_{COL}$ values for the individuals from Arroyo Seco 2 and Monte Hermoso 1.

values, whereas at the other extreme, with the most negative values, there are ten individuals with terrestrial diets which included the consumption of C_3 plants and/or herbivores that consumed them; and finally, with intermediate $\delta^{13}C_{COL}$ values are those individuals ($n = 16$) with mixed diets (Larsen, 1997; Barrett & Richards, 2004; Borrero & Barberena, 2006) (see Figure 5). It is noteworthy that all the $\delta^{13}C_{COL}$ values are consistent with the results obtained from the fauna most represented at the archaeological sites under study (guanaco, Pampean deer, and Otariidae).

Recently, $\delta^{13}C_{AP}$ studies were performed at the Laboratory for Archaeological Science of the University of South Florida. In order to minimise the error among these samples, only rib bones were selected. The objective of this type of analysis was to discriminate with greater precision the contribution of both C_3 and C_4 plants and marine foods in the diets of the individuals (see Harrison & Katzenberg, 2003). As previously stated, the studies on the inorganic bone fraction are of great use since they give a more complete picture of the diet of the individuals; they reflect more than just the protein component, which is the main result of analysis of the organic fraction (Sullivan & Krueger, 1981; Ambrose & Norr, 1993; Ambrose & Krigbaum, 2003).

So far, 22 $\delta^{13}C_{AP}$ results have been obtained from the inorganic bone phase. The range of values is quite limited, being between −7.2‰ and −12.5‰ with a mean of −10‰. These results show that the diet of the Early-Middle Holocene Pampean hunter-gatherers included the consumption of C_4 plants or marine foods, or a combination of both (Ambrose *et al.*, 2003; Harrison & Katzenberg, 2003). In sum, $\delta^{13}C$ determinations for both bone fractions are now available for 18 individuals (Table 3).

Based on the summarised values, two situations can be observed. On one hand, a first group includes the samples with enriched $\delta^{13}C_{AP}$ values (−8.8 to −10.9‰ range, mean = −9.5‰) and depleted $\delta^{13}C_{COL}$ (−18.3‰ to −19.6‰ range, mean = −18.8‰). This suggests a diet based on herbivorous consumers of C_3 plants, with the incorporation of C_4 plants in very low quantities (as reflected in the apatite values) for group includes individuals AS3, AS5, AS7, AS26, AS32 and AS39 (Figure 6). On the other hand, there is a second group formed by individuals with

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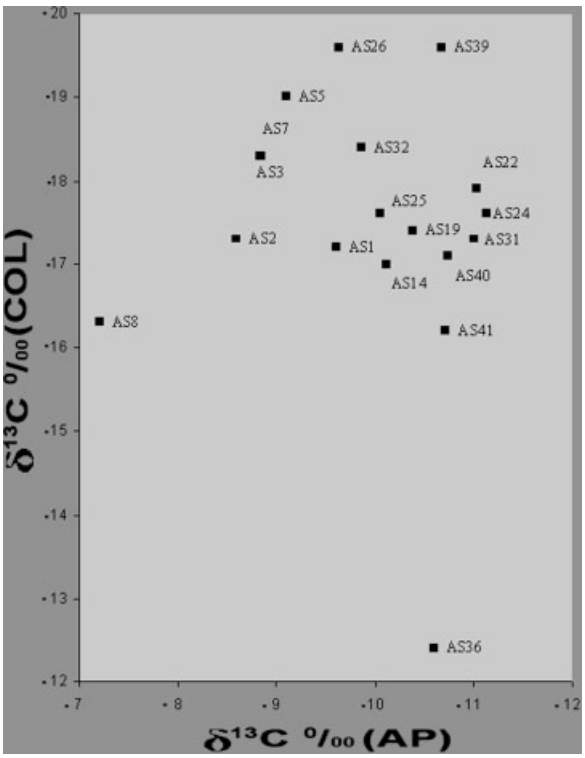

Figure 6. $\delta^{13}C_{COL}$ and $\delta^{13}C_{AP}$ values for the individuals from Arroyo Seco 2.

depleted $\delta^{13}C_{AP}$ values (−8.6 to −11.1‰ range, mean = −10.2‰) and enriched $\delta^{13}C_{COL}$ values (−17.0‰ to −17.9‰ range, mean = −17.3‰). These results indicate mixed diets that included the consumption of marine protein. However, the enriched apatite values cannot be explained only on this basis, leading us to suggest that these values might reflect the consumption of C_4 plants in low proportions. This group includes individuals AS1, AS2, AS14, AS19, AS22, AS24, AS25 and AS40 (Figure 6).

Individual AS41 is an interesting case that presents a low $\delta^{13}C_{COL}$ value (−16.2‰) and a $\delta^{13}C_{AP}$ value of −10.7, suggesting a significant consumption of marine resources. However the low $\delta^{15}N$ value of 10‰ does not support this hypothesis. On the other hand, it has been noted that the individuals from the first group present the highest $\Delta\delta^{13}C$, between 10 and 8.5‰ (Figure 7). This difference matches with a diet combining C_3 proteins and C_4 carbohydrates (Ambrose, 1993). In the second group the differences between the $\delta^{13}C$ values from both fractions are between 7.6 and 5.5‰, which can be explained by consumption of C_3 protein and marine resources in combination with C_4

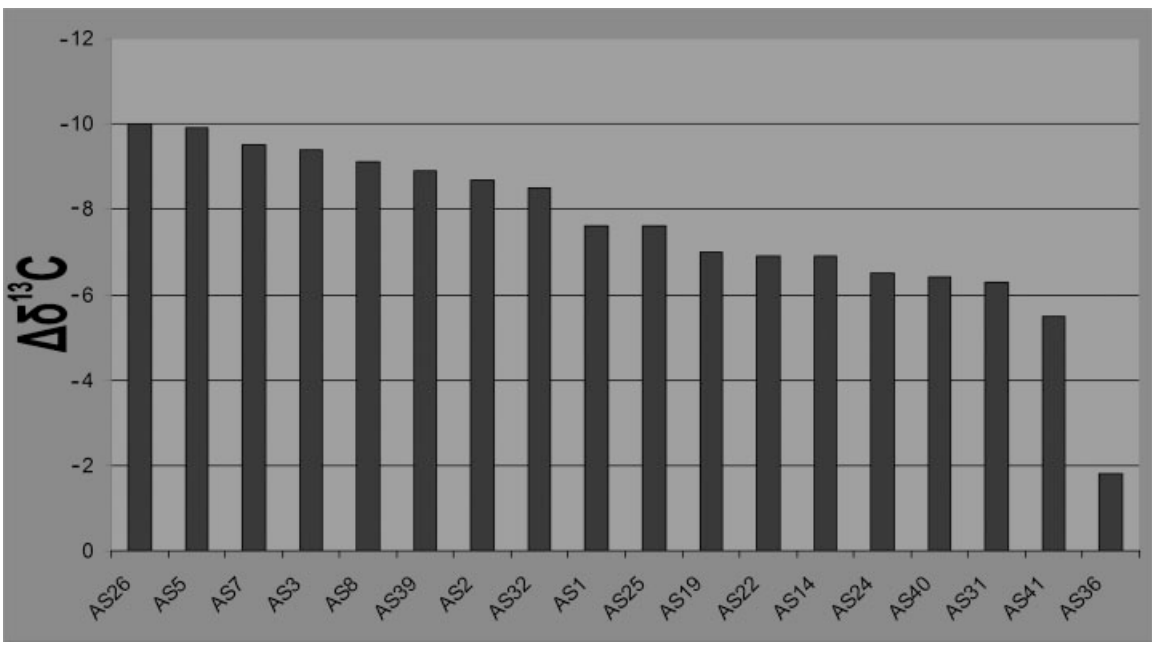

Figure 7. $\Delta\delta^{13}C$ values for human samples from Arroyo Seco 2 site.

DOI: 10.1002/oa

plants. A *t*-test shows significant differences in the means of both $\Delta\delta^{13}C$ values ($p < 0.05$).

The 12 $\delta^{15}N$ results (Table 3) gave values between 10.1 and 12.7‰ (mean = 11.8‰). Although these results are relatively low and do not indicate a significant consumption of marine foods, they should be interpreted taking into account the other available isotopic information. This issue is still under study.

A relevant case is individual AS36, a young adult male who presents the most enriched $\delta^{13}C_{COL}$ value ($\delta^{13}C = -12.4$‰) and a small range between both bone fractions ($\Delta\delta^{13}C = 1.8$‰), indicating that marine foods provided the basis of his diet. Two values for human remains from the coastal MH1 site were used for comparison. These values come from two skeletons dated at 6606 and 7866 years BP, recovered from the sand-dunes close to the shore. The $\delta^{13}C_{COL}$ values indicate a marine diet. If we compare the AS36 values with MH1, we see that AS36 consumed more marine foods than the individuals recovered on the Atlantic coast (MH1-1, MH1-2).

Conclusions

Although most of the Pleistocene mega-mammals were extinct when the Arroyo Seco burials occurred (the exception being *Megatherium*), their isotopic values indicate that most herbivores were consuming C_3 plants, but at least one (*Toxodon*) was also incorporating C_4 plants.

Isotopic results presented here show that the diet of the Pampean populations of the Early-Middle Holocene was based on the consumption of terrestrial herbivores which in turn consumed C_3 plants, with the exception of two individuals recovered at the Atlantic coast (MH1-1 and MH1-2) and one individual from AS2 (AS36), whose diet incorporated large amounts of marine foods. The isotopic values obtained for all these remains are consistent with the isotopic data available for the most representative fauna in the region.

On the other hand, the values obtained from the individuals of AS2 show dietary differences. The diets of all individuals involved the consumption of terrestrial herbivores which were consumers of C_3 plants, which could include guanaco, Pampean deer and, eventually, Pleistocene fauna (*Megatherium*) and a small amount of C_4 plants. However, some individuals (mostly men, 75%) added proteins of marine origin to their diet. These results are interesting from two points of view. Firstly, they constitute the first regional evidence of intra-population dietary differences. Secondly, we were able to obtain a wider picture of the diet of these groups by means of isotopic studies by recognising the consumption of plants, which are usually left out of the subsistence reconstructions due to poor preservation. Furthermore, the existence of type C_4 plants in the region during at least the Late Pleistocene has been recorded from the new $\delta^{13}C_{AP}$ results.

Whether the consumption of marine foods – obtained over 50 km away from the site – by some individuals implied the mobility of this part of the group only, or if the entire group moved to the coast, is still an unresolved issue. One possibility is that AS2 men and some women regularly visited the coast during foraging trips and consumed marine resources there, while others, mostly women and children, remained in the inland residential camps. A second possibility is that some food taboo or dietary restrictions existed between different members of the group. A third possibility is that people from coastal regions – mostly men – coupled others from inland areas and followed a matrilocal residential pattern. In this sense, the strong marine resource consumption during part of their life may have left an isotopic trace that is still recognisable. This could be the case for individual AS36, a young adult that presents enriched $\delta^{13}C$ values. Moreover, he was buried with a young female (Figure 4). We should also take into account that the two individuals from the MH1 site indicate that Early-Middle Holocene coastal hunter-gatherers were intensively consuming marine resources.

The presented data and interpretations shed new light on some unexplored dimensions of the Early-Middle Holocene Pampean populations. We consider that the study of how members of the group accessed food allows us to approach social relationships in the past (Hastorf, 1999). In this way, food can be considered as a significant means of understanding and maintaining relation-

DOI: 10.1002/oa

ships among members of the group, and different groups' food being central to different cultural dimensions such as distribution, exchange, tribute and taboo. Therefore, food is an effective and frequently used means of making distinctions within and between human groups (DeBoer, 1987: 45; Politis & Saunders, 2002).

Acknowledgements

This research has been supported by the Agencia Nacional de Promoción Científicas y Técnológica (PICT 04-12776) and by the annual grant given to the INCUAPA by the Secretaría de Investigaciones Científicas. Cristina Bayón and Pablo Messineo offered access to their isotopic data. Finally, the editors provided help and advice during the publication process. None of them, however, are responsible for the opinions expressed in this article.

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