

# Resource Exploitation and Human Mobility: Trends in the Archaeofaunal and Isotopic Record from Central Western Argentina

G. NEME,\* A. GIL, C. OTAOLA AND M. GIARDINA

CONICET-IANIGLA-Museo de Historia Natural de San Rafael, San Rafael, Mendoza, Argentina

**ABSTRACT** Previous researches have examined the zooarchaeological record to understand changes in human diet in central western Argentina through time. This research has focused on variations in the relative abundance of large prey in archaeofaunal contexts. The observed changes were explained by a decrease in residential mobility, forced by both the intensification in the use of resources and the introduction of the first domesticated plants ca. 2000 years BP.

In this paper, we revised archaeofaunal interpretations by taking into account zooarchaeological assemblages and human isotope records within the biogeographical distributions of prey in the region. Our results demonstrate that faunal diversity in zooarchaeological assemblages has a stronger correlation with the natural distribution of resources (especially with altitude) than with chronology, as was proposed previously. However, archaeofaunal information, including human isotopic data, suggests that a decrease in residential mobility, postulated in a previous paper, took place, modifying the expected diversity distribution throughout the landscape. Copyright © 2013 John Wiley & Sons, Ltd.

*Key words:* zooarcheology; South America; hunter-gatherers; subsistence; late Holocene

## Introduction

During the last 10 years, the archaeofaunal record from the southern Mendoza province (Figure 1) has been used to address several subjects related to human subsistence (Neme *et al.*, 1995, 1998, Neme & Gil, 2008; Giardina, 2010; Otaola, 2013). Scholars have tried to explain differences in archaeological tendencies through time by applying optimal foraging theory. These approaches have been useful in the development of ideas related to the incorporation of agriculture in the region, resource intensification, the impact of introduced domestic plants and the incorporation of marginal environments into hunter-gatherers' settlement patterns (Neme, 2007; Neme & Gil, 2008). All of these approaches have focused on chronological tendencies in archaeofaunal assemblages, paying less attention to environmental heterogeneity and its possible influence on the studied archaeofaunal patterns.

Different archaeofaunal studies have shown the influence of natural animal biodiversity in the taxonomic richness of the assemblages (Grayson, 1991;

Broughton, 1994; Broughton *et al.*, 2008). The high landscape variability in southern Mendoza may have played an important role in the formation of archaeofaunal assemblages. In this paper, we analyse zooarchaeological data and stable isotopic information from human bones to examine spatial tendencies in relation to the structure of present ecosystems. We then compare these results with previous ideas about human mobility and their use of animal resources in the region.

## Previous research

Southern Mendoza region was populated ca. 10 000 years BP and has been considered the limit of Andean agriculture in South America since the last 2000 years BP (Lagiglia, 1968, 1999; Hernández, 2002; Gil, 2003, 2006). Several questions remain regarding the real significance of cultigens in the diet and the impact they had on pre-Columbian societies, but apparently, the domesticates were never a staple resource for these groups (Gil, 1997–1998, 2003, Gil *et al.*, 2010, 2011).

In relation to faunal consumption, on the basis of the changes in taxonomic diversity and the artiodactyl index through time in southern Mendoza [(estimated with the formula:  $AI = \frac{\sum NISP \text{ artiodactyls}}{\sum \text{Number}}$ ]

\* Correspondence to: Gustavo Neme, CONICET-IANIGLA-Museo de Historia Natural de San Rafael. Av. Ballofet s/n Parque Mariano Moreno, San Rafael, Mendoza, Argentina, (CP: 5600).  
e-mail: gustavoneme@arqueologiamendoza.org

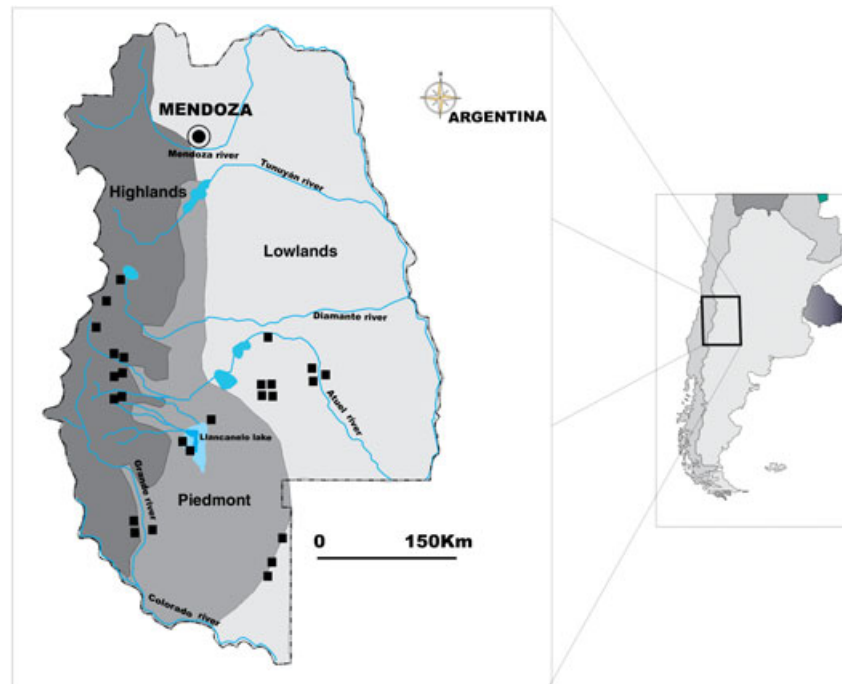


Figure 1. Mendoza province showing biogeographic zones and archaeological sites analysed in this paper. This figure is available in colour online at [wileyonlinelibrary.com/journal/oa](http://wileyonlinelibrary.com/journal/oa).

of Identified Specimens (NISP, Lyman, 1994) of all taxa identified) (Broughton, 1994)] researchers discussed ideas about changes in animal use and the consequences of the arrival of domestic plants to the region ca. 2000 years BP (Neme, 2007; Neme & Gil, 2008). The main observed trend is the decline in the artiodactyl index, along with the increasing consumption of smaller taxa (Neme, 2007; Neme & Gil, 2008). This tendency implied an increase in the processing cost and was explained by the development of an intensification process, originated by the imbalance between human demography and high return rate prey (mostly guanaco, *Lama guanicoe*). During the last 4000 years BP foraging societies overhunted guanacos, this led to the diminution of guanacos' encounter rate, and as a result they incorporated lower ranked taxa into their diet (Neme, 2007; Neme & Gil, 2008; Neme et al., 2012).

By applying models derived from optimal foraging theory (Szuter & Bayham, 1989; James, 1990; Winterhalder & Goland, 1997; Barlow, 2002; Cannon, 2003; Bettinger, 2009), it has been thought that the observed regional archaeofaunal tendencies were related to the introduction of agriculture to the region, which in turn caused a decrease in human residential mobility. Consequently, people overexploited animal resources around their camps, leading to a decrease in prey encounter rate.

On the basis of the diet breadth model, it was expected that prior to the introduction of the first

domesticated plants, resource over-exploitation generated two tendencies: first, an increase in taxonomic diversity (broader diet) related to the decrease of large prey, followed by a decrease in diversity (narrower diet breadth). This would be related, as we said, to the incorporation of the first domestic plants and the corresponding increase in sedentism (Figure 2). This decrease in faunal diversity is related to the exploitation of animals in the surrounding areas of the camps, and as a consequence, there was an increase in travel distance for hunting that focused on large game (Szuter & Bayham, 1989; James, 1990; Winterhalder & Goland, 1997; Neme & Gil, 2008).

Ideas concerning resource intensification were supported in part by archaeobotany and recent archaeofaunal data (Giardina, 2010; Llano, 2012; Otaola et al., 2012). However, while the archaeobotanical record shows strong evidence for intensification (Llano, 2012; Llano et al., 2012), new archaeofaunal data suggest that this process could only be supported in some of the southern Mendoza biogeographic regions (Giardina, 2010; Otaola, 2013).

Stable isotopes show a more diverse picture of resource consumption than previously accepted. First, human stable isotope data ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) have very different values for individuals from the same geographic area and time period (Gil et al., 2010; Gil et al., 2011); and second, there is a strong

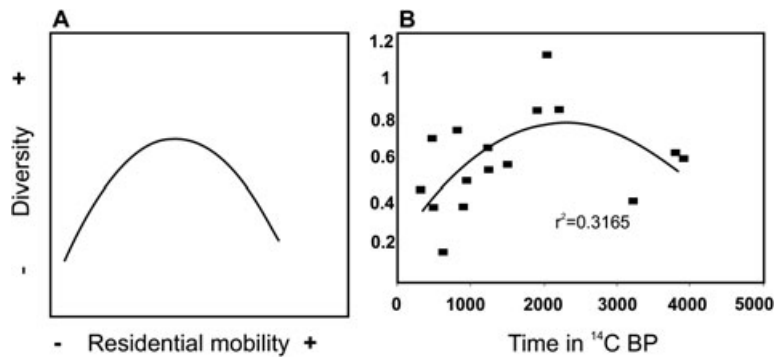


Figure 2. (A) Expected changes in resource use in relation to mobility. (B) Observed temporal trends in the zooarchaeological record from southern Mendoza (Neme & Gil, 2008).

isotope signal for maize consumption in the northern area of the region for only the last 1000 years BP.

Archaeobotany and isotope records indicate that the introduction of the first domesticates (maize, quinoa, beans and squash) did not have an important role in regional human subsistence. On the contrary, most of the regional population continues to live off wild resources, complemented with domesticated plants in some areas, especially in the Lowlands (Gil, 1997–1998, 2006; Gil *et al.*, 2010; Llano, 2012). Only in few small places located at the middle Atuel and Diamante River valleys, the domesticates become probably in a staple resource with important consequences for the human way of life (Lagiglia, 1968, 1999).

However, an important regional consequence of the intensification process was the populating of the most marginal areas from southern Mendoza (Gil, 2006; Neme, 2007; Neme & Gil, 2008). The marginal areas include the driest areas from the Payunia region (SE Mendoza) and the highlands of the Andes, located above 3000 mamsl. Apparently, this regional migration to uninhabited places was related to the use of new resources that were not previously exploited. In this sense, the intensification followed by the introduction of domesticates (ca. 2000 years BP) was characterised by an increase in diet breadth (plants and animals). Finally, the use of marginal environments does not appear to be related with environmental changes (Neme, 2007).

## Ecology and resource availability

Southern Mendoza is located between 34° and 37° south latitude, bounded on the west by the Argentine–Chilean border in the Andean Cordillera and the dry pampas to the east (between 66° and 70° west longitude). Three

main rivers irrigate the landscape and drain from west to east. From north to south, these rivers are the Diamante, Atuel and Grande Rivers (Figure 1). It is a heterogeneous landscape composed of three main ecological regions: the Lowlands to the east, Highlands to the west and Piedmont in between, which expands to form a large area in the South (Figure 1).

The presence of the Andes' cordillera to the west has a strong impact on weather, and thus, the distribution of plants and animals. The southern Mendoza province's elevation creates a semiarid environment where phytogeographical characteristics are transitional between the Patagonia and El Monte provinces (Capitanelli, 1972). The former is considered a grass steppe and the latter a shrub-dominated landscape (Roig, 1972). Annual rainfall is between 200 and 300 mm, with temperatures ranging from 5 °C to 35 °C.

The altitude in the east is lower than in the west. This altitudinal gradient generates vertically arranged vegetation and faunal distribution zones (Roig, 1972), with a high taxonomic diversity in the Lowlands (from 400 to 1200 mamsl), less taxonomic diversity in the Highlands (from 2000 to 3600 mamsl) and the Piedmont in between (from 1200 to 2000 mamsl). This trend follows the commonly observed pattern of decreasing diversity in elevation around the world (Pianka, 1972) (Figure 3). Water is scarce on the landscape. The main water resources are creeks, rivers and lagoons in the Andes, and rivers and springs outside the mountain areas.

*Lama guanicoe* (guanaco), the largest species, was the main dietary resource throughout time in all regions. *Rhea americana* (greater Rhea), *Rhea pennata* (lesser Rhea), *Lagidium viscacia* (vizcacha) and small mammals are some of the other important faunal resources in the area.

In the Lowlands, the number of species increase considerably because of the presence of a large number of rodent species [i.e. *Lagostomus maximus* (vizcacha),

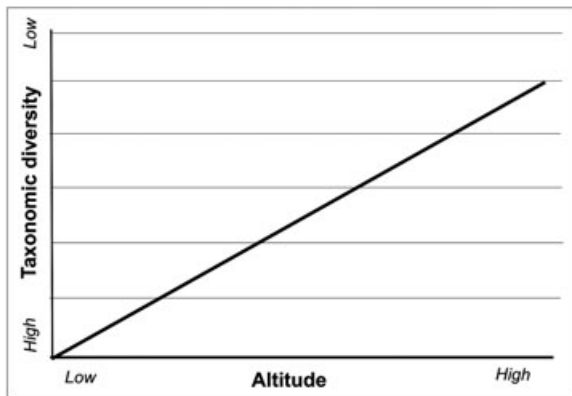


Figure 3. Ideal faunal diversity related to altitude.

*Dolichotis patagonum* (mara patagónica) and *Myocastor coypus* (nutria)], fishes [*Percichthys trucha* (perch), *Odonthestes hatcheri* (patagonian silverside)], birds [*Eudromia elegans* (elegant crested tinamou), *Coscoroba coscoroba* (coscoroba swan), *Phoenicopterus chilensis* (flamingo), *Phalacrocorax olivaceus* (neotropic cormorant)], armadillos [*Zaedyus pichiy* (pichi), *Chaethopractus vellerosus* (larger hairy armadillo)] and other small mammals (Roig, 1972). Even considering the ideal distribution of the species through altitude, it is important to remark that small changes in the environment (especially the plant distribution) could affect the altitude limits of many of the local species.

Two major environmental changes took place during the late Pleistocene and mid-Holocene. The first one is related to the glacial shrink between 14 000 and 12 000 BP. This had a strong impact on the Andes, but its implications reach most of southern Mendoza. A major vegetation change occurs during this transition, with vegetational shift in the Lowlands from a more patagonian grassland (with winter precipitation) to Monte province (more xeric environment), which has summer precipitation (D'Antoni, 1983; Markgraf, 1983; Zárate, 2002; Navarro et al., 2012). The last megafaunal survivors disappear around 8000 BP (Long et al., 1998; Dieguez & Neme, 2003; Forasiepi et al., 2011; Neme & Gil, 2012) with no evidence of interactions with the first human populations in the region.

There is no agreement about environmental changes between 7000 and 4000 BP during the mid-Holocene. Some paleoecologists support the idea that less precipitation and higher summer temperatures led to environmental deterioration (D'Antoni, 1983; Markgraf, 1983; Zárate, 2002). However, other researchers suggest that there was an increase in winter precipitation and in lake levels (Navarro et al., 2012). The presence of two contrasting climatic systems (one in the West controlled

by the Pacific anticyclone and the other in the East dominated by the Atlantic anticyclone) could be responsible for this ambiguous paleoecological signal. Finally, palaeoecological data suggest that the environment has been consistent during the last 4000 years (D'Antoni, 1983; Markgraf, 1983; Zárate, 2002). The faunal record agrees with this palaeoenvironmental reconstruction, indicating the presence of the same species throughout this period (Neme et al., 1995, 1998; Gil & Neme, 1996).

Although there is some palaeoenvironmental data indicating environmental changes, it is not clear how these changes impact the spatiotemporal scale of animal populations. For this reason, it is unclear how animal populations (especially large prey) react to environmental changes during the Holocene, and thus, how it impacts human behaviour.

## The archaeofaunal record

A total number of 25 archaeological sites were considered for this zooarchaeological study (Table 1, Figure 2). This sample represents all of the archaeological sites from the southern Mendoza province with archaeofaunal data. Because some are multicomponent sites, the number of archaeofaunal assemblages totals 36.

The archaeological sites are located in different ecological regions including mountain slopes and cliffs, meadows, creeks, river margins and terraces. Some are open air sites ( $n = 15$ ), and others are caves and rock shelters ( $n = 10$ ). Their altitude ranges from 400 mamsl on the plains to 3600 mamsl in the Andes. There is also variability in site function; many of these sites could be characterised as base camps or multiple-activity sites, special-purpose sites and some changed function through time. The total sample includes 93 222 bone specimens, 12 471 (13.3%) of which were identified at least to the family taxonomic level. In general, the predominant weathering stages are one or two on the Behrensmeier scale (Gil & Neme, 1996; Otaola, 2013), increasing to three or four at high-altitude sites where environmental conditions are harsher (Neme, 2007).

It is important to mention that other non-human taphonomic agents contributed to the faunal taxonomic compositions of these sites (especially those located in caves), creating more diverse assemblages. Numerous taphonomic studies in this region detected additional taxa related to activities of non-human predators (Giardina, 2010; Fernández, 2012; Otaola, 2013; Otaola et al., 2013). For this reason, in order to avoid an overestimation of faunal diversity, taxa with evidence of non-human consumption were excluded from the taxonomic analyses.



Table 1. Zooarchaeological assemblages used in this paper (Giardina, 2010; Fernández, 2012; Otaola et al., 2012)

Assemblage	Assigned date in years BP	Altitude in meters	NISP	NTAXA	Diversity	
					(Shannon)	Artiodactyl index
Los Peuquenes	280	3100	1566	3	0.13	0.97
Laguna El Diamante	600	3300	699	7	0.27	0.94
El Indígena	900	3600	84	2	0.18	0.95
Ao. Colorado cave A	1250	2160	3120	3	0.09	0.99
Ao. Colorado cave B	3200	2160	1138	3	0.1	0.98
Arroyo Malo 3 I	2200	2170	86	3	0.78	0.57
Arroyo Malo 3 II	3800	2170	84	3	0.7	0.72
Arroyo Malo 3 III	5500	2170	44	2	0.41	0.85
Arroyo Malo 3 IV	8000	2170	141	2	0.28	0.93
Arroyo Malo 1	550	2110	25	1	0	1
Arroyo El Desecho 4	5500	2060	6	1	0	1
Palulo A	130	2280	453	3	0.21	0.95
Palulo B	2200	2280	919	2	0.12	0.97
Palulo C	3970	2280	374	3	0.55	0.8
Panchino A	1048	2290	42	1	0	1
Panchino B	2793	2290	97	2	0.32	0.9
Cueva de Luna A	500	1330	891	6	0.56	0.84
Cueva de Luna B	1490	1330	322	3	0.7	0.64
Cueva de Luna C	3800	1330	80	3	0.72	0.68
Alero Puesto Carrasco A	470	1350	632	7	0.47	0.88
Alero Puesto Carrasco B	2100	1350	907	6	1.609	0.36
El Manzano ABC	1300	1335	185	4	0.83	0.57
El Manzano D	7190	1335	169	4	0.84	0.34
Agua de los Caballos	1240	1015	176	3	0.81	0.6
Puesto Ortubia	910	1035	120	3	0.64	0.76
La Corredera	1930	1170	72	4	0.78	0.27
Los Leones 3	200	1040	86	3	0.56	0.08
Los Leones 5	870	1050	7	1	0	0
La Peligrosa	1200	1140	245	2	0.03	1
Llan 17	1000	1345	32	2	0.69	0
Llan 22	798	1340	1	1	0	0
Llan 50	3000	1360	1103	1	0	0
La Olla	1000	475	1026	5	0.61	0.062
Rincón del Atuel 1	980	660	284	5	1.04	0.16
El Bosquecillo 3	886	490	3	1	0	0
El Bosquecillo 5	903	495	4	1	0	0

Many authors have emphasised problems related to the high correlation between taxonomic richness and sample size and how this correlation can affect zooarchaeological interpretations (Grayson, 1989, 1991; Kintigh, 1989; Lyman, 1994; Azanza *et al.*, 1999). For this reason, before using the archaeofaunal data, we must consider the potential effects related to the sample size. Therefore, we correlate theNTAXA of each assemblage with their sample size (NISP) (Figure 4). The result shows a weak correlation (linear regression) ( $R = 0.16$ ;  $p < 0.05$ ) between these two variables, suggesting that the samples are not strongly influenced by their size. We also generated a linear correlation betweenNTAXA-NISP from each biogeographic area, and the results show that sample size does not affect the number of taxa significantly in the Highlands ( $R = 0.15$ ;  $p > 0.05$ ) and Lowlands ( $R = 0.5$ ;  $p > 0.05$ ), but the opposite occurs with the Piedmont samples ( $R = 0.83$ ;  $p < 0.05$ ).

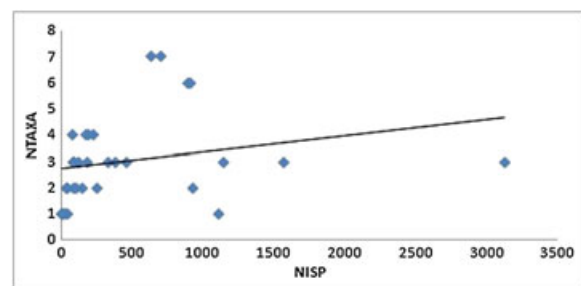


Figure 4. Correlation betweenNTAXA andNISP from southern Mendoza archaeofaunal assemblages. This figure is available in colour online at [wileyonlinelibrary.com/journal/oa](http://wileyonlinelibrary.com/journal/oa).

### Zooarchaeological diversity and resource distribution

In order to determine whether the negative correlation between diversity and altitude (less diversity at higher elevations) affected previous interpretations (Neme &

Gil, 2008), we calculated the Shannon diversity index for each assemblage (Table 1) and then correlated (Spearman's rho) the obtained values with their altitude. The negative correlation between diversity and altitude is weak ( $r_s = -0.16$ ;  $p = 0.34$ ). Therefore, we adjusted this curve by excluding sites with small samples where the diversity index equaled zero. As a result, the adjusted curve improves the correlation ( $r_s = -0.51$ ;  $p < 0.01$ ) (Figure 5). Further, this correlation can be strengthened, if we exclude the only remaining outlier (Alero Puesto Carrasco B).

The NTAXA from each assemblage follows the same pattern as the diversity index, but the linear correlation between NTAXA and altitude is weaker and not significant ( $R = -0.22$ ;  $p < 0.05$ ).

This negative correlation between altitude and diversity suggests that the archaeofaunal tendencies are more in agreement with environmental diversity and the distribution of faunal resources (specifically with altitude), than with expectations related to changes in resource exploitation by humans, as was suggested in a previous paper (Neme & Gil, 2008). The higher the elevation of the archaeological site, the less diverse the archaeofaunal assemblage. This trend was observed by other researchers from the region (Otaola et al., 2012).

It is important to clarify that the sites located at higher elevations (more than 3000 mamsl) with lower diversity values are not special purpose sites associated with short stays that could affect the faunal diversity. On the contrary, all of the sites are multiple-activity sites, highly re-occupied and related to hunting, plant processing, cooking, lithic refitting and exchange among others (Neme, 2007). The high presence of pottery and habitation structures reinforce this idea. This suggests that the low diversity values from the archaeofaunal assemblages in high elevations sites do not depend on the site's function.

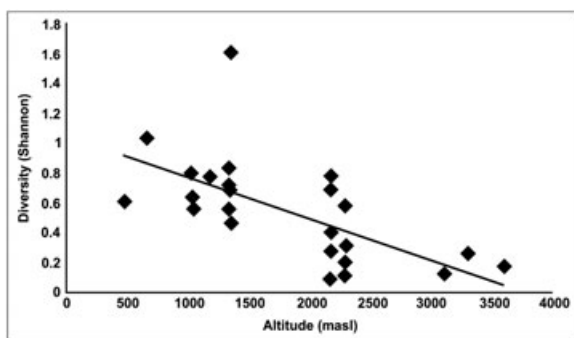


Figure 5. Correlation between altitude and Shannon diversity index from southern Mendoza zooarchaeological assemblages (adjusted curve).

The rest of the ecologic floors have different kind of sites, and the way in which this affects samples is the same for every ecologic floor (less diverse for single activity sites and more diverse for multiple activity sites), averaging the results.

## Zooarchaeological diversity and human mobility

The proposed changes in the use of fauna through time rely mainly on expectations about changes in mobility (Neme & Gil, 2008). As a consequence, if the subsistence models proposed in previous papers are not correct, as the data earlier suggest, then the changes in the residential mobility pattern from more mobile (pre 2000 years BP) to less mobile (last 2000 years BP) must be tested by other lines of evidence. Several indicators were used to characterise changes in residential mobility in the region, for example, an increase in the size of base camps, in lithic artefact diversity, a more expedient technology, more structured exchange networks and the use of pottery during the last 2000 years (Gil, 2006; Neme, 2007; Giesso et al., 2011).

To test this hypothesis about residential mobility (more sedentary over time), we used the same archaeofaunal information and divide it in two temporal groups. The first group consisted of samples older than 2000 years BP ( $n = 13$ ), and the second group consisted of samples younger than 2000 years BP ( $n = 23$ ). We generated different expectations in relation to mobility. First, there would be a more averaged archaeofaunal record between the different biogeographic areas (Lowland, Piedmont and Highland) for assemblages older than 2000 years BP, because they are moving longer distances and consuming resources from different altitudinal levels. Second, there would be stronger differences between the diversity values from the different biogeographic areas in assemblages younger than 2000 years BP, because human populations are more sedentary and consuming resources from the same altitudinal level where their camps are located.

For each interval, we correlated diversity values with the altitudinal level of the site. In both cases, there is a strong and significant negative correlation between these two variables:  $r_s = -0.58$  ( $p < 0.05$ ) for earlier times and  $r_s = -0.78$  ( $p < 0.01$ ) for later ones. However, archaeofaunal assemblages from later times show a stronger correlation, with greater differences between the biogeographic areas than predicted. Figure 6 shows

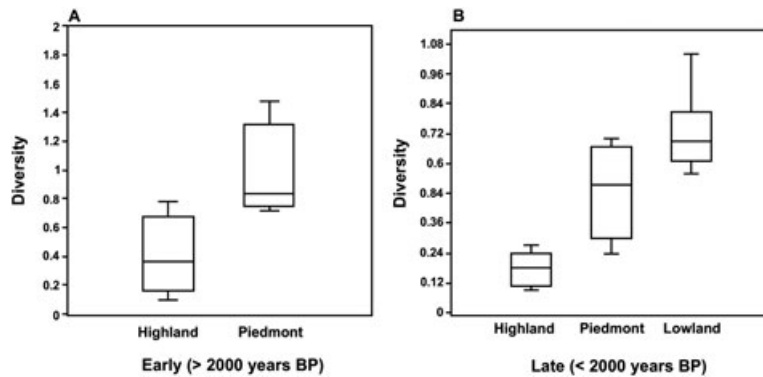


Figure 6. Comparison of the assemblage diversity in the different biogeographic areas during (A) earlier times, >2000 years BP and (B) later times, <2000 years BP.

box plots comparing the diversity distribution of the assemblages in the biogeographic areas (for the earlier times, we have only samples from Highland and Piedmont, whereas for the later times, there are samples from the three biogeographic areas: Highland, Piedmont and Lowland).

The strong differences between the zooarchaeological assemblages from the biogeographic zones could be representing smaller territories from which human populations were hunting prey, in comparison with those from previous times. However, we need to take into account that the residential versus logistical mobility patterns could affect expected patterns in a different manner. For this kind of mobility, it is possible that the logistical pattern expected during later times generated a more averaged archaeofaunal record because of an increase in the resource catchment area around the residential camps.

### *Discussing faunal tendencies with the human isotope record*

The isotopic data were analysed to assess mobility expectations following a previous model employed for  $\delta^{18}\text{O}$  (Gil *et al.*, 2011b; Ugan *et al.*, 2012). This model assumes that resources from each ecologic zone have different isotopic signals related to the vegetal structure and distribution of  $\text{C}_3$  and  $\text{C}_4$  plants (more  $\text{C}_3$  plants in the highlands and more  $\text{C}_4$  plants in the Lowlands) (Cavagnaro, 1988). Similar trends occur with the  $\delta^{15}\text{N}$  isotope values. In this way, we expect more enriched isotope values for animal resources from the Lowlands and less enriched isotope values for animals in the highlands because of the climatic response of  $\delta^{15}\text{N}$  (Ambrose, 1990; Hartman, 2011). We assume humans transport prey in a variety of ways between

different ecologic floors. However, considering the human effect associated to the transport of prey, if human populations were more or less mobile, the human isotopic signal would be different because of variation in resource availability between ecological floors.

Thus, if populations were more mobile, the isotopic data  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  should be similar between the different areas, because of lifetime human mobility between different environments. Humans consume resources from every region and therefore average their isotopic signal. On the contrary, if populations became less mobile, then their isotope signals should represent the area where they were living (more or less the same through space). It is expected that people would take resources from around the area where they live, and the occasional resources from other ecological regions would not be reflected in their isotope signal. This is because isotopic levels in humans are an average of the food eaten during the last 10 years of their lives. In sum, we expect more averaged values from earlier samples (>2000 years BP) if people were moving around different environments, and on the contrary, we expect stronger differences with more sedentary people in later samples (<2000 years BP) from each biogeographic zone.

Here, we use  $\delta^{13}\text{C}$  data obtained from the bone collagen of 65 human individuals from southern Mendoza archaeological sites (see details in Gil *et al.*, 2010). The human bone samples are located in the same areas as the zooarchaeological record considered here (see map in Gil *et al.*, 2010). The present study includes human remains from the last ca. 8000 years BP and were divided in two temporal units (early: >2000 years BP and late: <2000 years BP) and in three different biogeographic areas: Lowlands, Piedmont and Highlands. We do not have human isotope samples for the last interval in the Highlands. More details on

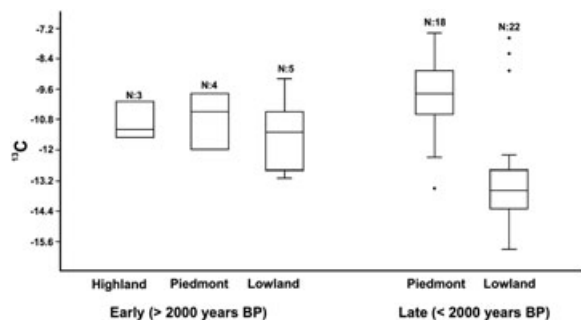


Figure 7. Human bones  $\delta^{13}\text{C}$  isotopes values for each biogeographic region of both analysed intervals (older than 2000 years BP and later than 2000 years BP).

the isotopic record were described in previous papers (Gil *et al.*, 2010; Gil *et al.*, 2011a; Gil *et al.*, 2012). Figure 7 shows the obtained results from early and late time periods of human samples in southern Mendoza. These results are in agreement with our expectations in terms of mobility. There are no significant differences between the biogeographic areas in early samples (one way ANOVA  $F=0.40$ ,  $p=0.678$ ) and significant differences between the areas for later samples (one way ANOVA  $F=25.08$ ,  $p=1.29\text{E-}05$ ). This suggests that the earlier human population (>2000 years BP) was consuming resources with similar isotopic signals. Variations in the isotopic structure imply an average diet with resources from different biogeographic areas (Cavagnaro, 1988; Giardina *et al.*, 2013). On the contrary, there is a significant difference between human bone samples from separate biogeographic areas during later times (<2000 years BP). This suggests that groups with diet differentiation between areas probably have less residential mobility and use more restricted areas. It is interesting that archaeofaunal data are following a similar pattern to the isotope record even though they work at different spatial and temporal scales. However, we need to remember that these two lines of evidence measure different aspects of subsistence and diet (Barberena & Borrero, 2005).

## Conclusions

The archaeofaunal record from southern Mendoza was used to understand changes in human subsistence through time. The observed tendencies were usually interpreted exclusively as products of human decisions, related with changes in the resources availability (Neme, 2007; Neme & Gil, 2008). However, recent research has demonstrated that not all the changes in

the archaeofaunal assemblages can be associated with diet changes. On the contrary, many of the regional assemblage owed much to taphonomic process and natural resource distributions (Giardina, 2010; Otaola, 2012; Fernández, 2012; Otaola *et al.*, 2012).

As in most montane environments, natural resources have a vertical distribution from high diversity in the Lowlands to very low diversity in the Highlands (Pianka, 1972; Grayson, 1991). In this paper, we demonstrate that the diversity in the zooarchaeological assemblage in central western Argentina is associated more with this vertical resource distribution than with differences in human diet breadth through time.

The increase in processing costs, associated with intensification or with the domestication process, is very closely related to a decrease in residential mobility (more costly resources—less residential mobility). This is why previous models (Neme & Gil, 2008) suggested changes in residential mobility (from more mobile, >2000 years BP, to less mobile, <2000 years BP). To test this hypothesis, we used information from human  $\delta^{13}\text{C}$  isotopes. The results of these analyses are in agreement with the expectation related to changes in mobility. The isotope record from southern Mendoza indicates a more restricted use of resources in each biogeographic area during later times (last 2000 years BP), meanwhile during earlier times, human isotopic data were an average from different areas, suggesting each individual used resources from all vertical zones.

The zooarchaeological analysis had a similar pattern to the  $\delta^{13}\text{C}$  data (more averaged diversity values during early times and more sectorized during later times); however, archaeofaunal data from both time periods show significant differences within each ecozone. Even considering the strong statistical differences of the faunal assemblages and isotopic results shown by the box plot from each ecologic floor, there is an overlap between sites. This overlap could be explained by the continuum in the distribution of taxa, the site's function and small changes in the environment that could affect altitude limits of species through time.

The nature of the scale in which both lines of evidence work (human isotopes and archaeofaunal assemblages) explains the differences in the significance of the obtained correlations, more clearly observed in the isotope record.

Finally, it is interesting to remark that even though the natural species distribution on the landscape explains most of the differences in the diversity values in the zooarchaeological assemblages, originally proposed changes in mobility still could occur but with less impact on the zooarchaeological record than originally proposed.



## Final remarks

Results from this paper highlighted the problems in the use of optimal foraging models if landscape diversity at a regional scale is not taken into account. Resource distribution in a heterogeneous landscape is a strong force that could affect interpretations.

Both lines of evidence, human isotopes and archaeofaunal remains, allow us to discuss mobility at a regional scale with more confidence and contrast proposed ideas within central western Argentina.

During the last few years,  $\delta^{18}\text{O}$  information has been used to discuss Late Holocene human mobility (Gil *et al.*, 2011; Ugan *et al.*, 2012). This research suggests that residential mobility from central western Argentina was higher than previously expected, even for agricultural societies from the southern San Juan and northern Mendoza (Gil *et al.*, 2011; Ugan *et al.*, 2012). However, both faunal diversity in the archaeological assemblages and the  $\delta^{13}\text{C}$  tendencies by biogeographic region can give us a better idea about human residential mobility and their use of local resources in each settlement.

We need to improve the number and quality of samples especially from the Lowlands, where faunal data are scarce. Additionally, it is necessary to have more comprehension of the scales in which faunal assemblages and human isotopic data work to understand archaeological implications and the use of different lines of evidence.

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