

New Data on South American Camelid Bone Size Changes during Middle-Late Holocene Transition: Osteometry at Peñas Chicas 1.5 (Antofagasta de la Sierra, Argentinian Puna)

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ABSTRACT Approaching the study of camelid bone size change in the meridional portion of the South Central Andes is a significant subject especially when the assemblages are associated to radiocarbon dates placed at a time of social transition from an extractive to a producer economy. In this sense, this paper presents the results of applying osteometric techniques on a set of 10 elements from the Peñas Chicas 1.5 site dated around 3800 BP. The analysis shows the presence of at least three individuals, one of which corresponds to an Andean guanaco (*Lama guanicoe*) morphotype. The second and the third are similar in size to a modern llama (*Lama glama*) in their 'intermediate' and 'cargo' morphotypes. This is consistent with patterns already seen for sites from the Argentinian and Chilean Puna where the identification of larger individuals than the Andean guanaco modern standard shows the early stages of an increasingly bone size variability of South American camelids. This paper contributes with new data to understand the complex processes that occurred in the South Central Andes that led to the domestication of one of the most conspicuous animals in the archaeological record of the Argentinian Northwest. Copyright © 2012 John Wiley & Sons, Ltd.

Key words: Andean zooarchaeology; Argentinian Puna; Late-Middle Holocene; osteometry; South American camelids; transitional hunter-gatherers

Introduction

The use of metrical values obtained through osteometric techniques has lately become widespread. In the last 15 years, continuous variables have been used to define species or morphotypes in more than 29 different contexts of the Argentinian northwest (NWA). The cases in Perú, Bolivia and the north of Chile should also be taken into account (Izeta, 2008). Hence,

the study of metric variables becomes an important tool to define bone size and thus generate a distribution to a determined species that might help solve archaeological problems of different sorts.

In this case, approaching the process of camelid bone size change in the meridional portion of the South Central Andes is significant because of the finding of remains radiocarbon dated at a time when a social transition from an extractive to a producer economy occurs.

In fact, the study area participated of a macro-regional process of socioeconomic change that transformed the hunter-gatherer economy into farmers and/or shepherds. In this sense, it has been proposed that such changes

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occurred inside the local hunter-gatherer groups and were not due to transformational stimuli from 'nuclear areas' (Núñez, 1994; Yacobaccio *et al.*, 1994; Olivera, 1998; Yacobaccio, 2001; Nuñez *et al.*, 2006; Cartajena *et al.*, 2007). Actually, available data for both east and west Andean slopes suggest that productive practices appeared as local, multiple, independent or related and relatively synchronic developments towards the end of the Middle Holocene (Núñez, 1994; Yacobaccio, 2001; Nuñez *et al.*, 2006). Camelid samples recovered from the Peñas Chicas 1.5 site make possible the exploration of these changes in economy models by means of the investigation based on one of the most popular techniques of species discrimination in this family of South American animals.

Camelid differentiation by morphological and metric characteristics in South America

Camelid differentiation by morphological and metric characteristics has been the centre of discussion for archaeologists and biologists for some decades (e.g. Kent, 1982; Mengoni Goñalons & Yacobaccio, 2006; Cartajena *et al.*, 2007; Izeta *et al.*, 2009). This topic is still debated because the systematic characteristic of this family has not been established yet (Labarca & Prieto, 2009). However, there are many questions that may be answered just by the effective differentiation of South American camelid species. Thus, different approaches have been taken to carry out the task with different degrees of success. Several morphological dental, cranial and postcranial characteristics have been defined (e.g. Wheeler, 1982; Lavallée, 1990; Benavente *et al.*, 1993). However, many of them do not cover the wide range of variability observed in current populations. Another type of approach is the analysis of camelid fibres already tested in different Andean and Patagonian assemblages. It has shed new light on the variability of this kind of remains and helped differentiate species in a wide range of contexts (Reigadas, 2001; Urquiza *et al.*, 2012).

Finally, there is a metric approach based on the measurement of bone continuous variables, basically from the postcranial skeleton. These techniques have been well known in the Argentinian palaeontology since the 1980s when they were used to differentiate an extinct camelid of the Argentinian pampas (Menegaz *et al.*, 1989).

Also, these techniques disclosed the presence of different groups of sizes within the archaeological assemblages which would hopefully answer the questions that we had been asking: When did the bone size variability begin? What was the predominant

strategy in the transition from hunting-gathering to production? How many types of camelids were there in the past?

Historically, camelid differentiation has been an important subject in the development of archaeological research in South America. This may be seen in the growing use of this kind of methodology in practically all investigation protocols, particularly in contexts of the NWA, northern Chile, Bolivia and Perú, and it is currently being applied in different South American ecological zones such as Patagonia, Pampa, Sierras Centrales and Cuyo (e.g. Cartajena, 2009; Izeta *et al.*, 2009; Kaufmann & L'Heureux, 2009; Labarca & Prieto, 2009; Vásquez Sánchez & Rosales Tham, 2009).

It is important to know what current populations are like, from a metric point of view, if we want to be able to differentiate the camelids of the past. For this reason, camelid data began to be gathered in Argentina and Perú. Thus, in the 1970s and 1980s, a large number of local llamas, alpacas and vicuñas were surveyed at La Raya Reserve in the Peruvian Puna (Miller, 1979; Kent, 1982). Guanacos were not included as they do not live in that area at present times. In the 1990s, Mengoni Goñalons and Elkin took measurements of the postcranial skeleton of a guanaco (*Lama guanicoe*) of the Cumbres Calchaquíes (Salta, Argentina) (Elkin, 1996a) to use them as a local metric standard because the size difference between this species and the Patagonian guanacos was already known. For several years, this information was the only one available until Izeta (2004; Izeta *et al.*, 2009) added further data of another guanaco from the west slope of the Aconquija (Catamarca, Argentina, 40/50 km south from the place where the other modern specimen was collected).

Even though the specimens are few and surely do not represent the expected variability for a population, they are the closest we currently have concerning camelid size to be found in the Andean region. This is of vital importance because several authors have adopted the measures of Patagonian guanacos as a standard for wild animals. It is well known that the former are larger than the biggest Andean camelid as it has been repeatedly noted before (e.g. Elkin *et al.*, 1991; Yacobaccio *et al.*, 1997/98; Mengoni Goñalons & Yacobaccio, 2006; Izeta, 2007; Mengoni Goñalons, 2008).

In 1991, Elkin *et al.* popularised a method of scaling the body size of the NWA camelids by suggesting a size gradient that went from the smallest specimens (*Vicugna vicugna*) to the largest ones (*Lama glama*). Thus, all Andean camelids would be divided in a small group including vicuñas and alpacas (*Vicugna pacos*) and a large group conformed by guanacos and llamas, following that order.

This gradient based on the body size of current live animals was straightaway used as a model to establish bone metric standards from data obtained from a single NWA *L. guanicoe*. The same individual is still being used as the metric standard to differentiate large camelid species (e.g. Mengoni Goñalons & Yacobaccio, 2006; Grant, 2008; López, 2009). Undoubtedly, that specimen itself still has to bear all the variability of the species nowadays. Hence, an agenda that facilitates understanding bone sizes for this species in terms of population, not only of an individual, is indispensable. Although this situation has not been solved yet, there is a growing conscience of the problem that will eventually result in the use of data from more than one Andean guanaco that will open the way towards an insight of the species as it has already happened in Patagonian assemblages (L'Heureux, 2007).

The size gradient used by Elkin *et al.* (1991) differs from the ones previously used by American researchers who worked with South American camelids from Peruvian archaeological contexts (e.g. Miller, 1979; Kent, 1982). The comparative standard these scientists had were guanacos from Patagonia, a region thousands of kilometres south of the study area. Patagonian specimens were larger than today's llamas. Hence, species classifications and allocations carried out with metric analyses assigned the largest specimens to the wild species of large camelids. Undoubtedly, this is a problem that has lately been observed over and over again, and it is another reason why the regional database of South American camelid bone sizes should be enlarged so as to determine if they may help in size and species allocations.

Towards the end of the 1990s, a member of our team made us notice this size gradient with metric data of contemporary camelids from various South American regions, supporting the size gradient proposed by Elkin *et al.* (1991) with osteometric data (Cardich & Izeta, 1999–2000).

On the basis of this observation, we mean to explore the metric values of camelid bones from an Argentinian Puna archaeological context so as to explore into the size evolution of bone elements recovered there.

Antofagasta de la Sierra regional settings. The Puna environment and paleoenvironment

The Argentinian Puna is a natural continuation of the Peruvian–Bolivian high mountain plateaus and is part of the Atacama Puna. From the geographical point of view, it is a block of high elevated plateau surrounded by towering mountain ridges. Between them, there are submeridian inner mountains of mild slopes and high basins and valleys 3500–4000 masl (Bruniard, 1999).

From an environmental point of view, the Puna is a high desert biome characterised by an arid and cold climate, intense solar radiation due to the height, ample day/night thermal range, poor summer rains, low atmospheric pressure and marked seasonality. The rain average goes from 18 to 400 mm a year in the area with the most humidity, and it decreases from the NE to the SW. Vegetation is scarce and mainly xerophytic (Yacobaccio, 1998). The weather is absolutely unpredictable in the short and medium terms. The summer rainfall regime, for example, may alternate years of extreme drought with periods of abundant rains, but conditions from year to year are practically unforeseeable (García *et al.*, 2000).

According to Troll (1958), different sectors with specific environmental characteristics may be found within the Puna. The Argentinian Puna includes the dry and the salty or desertic Puna. The first one, and most humid, is in the NW section, whereas the second one is drier with large salt flats and salt lakes as a result of reduced humidity and high evaporation rates (Olivera, 1998; Yacobaccio, 1998). Antofagasta de la Sierra is included in the salty Puna.

The area of study is in the NW angle of Catamarca Province (Figure 1). It includes a diversity of landforms and a mosaic of resources and microenvironments that represent the salty Puna. Its geographic boundaries correspond to a rectangular figure 90 km N–S and 50 km E–W of about 4500 km² (Aschero *et al.*, 2002–2004).

The landscape of the region has gently rolling plains, interrupted by igneous and metamorphic rock outcroppings as well as by volcanic chains and sedimentary rock sequences (González, 1992).

The area has always been apt for human occupation: there are permanent, although limited, riverbeds that are associated with pastures and fauna and an excellent availability of lithic raw material and other mineral resources such as edible salts and alums. Natural shelters made of ignimbrite rocky peaks and associate landslides are abundant (Aschero *et al.*, 2002–2004). The case of Antofagasta de la Sierra would be the product of a patch environment with many 'nutrient concentration zones' (Yacobaccio, 1994) surrounded by an extreme desert and related to the Río Punilla basin.

Olivera *et al.* (2006) obtained local palaeoenvironmental information based on sedimentological, geomorphological and pedological *proxy* data, as well as on ¹⁸O and ¹³C isotopic analyses in lagoons, water streams and *vegas* (fertile low lands). According to the results achieved (Olivera *et al.*, 2006; Tchilinguirian & Olivera, 2009), the study area was subjected to a series of acute environmental changes. A gradual process of desertification that began 8500 BP became very

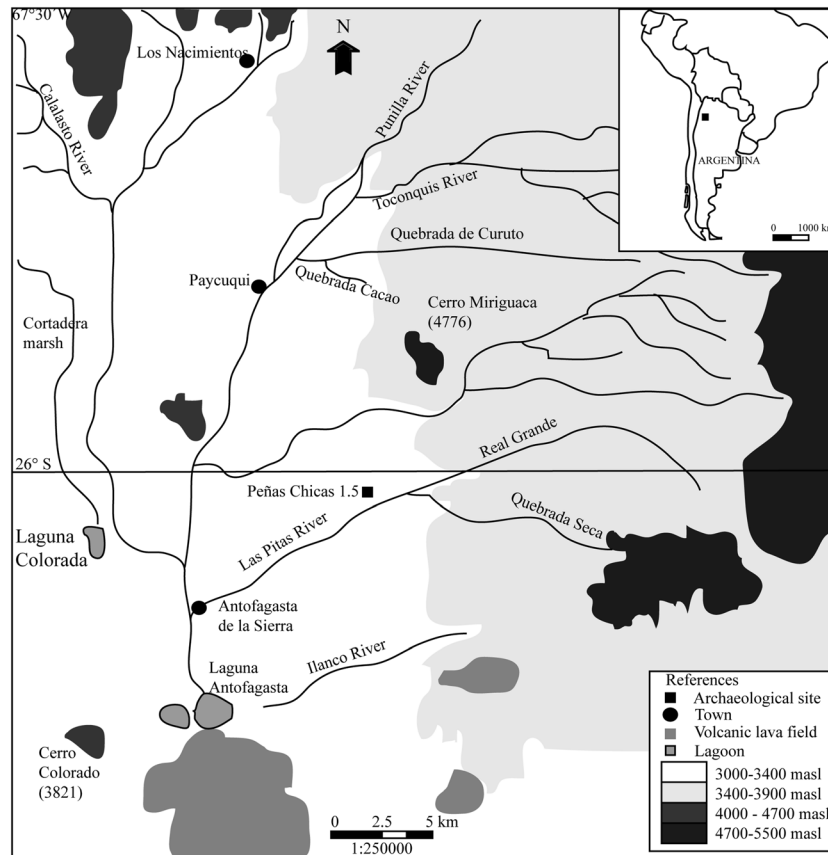


Figure 1. Map showing the micro-region of Antofagasta de la Sierra and the location of Peñas Chicas 1.5 site.

evident, 6500/6000 BP with an increase in temperature and aridity. Towards 4500/4000 BP, there is a period of high humidity and water abundance that finishes circa 1600 BP. After this date, a new desertification process begins that originates the current environment. The outstanding feature of this dynamic environmental history of Antofagasta de la Sierra is that, even at times of extreme aridity, the area always had important water resources and wetlands with the corresponding flora and fauna association.

Characteristics of the local archaeological sequence. *Peñas Chicas 1.5 site*

Investigations in Antofagasta de la Sierra (Argentinian Puna) have yielded abundant and relevant information regarding the transition from hunter-gatherers to farmer-shepherds, a process that took place between 5500 and 1500 BP. Evidence shows a progressive decline in residential mobility that ends up in a high degree of sedentarism with occupied dwellings the year around towards 2000 BP; recurrent findings of residential stone structures under rock shelters between 4000

and 3000 BP; growing signals of identity and territorial rights; long distance interaction networks involving biotic and abiotic resources, knowledge and information that covered the NWA and the Chilean desert and coast; a surge in the exploitation of subsistence resources, including the local development of production alternatives both animal and agricultural; and an increase in ritual activity (Aschero *et al.*, 1991; Aschero *et al.*, 1993–94; Elkin, 1996a; Pintar, 1996; Olivera, 1998; Reigadas, 2000–2002; Reigadas, 2008; Hocsman, 2002; Hocsman, 2006; Olivera *et al.*, 2003; Babot, 2004; Rodríguez, 2004; Aschero, 2007; Aschero & Hocsman, 2011). From these and other lines of evidence considered, the nucleus of the transitional process would have occurred locally circa 3500 BP.

The signs of human occupation grow markedly in Antofagasta de la Sierra since 4000 BP approximately, when considering sites with absolute chronology exclusively. Not only are sites more numerous, but the number of relatively synchronic settlements also increases (Hocsman, 2002; Hocsman, 2006).

The archaeological sites of Punta de la Peña 4 and Peñas Chicas 1.1 and 1.3 are interesting for our study

case. The pattern of settlement here is characterised by residential bases scattered in a micro-region, although the sites may be quite close to each other, at shorter distances than 700 m. The residential bases are mostly under rock shelters, contexts being differentiated by conditioned spaces and site equipment, Punta de la Peña 4 and Peñas Chicas 1.3; with conditioned spaces, Peñas de las Trampas 1.1; and with site equipment, Peñas Chicas 1.1; open-air residential bases with equipment, Peñas Chicas 1.6, and intentional object deposits such as tombs and offerings, Punta de la Peña 11A, Punta de la Peña 11 B and Peñas Chicas 1.5 (Hocsman, 2006; Aschero & Hocsman, 2011), are added to caves and rock shelters.

The site dealt with in this work, Peñas Chicas 1.5 (PCh1.5), is in the archaeological locality of Peñas Chicas at 3578 masl. Its coordinates are 26°01'811" S and 67°20'998" W (Figure 1). It is a rock ledge of reduced dimensions with an intentional deposit of objects. At the moment of discovery, wool strings and bone material could be seen on the surface. Probe

digging revealed two rodent caves with strings and wool tufts and an untouched area formed by a circle of rocks with diverse archaeological material in a particular disposition at the back of the shelter. There were many strings of plant and animal fibres, dyed and undyed, vegetal traces, wool tufts, a fragment of a vessel made of vegetal fibre covered with uncooked clay, considered a precedent of a later ceramics production (Cremonte *et al.*, 2010), and camelid bone remains that are the object of this work. This association was affected by a large fallen block, but it was evident that the remains distribution continued under it, and it is necessary to proceed with the digging. The camelid bone was dated at 3830 ± 50 BP (UGA 15097) (Aschero & Hocsman, 2011).

Peñas Chicas 1.5 camelid sample

The bone assemblage is composed of a number of specimens = 154 (Table 1), and 99.35% of it corresponds

Table 1. Relative abundance of adult camelid skeletal parts expressed as NISP, MNE and MNI

Element	NISP				MNE					MNI
	Axial	N/D			Right	Adult		Subadult		Right
		Left	N/S	Right		N/S	Right	N/S		
Atlas	1	1	—	—	—	—	—	—	—	1
Axis	2	2	—	—	—	—	—	—	—	2
Cervical	1	1	—	—	—	—	—	—	—	2
Vertebrae	9	—	—	2	—	7	—	—	—	1
Ribs	9	—	—	9	—	—	—	—	—	1
Tooth (frag)	1	—	—	1	—	—	—	—	—	1
Scapula	4	—	1	3	—	—	—	—	—	1
Humerus	2	—	1	—	—	—	1	—	—	1
Carpal	3	—	—	3	—	—	—	—	—	1
Intermediate carpal	2	—	1	—	1	—	—	—	—	1
Radial carpal	1	—	1	—	—	—	—	—	—	1
Second carpal	1	—	1	—	—	—	—	—	—	1
Third carpal	1	—	1	—	—	—	—	—	—	1
Innominate	4	—	2	—	2	—	—	—	—	2
Femur	6	—	1	2	1	—	—	1	1	2
Patella	1	—	—	1	—	—	—	—	—	1
Metatarsal	1	—	—	—	1	—	—	—	—	1
Calcaneus	3	—	—	—	3	—	—	—	—	3
Astragalus	1	—	—	—	1	—	—	—	—	1
Fourth tarsal	4	—	1	—	3	—	—	—	—	3
Sesamoid	1	—	—	1	—	—	—	—	—	1
Metapodial	3	—	—	—	—	1	—	2	—	2
First phalanx	4	—	—	—	—	4	—	—	—	1
Second phalanx	2	—	—	—	—	2	—	—	—	1
Third phalanx	2	—	—	—	—	1	—	1	—	1
Cartilage	1	—	—	1	—	—	—	—	—	—
Cancellous bone	38	—	—	38	—	—	—	—	—	—
Flat bone	24	—	—	24	—	—	—	—	—	—
Long bone	21	—	—	21	—	—	—	—	—	—
Total	153									

NISP, number of identified specimens; MNE, minimum number of elements; MNI, minimum number of individuals; N/D, undetermined age; N/S, not sided.

to Artiodactyl and South American camelid specimens and elements ($n = 153$). The 80 specimens identified as Artiodactyls have not been defined as camelids because they lack diagnostic zones that may establish genus or species. At any rate, they may correspond to that taxon if we compare them with archaeofaunal assemblages of the Andean area. Under the light of this statement, we may hypothesise that almost all the assemblage would be composed of camelids. This is interesting because only one element was assigned to a small, undetermined vertebrate. Following the methodology already used, the specimens were grouped by genus or species into size groups according to the scale proposed by Izeta (2004; 2007), a product of the scale suggested by Brain (1981) for African ungulates. There are four size categories (1–4) where 1 corresponds to small-sized animals (rodents, reptiles, birds with live weights lower than 0.50 kg) and 4 to animals with live weights higher than 50 kg. With this criterion, 153 specimens were assigned to category 4 and only one to category 1. Taking into consideration this element homogeneity (all artiodactyls and camelids), we carried out one analysis for the whole assemblage.

Thus, we observed that generally none of the basic skeletal parts (head, neck, trunk and limbs) were absent, although there were some variations regarding the representation of each element as will be seen further on. From the head, we identified tooth fragments, but there were also specimens corresponding to flat bones and cancellous bone. The neck and trunk presented vertebrae and ribs, whereas the limbs showed all elements, both proximal and distal. The general description was carried out taking into consideration the element discrimination according to age group. Only two groups were established: adults (older than 36 months) and subadults (younger than 36 months) following Kent (1982) and Kaufmann (2009). This differentiation was based on the epiphyseal fusion of long bones, and for this reason, only few elements could yield this kind of data. Notwithstanding, they and the metric variables seen further on facilitated the construction of a maximum distinction minimum number of individuals. In this study, only 10 (of the number of identified specimens = 154) adult short bones were used for osteometrics.

Osteometry

As previously stated, the statistical processing of data obtained through osteometry has made possible the determination of morphotypes with similar metric characteristics as those of modern camelids in different assemblages of the NWA. They have been used in

Puna sites archaeofaunal assemblages as well as in the mesothermal valleys with satisfactory results both in the assignment of elements to diverse morphotypes and in data interpretation (e.g. Yacobaccio *et al.*, 1997/98; Izeta, 2007).

In this work, the results of the application of such techniques on a 10 bone assemblage are presented. They correspond to an intermediate carpal, a radial carpal, a second carpal, a third carpal, two first phalanges (rear limb), a second phalanx, two fourth tarsals, a first phalanx (forelimb) and a fourth tarsal. The variables used for each element can be found in Table 2.

The principal component analysis was carried out on the basis of the measurements obtained (Table 2) to observe the resulting groups in the first phalanges. This is particularly important when taking into account the ample metric data availability of this element. As for the rest of the elements (carpals, tarsal and second phalanx), hierarchical clusters (unweighted pair group method using arithmetic averages) were performed because of the scarcity of modern comparative elements. They were only used to confirm the trends observed in the first phalanges. The analyses were made with the 1.94b version of the PAST software (Hammer *et al.*, 2001).

Results

Data of only two variables could be obtained from the two first phalanges analysed here. F107-25-4 can be seen to fall in the group of large camelids, and the association with the intermediate llama is clear. F107-34-1 is grouped with elements that correspond to the Andean guanaco (Figure 2). The second phalanx (F107-25-2) is linked to similar values as those of the modern Andean guanaco. This second phalanx had remains of hide and fibres which, when analysed, showed a coincidence with the previous specific assignment carried out by means of osteometry. The fact that two independent techniques gave similar results strengthened the value of assignments through osteometry.

The first phalanx (F107-25-5) only had four variables in adequate conditions to be measured because of preservation matters. In this case, Figure 3 shows that the values obtained associate it with comparative contemporary elements belonging to large camelids such as the llamas used today as carriers. These size relations were represented in a biplot graph to make them more evident.

Out of the elements in conditions to be measured in Table 2, a right and left tarsal were assigned to the intermediate llama morphotype (Figure 4(a)). Four

Table 2. Osteometric variables used in this work. References: Kent (1982), Von den Driesch (1976), Izeta (2004), L'Heureux (2007).

Element	Code	Description	Equivalences			
			Kent	Von den Driesch,	L'Heureux	Izeta
First phalanx	PHF01	Maximum length, parallel to the main axis, using the tangent formed by the proximal plantar condyles and the end at the most distal point of the distal articular surface as a base.	FP1V1; BP1V177	GI		
	PHF02	Proximal articular surface width	FP1V2; BP1V178	BFp		
	PHF03	Proximal articular surface height	FP1V3; BP1V179			
	PHF04	Distal articular surface width	FP1V4; BP1V180	Bd		
	PHF05	Distal articular surface height	FP1V5; BP1V181			
Second phalanx	PHS02	Proximal articular surface width. Taken as measure 2 of the first phalanx.	P2V7	BFP	4	2
	PHS04	Proximal articular face depth. It is quantified in the same way as measure 3 of the first phalanx	P2V8		7	3
Intermediate carpal	D	Depth, the element is placed in its normal anatomic position and the maximal value is measured from the anterior face to the posterior part of the element.				D
	L	Length, measured on the anterior face of the element from the articular facet with the radius-ulna to the edge of the articular facets with carpal 3 and carpal 4				L
	W	Width, measured in the anterior portion. Maximum width of the articular facet with the radius-ulna.				W
Radial carpal	D	Depth, the element is placed in its normal anatomic position and the maximal value is measured from the anterior face to the more posterior part of the element				D
	L	Length, measured on the anterior region from the radioulnar most proximal articular facet to the most distal part of the articular facet with carpal 3.				L
	W	Width, measured in the distal region. Maximal width of the articular facets with carpal 3.				W
Carpal 2	D	Depth, measured on the articular facet with the metacarpal from the anterior to the posterior edges.				D
	L	Length, maximal value between the articular facet with the radial carpal and the articular facet with the metacarpus.				L
	W	Width, from the outer face to the articular facets with carpal 3.				W
Carpal 3	D	Depth, maximal value between the anterior face and the most caudal portion of the element.				D
	L	Length, measured on the anterior region. Maximal value between the articular facets with the radial carpal and the intermediate carpal and the articular facet with the metacarpal.				L
	W	Width, measured on the anterior region from the outer face to the articular facets with carpal 4.				W
TR4	D	Depth, maximal value between the anterior face and the most caudal portion of the element.				D
	L	Length, measured on the anterior region. Maximal value between the articular facets with the radial carpus and the intermediate carpal and articular facet with the metacarpal.				L
	W	Width, measured on the anterior region from the outer face to the articular facets with carpal 4.				W

carpals correspond to the left side and fall into the group of modern llama elements (Figure 4(b–d)).

Similar morphotypes to those of the modern Andean guanaco, intermediate llama and a larger camelid than the intermediate llama, were identified in this analysis

(Table 3). It is interesting that in this context, the presence of vicuñas was not detected through osteometry, although this is one of the most frequently found animals in archaeological sites of the zone. This might confirm the particularity of the context.

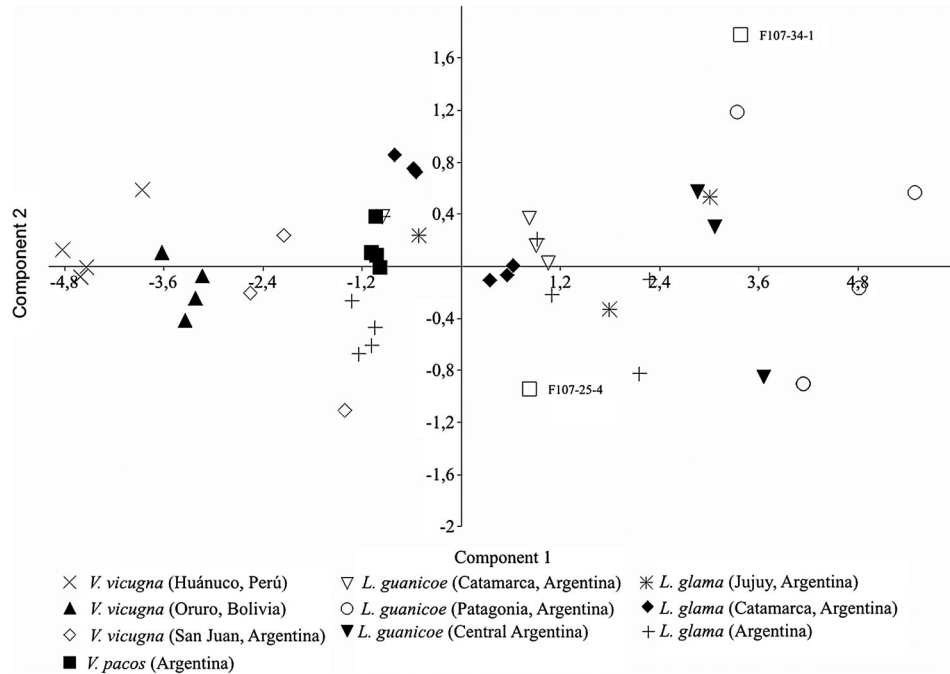


Figure 2. First phalanx (rear limb) principal components analysis showing archaeological bones grouping with those of well-known modern South American camelid samples.

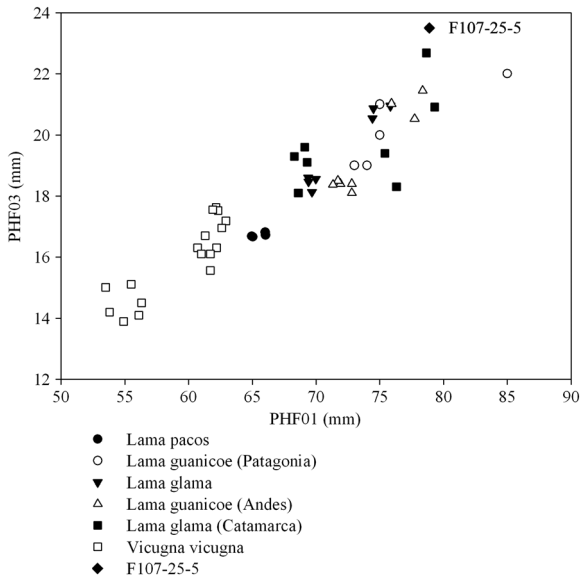


Figure 3. Biplot showing the relationship between the archaeological sample and modern South American camelids first phalanges (forelimb).

Discussion

The role given to camelid handling and the development of herding in the Puna and surrounding areas of Chile and Argentina is undoubtedly fundamental in the socioeconomic process of change (Yacobaccio

et al., 1997/98; Olivera, 1998; Nuñez *et al.*, 2006). This is partly due to the extreme environmental characteristics of the dry and salty puna that hypothetically would not have favoured the growth of agriculture in either region. However, new evidence shows that camelid handling was associated along low scale early agricultural/horticultural practices (see Aschero & Hocsman, 2011 for a discussion on this subject).

Antofagasta de la Sierra, in the Southern Argentinian Puna, was always considered a promising area for the emergence of camelid domestication practices even though the results were ambivalent (Olivera & Elkin, 1994; Elkin, 1996a). In fact, there were no solid, osteometric evidences up to now of a local bone size change process, particularly of morphotypes similar to those of the modern llama, in the area of study. A series of relevant results from the Peñas Chicas 1.5 site is presented in this work to that effect.

There is a consensus that camelid exploitation, a basic subsistence resource in the Central Southern Andes (Olivera, 1998), became intensified around 5000 BP, and this brought a specialised hunting and a process of domestication (Núñez, 1981; Yacobaccio *et al.*, 1997/98; Olivera, 1998; Yacobaccio, 2001; Izeta, 2010). Concerning this subject, Yacobaccio (2001) states that this specialisation would not have taken place in Antofagasta de la Sierra because camelid population remained relatively constant throughout the

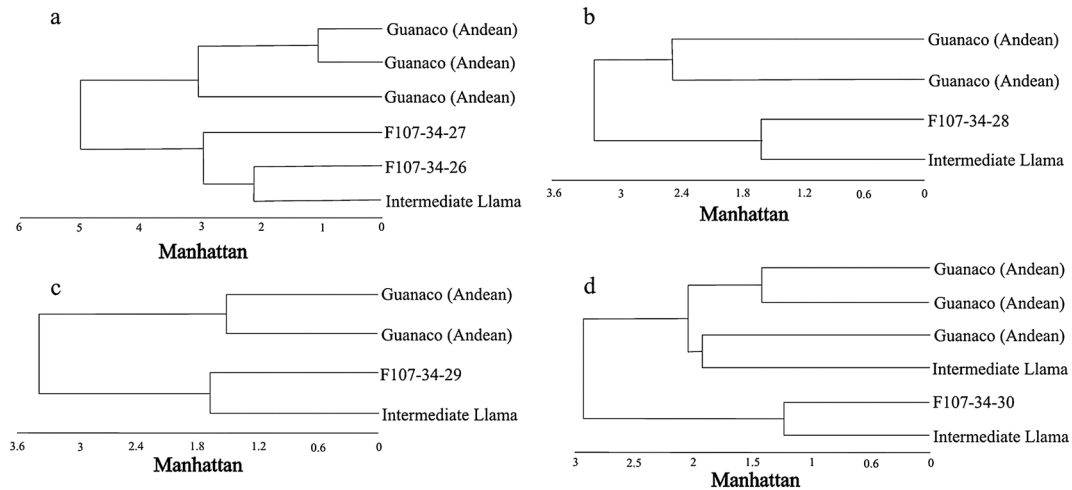


Figure 4. Hierarchical cluster analysis (unweighted pair group method using arithmetic averages): (a) fourth tarsal, (b) radial carpal, (c) intermediate carpal and (d) third carpal.

Table 3. Osteometric values obtained from Peñas Chicas 1.5 South American camelids and morphotype assignation

Element	Catalogue #	Measurement code/values (in mm)				Morphotype
Intermediate carpal	F107-34-29	W	L	D		Intermediate <i>Lama glama</i>
		12.5	20.92	21.51		
Radial carpal	F107-34-28	W	L	D		Intermediate <i>L. glama</i>
		15.5	19.8	25.43		
Second carpal	F107-34-31	W	L	D		'Cargo' <i>L. glama</i>
		13.89	13.81	9.02		
Third carpal	F107-34-30	W	L	D		Intermediate <i>L. glama</i>
		18.9	12.5	22.47		
First phalanx (rear limb)	F107-25-4	PHF01	PHF03	PHF04	PHF05	Intermediate <i>L. glama</i>
		69.30	17.70	15.70	15.59	
Second phalanx	F107-25-2	PHS07	PHS08			Andean <i>L. guanicoe</i>
		16.43	12.68			
Fourth tarsal	F107-34-27	W	L	D		Intermediate <i>L. glama</i>
		20.9	22.73	32.7		
Fourth tarsal	F107-34-26	W	L	D		Andean <i>L. guanicoe</i>
		20.46	22.51	31.2		
First phalanx (forelimb)	F107-25-5	PHF01	PHF03			'Cargo' <i>L. glama</i>
First phalanx (rear limb)	107-34-1	PHF04	PHF05			Andean <i>L. guanicoe</i>
		19.47	15.63			

Holocene. Whether or not such process had taken place locally, it is feasible to propose that intensive camelid exploitation occurred in Antofagasta de la Sierra between 5500 and 3500 BP because of the absolute predominance of camelid remains over other taxa with very high number of individual specimen values for Quebrada Seca 3 and Peñas Chicas 1.1. (Aschero *et al.*, 1991; Olivera & Elkin, 1994; Elkin, 1996a; Elkin, 1996b).

As for the process of bone size change, there were no safe osteometric evidences of such so far as mentioned before. Even though two groups of camelids were identified through osteometric analyses in the

levels corresponding to the period 5500–4500 BP at Quebrada Seca 3, one group comparable with the modern vicuña (*V. vicugna*) and another group to guanaco (*L. guanicoe*), with a predominance of smaller forms (Elkin, 1996b); the only fact that could back the presence of domesticated camelids is the existence of robust phalanges and bones of equal size as those of the modern llama (*Lama glama*), but such evidence is weak (Elkin, 1996a).

The presence of vicuña and guanaco is further confirmed by the finding of fibres and lower incisors, although the situation is not so clear with guanaco incisors because they are similar to those of llama (Olivera

& Elkin, 1994). In addition to the difficulty of distinguishing between guanacos and llamas based on bone remains, there is the presence of a fibre, analogous to that of the modern llama, called intermediate llama, of early generalised use that goes on through the rest of the Holocene (Reigadas, 1994; Reigadas, 2008; Olivera, 1998; Yacobaccio, 2001).

Beyond these ambiguities, Reigadas (2000–2002; 2008) on the basis of fibre analysis proposes that there was a stage of *experimentation* in Antofagasta de la Sierra with an *intentional* control in the levels dated between 4700 and 4500 BP at Quebrada Seca 3 because of available evidence. Yacobaccio (2001), states that it is possible that in this micro-region, there was a *protective herding* strategy, where humans change the predator–prey relation in favour of a particular species or population by giving it a certain degree of protection from other predators and granting a safer access to food sources without intervening in reproduction (Yacobaccio, 2001; Yacobaccio & Vilá, 2002). This is important because such management does not necessarily imply a control or selection directed towards changing animal size, although it may include taming and confining and hence some form of control. (Yacobaccio, 2001; Yacobaccio & Vilá, 2002).

Other site near to Peñas Chicas 1.5 is Peñas Chicas 1.1 (PCh 1.1). In this last site, the absence of complete incisors or fibre remains and the poor preservation of highly fragmented bone material conditioned taxa identification by osteometric criteria to few specimens with coincident results with those of vicuña modern standards (Olivera & Elkin, 1994).

On the basis of the information generated, there emerged the existence of two populations of different size and the absence of clear osteologic evidence that

showed a local process of bone size change. In this sense, Yacobaccio (2001) points out that it is significant that the Quebrada Seca 3 sequence ends towards 4500 BP, some 500 years before the first evidences of camelid size change were detected in the bones of other Puna areas.

Paradoxically, only one wild species was found at Peñas Chicas 1.1 when, because of the occupation chronology, there should have been evidence of a change in bone size, although this may be due to the highly fragmented bone sample or to the function of the site among other factors.

Given the earlier situation, the results of the osteometric analysis at Peñas Chicas 1.5 are thus the first clear indication of camelid size change. The absence of vicuña in the analysed bone assemblage, although this animal is present in relatively synchronic residential contexts, is surprising. In this sense, it is remarkable that the individuals present correspond to large morphotypes (both wild and domesticated) in a ritual context, be it a burial or an intentional object deposit. At this point, we suggest that the increasing variability of bone size occurs at the same time in other South Central Andes camelid assemblages which for us is associated with human management rather than the product of local or regional environmental processes that affects bone size (Izeta, 2007). It is important to notice that a morphotype similar to the Andean guanaco is found in the Andes from at least the last 14 Kybp (Cardich & Izeta, 1999–2000) which can give us some idea of the stability of the metrics of that size through time in the Andean region.

Finally, the presence, in the site, of an animal whose size resembles that of the 'cargo llama' is particularly relevant for the archaeology of the transitional process because it opens the way to considering alternative of acquisition and transportation of resources in short or



Figure 5. Camelid with cargo and halter. Río Punilla style and Peñas Coloradas 1 site.

long distance interaction networks (Núñez & Dillehay, 1995). Besides osteometric data, complementary information may be obtained from cave or rock paintings. This is the case of the 'Río Punilla style' that was dated towards 3500 BP (Aschero, 2006; Aschero, 2007) when analysing these paintings and their relation with dated stratigraphic contexts. Thus, there is a synthetic figurative camelid of this style at Peñas Coloradas 1 with clearly visible evidence of cargo and halter (Figure 5).

Conclusion

The domestication precedents of South American camelids show that the period between 4000 and 3500 BP is a key moment because it is here that metric differences begin to be noticeable in camelid size. This is more relevant in the case of Antofagasta de la Sierra because in a limited context, as far as recovered bone remains is concerned, a total of 10 elements were obtained that facilitated bone and size discrimination through osteometry.

The results obtained using multivariate statistics on these osteometric values provided a size variability in the camelid assemblage recovered at Peñas Chicas 1.5.

The high integrity of the context gave significant and very coherent results in spite of the low number of specimens and elements. The four carpals and two tarsals show values in all variables that may be assigned to an only individual that in all cases is notably similar to the intermediate llama morphotype.

As for the interpretation of the results, we also noticed coherence with the expectations that researchers had had for more than a decade with regard to camelid assemblages with dates similar to those of Peñas Chicas 1.5, that is, animals of the same or larger size than modern llamas. In this case, not only the presence of an 'intermediate llama' is remarkable but also that of an individual whose size is bigger than the comparable modern specimens.

New possibilities are thus open through the study of the archaeofaunal record to understand the different processes that led to a change of economic strategies that a few centuries later evolved into societies with very different organisations than those of the peoples that inhabited the region 4000 years ago.

In summary, osteometry, associated with other types of evidences, may help us interpret the local and regional processes of animal utilisation and, on a general level, the relations between both species over an extended time period. In this sense Antofagasta de la Sierra archaeological record can now add new data to reconstruct the size variability of South American camelids.

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