

Morphometric Analysis of Camelid Remains from the Alero Deodoro Roca (ADR) Site (Córdoba, Argentina). An Attempt to Characterise Body-Size Variability in *Sierras Pampeanas Australes* Region

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ABSTRACT This paper focuses in the morphometric analyses of *Lama guanicoe* remains recovered from the hunter–gatherer archaeological site Alero Deodoro Roca, located at *Sierras Pampeanas Australes* region (Córdoba Argentina), an area that has little information on the body-size variability of these artiodactyls. Because of the sparse osteometric data in the region, we focused on determining inter-intraspecific differentiation of wild camelids through corroborated osteometric techniques and multivariate statistical analyses of proximal phalanges. Our results showed a clear interspecific differentiation between modern *vicuñas* and archaeological specimens. We could also distinguish at least three guanaco size groups (small, medium and large) with the archaeological remains from the late Holocene (3000–3600 BP) of the site, presenting medium-size characteristics. Finally this paper aims at establishing a first approach in the characterisation of guanaco body size in the mountainous region of Córdoba. Copyright © 2016 John Wiley & Sons, Ltd.

Key words: Chaco ecoregion; Córdoba Argentina; hunter–gatherer; *Lama guanicoe*; multivariate analyses; osteometrics

Introduction

The definition of body size in animal bone remains from archaeological sites is a concern that has been widely discussed, still having major consequences when trying to separate species with different body size or recognise processes in animal domestication (Albarella & Payne, 2005; Izeta, 2004, 2007; Izeta *et al.*, 2009, 2012; Mengoni Goñalons & Yacobaccio, 2006; von den Driesch, 1976; Zeder & Hesse, 2000 among others). In the case of South American camelids, the discussion is particularly well advanced because of the several continuing studies that had their starting point during the 1970s (see the work of Miller, 1979; Kent,

1982; Wheeler, 1995; Cardich & Izeta, 1999–2000; Izeta *et al.*, 2009, 2012; Mengoni Goñalons & Yacobaccio, 2006; Cartajena, 2009; Aschero *et al.*, 2014; Dantas, 2012; Gasco *et al.*, 2014; del Papa, 2015 among others). Nevertheless, much work has been developed in order to differentiate these ungulates in an interspecific way. Therefore, there are still relatively few publications dealing with the characterisation of body size in intraspecific populations (some exceptions include Kaufmann & L'Heureux, 2009; L'Heureux, 2005, 2010; Yacobaccio, 2006). Consequently, defining morphotypes in wild animal populations is necessary, especially if we recognise that artiodactyl body size positively influences their resistance to environmental variation or restriction (Lindstedt & Boyce, 1985). Moreover, it directly affects relations with other species because the maximum speed reached by an individual also varies positively in relation to ungulate size (Calder, 1984). Thus, it

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seems important to characterise weight and body mass to infer predator–prey/human–animal relationships and their adaptations to the environment (L'Heureux, 2008 and references there).

South American camelids from the Chaco region (Córdoba, Argentina)

The South American species of the Camelidae family are divided into two genera (*Lama* and *Vicugna*). These genera are separated into four species: *Vicugna vicugna* and *Lama guanicoe* as the wild representatives of the family and *Vicugna pacos* and *Lama glama* as the domesticated species (Wheeler, 1995; Jiménez *et al.*, 2010). These diurnal and gregarious herbivores can be found in arid and semi-arid environments (Canevari & Vaccaro, 2007). They also generally establish three basic social units: a territorial family harem, the non-reproductive male groups and the solitary male unit (González *et al.*, 2006; Canevari & Vaccaro, 2007). Outside the breeding season, these social structures can vary according to environmental conditions (González *et al.*, 2006; Canevari & Vaccaro, 2007).

It is also accepted that the Camelidae family does not present a marked sexual dimorphism, a fact that helps when trying to differentiate distinct taxa (Kaufmann & L'Heureux, 2009; Izeta *et al.*, 2012; Davis, 1987). Hence, differences in the ungulates morphology (or in other animals) can be the result of two types of pressure: anthropogenic or/and natural. The first can be associated with human management of an isolated population (L'Heureux, 2008; Yacobaccio & Vilá, 2013). On the other hand, natural changes in animal body sizes can be related to a wider range of phenomena, such as climate, environment-carrying capacity, interspecific competition, predation, population density, insularity, among other ecological factors (Lindstedt & Boyce, 1985; L'Heureux, 2008).

Currently, the *guanaco* (*L. guanicoe*) is the only camelid in Córdoba's territory, and its distribution is limited to certain regions such as the *Salinas Grandes* area (Diaz *et al.*, 1987; Rosacher, 1992, 2004; Geisa, 2012). However, in the *Geografía Física de la Provincia de Córdoba*, Río & Archával (1905) argued that *guanacos* could be seen in the mountainous region (*Sierras Pampeanas Australes*) until the beginning of the last century. They also mentioned that these animals were valued for their skin and meat (Río & Archával, 1905:349). According to Raedeke's (1979) estimations, about 50 million *guanacos* lived in the continent at pre-Hispanic times.

Based on pre-Hispanic archaeological data, some researchers suggested that *vicuñas* and domesticated

animals (*L. glama*) had also related with human groups in Córdoba's province throughout the Holocene (Pascual, 1954; Berberían, 1984; Bixio *et al.*, 2010 among others). Regarding *L. glama*, most of these claims were based on ethnohistorical descriptions that mentioned '*ovejas de la tierra*' ('sheeps from the land') and rock art or pottery representations without a real development of zooarchaeological techniques for intraspecific differentiation of regional camelids (Laguens & Bonnin, 2009; Costa, 2015). In contrast, Pascual (1954) inferred through bone morphology that *V. vicugna* might be one of the species recovered by Menghin & González (1954) in Alero Deodoro Roca (ADR) site, even though the palaeontologist never mentioned taking any measurement on the archaeofaunal remains. Recognising the lack of modern data, some few attempts have been made in order to differentiate local camelid population from archaeological sites through morphometric techniques (Medina *et al.*, 2007, 2014; Costa *et al.*, 2011; Costa, 2015).

Medina *et al.* (2014) recently attempted to differentiate interspecifically local populations (*L. glama* from *L. guanicoe*) USING two measurement variables of proximal phalanges (maximum width and thickness of the proximal condyles). Based on their osteometric results, the authors recognised the existence of a high variability in population size during the Middle and Late Holocene in the region, although some chronological mistakes are noticed in their paper (see the chronology of ADR site in Cattáneo *et al.*, 2013) and a serious methodological issue concerning the mixing of rear and fore limb phalanges does not allow differentiating properly between different body sizes (Kent, 1982; Izeta, 2007; Izeta *et al.*, 2009; Gasco *et al.*, 2014). As a result, Medina *et al.* (2014) concluded that it is not possible to argue in favour of the existence of domesticated ungulates (*L. glama*) in the province of Córdoba during the period studied. Nevertheless, we are cautious about the use of these results, as the lack of a fine grain chronology and an inadequate methodological approach make their use ambiguous.

Recognising the preceding texts and the lack of modern morphometric data comparable with Chaco's specimens (Izeta *et al.*, 2009; Medina *et al.*, 2014), this paper aims at adding new data for Late Holocene *L. guanicoe* in order to establish intraspecific body size variability which will help the interspecific differentiation of these ungulates in the Chaco's mountainous¹ area known as *Sierras Pampeanas Australes* (Figure 1).

¹ The Chaco ecoregion in Córdoba comprises seven ecological areas (Cruzate *et al.*, 2008); the area under study belongs to the Sierra Chaco District (Zak *et al.*, 2008).

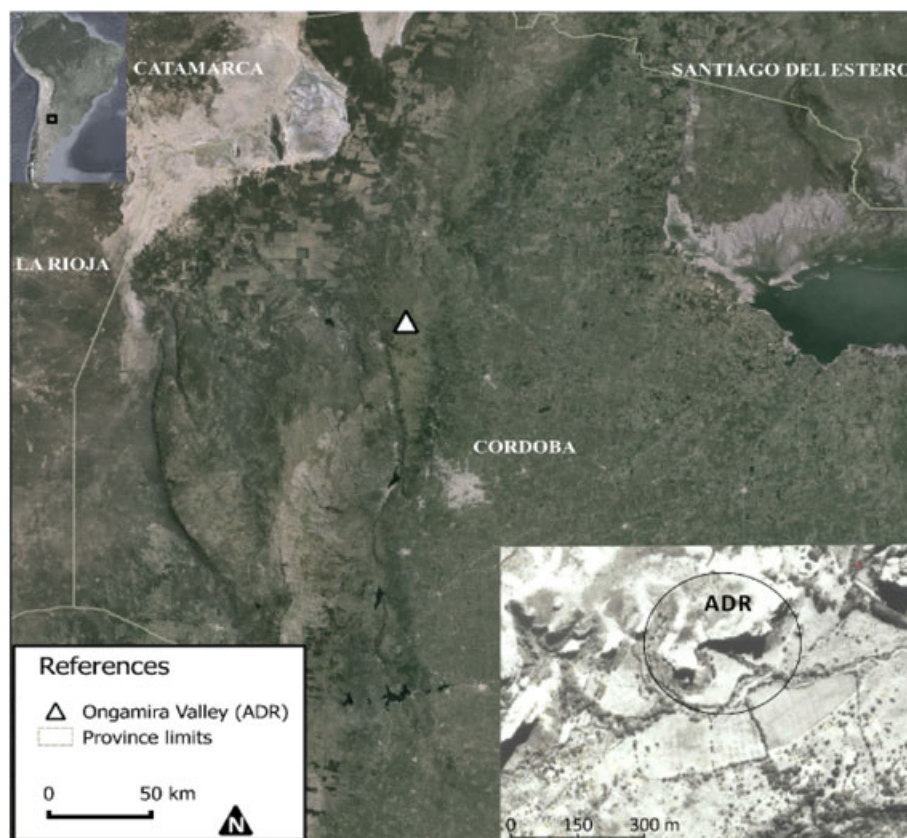


Figure 1. Map showing the location of Ongamira Valley in the mountainous region of Córdoba with detail of the archaeological site of Alero Deodoro Roca. [Colour figure can be viewed at wileyonlinelibrary.com]

Alero Deodoro Roca site

The rockshelter archaeological site ADR is located in the southern portions of the Gran Chaco area, in a mountainous region known as *Sierras Pampeanas Australes*. The site is 1000 m above sea level and has a unique landscape built on a Gondwana conglomerate, which includes a Cretaceous formation of red sandstone with several rockshelters that have been used by humans for more than 7000 years at least.

The site had been previously excavated by Aníbal Montes (1943) and Menghin & González (1954), who divided the 167-m-long rockshelter into two sectors, A and B. Since 2010, ADR-B is being excavated under new paradigms in the archaeological research (Cattáneo & Izeta, 2011; Cattáneo *et al.*, 2013). This approach characterised 114 stratigraphic units, as defined by Harris (1991), through a fine-grain examination of sediment composition, coloration and associated materiality (Cattáneo *et al.*, 2013; Izeta *et al.*, 2014; Costa, 2015; Caminoa, 2016; Robledo, 2016). It also showed the complexity

of the site chronostratigraphic composition, with hunter–gatherer occupations spanning from 1900 AP to 6500 BP (Cattáneo *et al.*, 2013; Izeta *et al.*, 2014; Yanes *et al.*, 2014; Costa, 2015; Caminoa, 2016; Robledo, 2016).

Alero Deodoro Roca's archaeozoological data suggest that the hunter–gatherers who occupied the site during the Late Holocene maintained a close relationship with *guanacos* by cohabiting and coevolving in the valley landscape (Costa, 2015). Previous research had also suggested the predominance of *L. guanicoe* remains in the rockshelter site under study (Pascual, 1954; Bonnin *et al.*, 1987; Laguens & Bonnin, 2009). Moreover, the archaeological record of surrounding areas such as southern Andes (Yacobaccio, 2003; Izeta, 2007; Dantas, 2012; Gasco, 2013; Aschero *et al.*, 2014), Argentinean Pampas (Martínez & Gutiérrez, 2004; Kaufmann, 2009) and Patagonia (Mengoni Goñalons, 1999; Miotti & Salemme, 1999) had also showed that guanacos were in a close relationship with the pre-Hispanic habitants of these areas.

Table 1. Measurements (mm) from archaeological front and hind limb first phalanges

Element	Code		1	2	3	4	5	GM	Data
Front 1 phalanx	60-132-1	OG1	76.45	23.91	20.15	18.24	15.21	25.23	Costa
Front 1 phalanx	60-132-8	OG8	74.90	23.62	21.73	19.53	16.40	26.19	Costa
Front 1 phalanx	60-132-11	OG11	72.63	21.41	19.21	16.57	15.81	23.92	Costa
Front 1 phalanx	60-132-12	OG12	70.99	21.82	19.02	18.06	16.34	24.43	Costa
Front 1 phalanx	60-132-13	OG13	69.66	22.33	20.30	20.30	15.47	25.08	Costa
Front 1 phalanx	60-132-14	OG14	70.31	21.56	19.09	18.35	14.69	23.90	Costa
Front 1 phalanx	60-132-15	OG15	71.24	21.04	18.41	16.73	15.95	23.63	Costa
Front 1 phalanx	60-132-16	OG16	77.52	22.75	20.93	19.15	14.50	25.24	Costa
Front 1 phalanx	60-132-18	OG18	68.92	22.59	20.00	17.18	14.88	24.00	Costa
Front 1 phalanx	ADR3	1357	76.50	21.36	19.78	17.71	14.22	24.11	Costa
Front 1 phalanx	ADR6	1535	71.83	20.86	19.87	16.95	15.02	23.76	Costa
Front 1 phalanx	ADR11	443	76.63	21.80	20.75	17.83	17.55	25.53	Costa
Front 1 phalanx	UE70	ADR13	75.58	23.35	20.53	18.80	16.66	25.76	Costa
Front 1 phalanx	UE70	ADR15	73.84	22.73	19.96	18.54	17.42	25.52	Costa
Front 1 phalanx	UE70	ADR17	65.75	21.59	18.86	17.52	15.79	23.65	Costa
Front 1 phalanx	UE70	ADR18	77.38	22.52	20.78	18.63	17.68	26.02	Costa
Front 1 phalanx	UE70	ADR19	76.44	25.04	20.44	17.67	15.79	25.56	Costa
Front 1 phalanx	UE70	ADR28	82.84	25.31	20.71	20.76	18.39	27.79	Costa
Front 1 phalanx	UE70	ADR33	79.55	23.31	20.57	19.27	17.25	26.34	Costa
Front 1 phalanx	UE70	ADR37	79.67	24.18	21.99	21.98	20.24	28.51	Costa
Front 1 phalanx	UE70	ADR45	75.10	21.68	18.98	18.24	16.46	24.75	Costa
Front 1 phalanx	ADR 51	3871	72.58	23.67	20.73	19.01	17.53	25.99	Costa
Front 1 phalanx	ADR 52	3810	79.18	23.77	20.71	18.60	18.27	26.57	Costa
Rear 1 phalanx	ADR4	446	72.35	22.18	18.85	17.79	16.09	24.41	Costa
Rear 1 phalanx	ADR8	1388	66.64	20.57	17.77	17.35	14.91	22.90	Costa
Rear 1 phalanx	UE70	ADR16	71.01	21.83	18.47	17.79	15.68	24.01	Costa
Rear 1 phalanx	UE70	ADR20	64.79	20.85	17.87	16.78	15.15	22.78	Costa
Rear 1 phalanx	UE70	ADR26	65.07	21.29	16.83	16.69	16.04	22.86	Costa
Rear 1 phalanx	UE70	ADR34	75.33	24.19	21.03	17.82	16.83	25.83	Costa
Rear 1 phalanx	UE70	ADR35	76.97	22.40	20.10	19.70	18.11	26.21	Costa
Rear 1 phalanx	UE70	ADR43	70.29	21.74	18.35	17.38	15.56	23.77	Costa
Rear 1 phalanx	UE70	ADR46	64.46	20.77	18.26	17.75	15.87	23.31	Costa
Rear 1 phalanx	UE70	ADR47	67.91	21.93	19.24	18.39	16.34	24.38	Costa
Rear 1 phalanx	UE70	ADR48	60.09	20.03	17.73	16.50	14.67	22.01	Costa
Rear 1 phalanx	ADR53	3670	68.87	21.91	19.20	17.92	16.99	24.50	Costa
Rear 1 phalanx	ADR54	3371	66.17	21.86	18.53	16.77	15.75	23.44	Costa
Rear 1 phalanx	ADR55	1339	64.46	20.12	18.47	17.01	15.60	22.94	Costa
Rear 1 phalanx	ADR56	5474	63.14	19.79	17.74	17.05	15.56	22.59	Costa
Rear 1 phalanx	60-132-18	OG5	66.65	23.41	19.02	20.53	15.09	24.70	Costa
Rear 1 phalanx	60-132-19	OG9	66.18	21.96	18.37	16.70	14.84	23.13	Costa
Rear 1 phalanx	60-132-20	OG10	68.85	20.13	18.12	16.94	15.20	23.02	Costa
Rear 1 phalanx	60-132-21	OG17	65.32	21.32	17.75	15.72	14.94	22.53	Costa
Rear 1 phalanx	60-132-22	OG20	68.41	21.43	18.52	17.90	16.18	23.94	Costa

Material and methods

In Argentinian zooarchaeology, the morphometric approach to elements of the postcranial skeleton is being used since the 1980s; as a consequence, several measurements have been used through the years (see Aschero *et al.*, 2014; Cardich & Izeta, 1999–2000; Dantas, 2012; Gasco *et al.*, 2014; Izeta *et al.*, 2009, 2012; L'Heureux, 2005; Menegaz *et al.*, 1989; Mengoni Goñalons & Yacobaccio, 2006 among others). In this paper, we use the osteometric variables proposed by Izeta *et al.* (2012) which comprise of 15 separate measurements on first phalanx, which have been used regionally. However, there are no data available to

compare all these variables; therefore, we used the five variables that can be compared with the existing databases. Thus, the measurements used in this paper are as follows: (i) maximum length, taken parallel to the major axis by using, as a basis, the tangent formed by the proximal and end plantar condyles at the most distal point of the distal articular surface (FP1V1 and BP1V17, Kent, 1982; Gl, Von Den Driesch, 1976; PHF01, Izeta *et al.*, 2012); (ii) width of the proximal articular surface (FP1V2 and BP1V178, Kent, 1982; BFP, Von Den Driesch, 1976; PHF05, Izeta *et al.*, 2012); (iii) height of the proximal articular surface (BP1V179 and FP1V3, Kent, 1982; PHF07, Izeta *et al.*, 2012); (iv) width of the distal articular surface (FP1V4 and

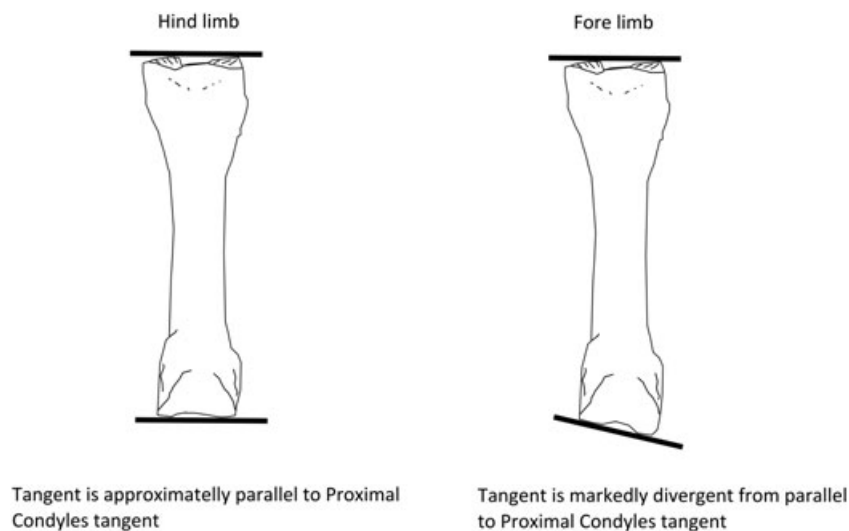


Figure 2. Characterisation of the front and rear proximal phalanges (adapted from Kent, 1982).

BP1V180, Kent, 1982; BFd, Von Den Driesch, 1976; PHF13, Izeta *et al.*, 2012); and (v) height of the distal articular surface (BP1V181 and FP1V5, Kent, 1982; PHF14, Izeta *et al.*, 2012).

In addition, Izeta *et al.* (2009) suggested that it is important to know how the current populations are behaving metrically in order to differentiate past camelids. Therefore, the data presented by the authors were used as a comparable database because they contain first phalange measures of camelids from different Argentinean latitudes and segregated variables for fore and hind limbs (Izeta *et al.*, 2009; Aschero *et al.*, 2014). Moreover, 110 first phalange measures of an archaeological sample from Midwest Argentina (COA) have been added (Gasco, 2013). The specimens measured by Gasco were determined as wild camelids (*L. guanicoe*), and they show radiocarbon dates spanning from 1700 to 1400 BP (Gasco, 2013).

The archaeological samples to be contrasted with the previous data were recovered at ADR site in different field seasons. The first collection was recovered by Aníbal Montes between the 1940s and 1950s (called OG and numbered from 1 to 20; Table 1). The second group had been unearthed through 2010/2013 excavations. This collection contains 56 first phalanges named ADR (1–56).² Some of these elements were associated to radiocarbon-dated units spanning from ~3000 BP (specimens 443, 446, 1339, 1357, 3371, 3670, 3810, 3871 and 5474) to ~3600 BP (1535 and 1388).

² Even though the first 48 specimens have been recovered from the fillings of previous excavations and do not have a clear stratigraphic association, they can be chronologically assigned to a span between 4500 and 1900 BP. For excavation details, see Cattáneo *et al.* (2013) and Yanes *et al.* (2014).

As for the characterisation of the rear and fore limbs, we followed the methodology described by Kent (1982). The author demonstrated that in *L. guanicoe*, the tangent of the distal condyle is parallel to the proximal epiphysis on the hind proximal phalanges of camelids, contrasting with the markedly diverge tangents of the front limbs (Figure 2).

Table 1 highlights 215 osteometric variables that were subject to various statistical analyses in order to observe trends in the grouping of elements. Therefore, principal component analysis (PCA), cluster (unweighted pair group method with arithmetic mean) and bivariate graphs were generated in order to characterise body size. In addition, the geometric means have been analysed through the mixture analysis technique in order to study groupings based in the shape of the elements (Menegaz *et al.*, 1989; L'Heureux, 2005; Izeta, 2007; Izeta *et al.*, 2009; Grant, 2010; Yacobaccio, 2010). PAST software version 3.11 (Hammer *et al.*, 2001) was used for statistical calculations.

Results

As explained earlier, the aim of this paper was to make a first classification of Chaco's *L. guanicoe*'s body size. Consequently, our analysis compares two species of wild camelids that could be interacting with the hunter–gatherer occupants of ADR, the smaller *V. vicugna* with *L. guanicoe*, because until now, we have no evidence of domesticated species in the study area.

Biplots

Considering variables 2 and 3, the biplots clearly display an intraspecific difference for both phalanges [Figure 3(a) and (b) anterior and posterior respectively]. However, when observing the specimens with bigger body size, it is possible to distinguish two groups for both phalanges.

The forelimb phalanges [Figure 3(a)] can be divided into two 'guanaco' groups: the bigger size specimens, which includes Patagonian specimens (GP), central-west Argentina (GSJ, LgCOA) and several specimens from the site (ADR), including some that have been associated with occupations spanning ~3000 BP (3871, 443 and 1357), and the smaller body size group that includes specimens from Catamarca (GC), central-

west Argentina (GSJ, LgCOA) and some from the site studied (OG and ADR).

The rear limb phalange group [Figure 3(b)] also displays two 'guanaco' size groups, even though the bigger/smaller specimens' division is fuzzier. In this case, the bigger body size group seems to be smaller, constituted by three Patagonian elements (GP); it also shows fewer phalanges from the site (ADR 34 and 35 and OG 5).

Principal component analysis

Principal component analysis also displayed a clear distinction between *V. vicugna* (VSJ, VH and VO) and the 'guanaco' size groups for both limbs, as demonstrated in Figure 4. Despite the clear interspecific

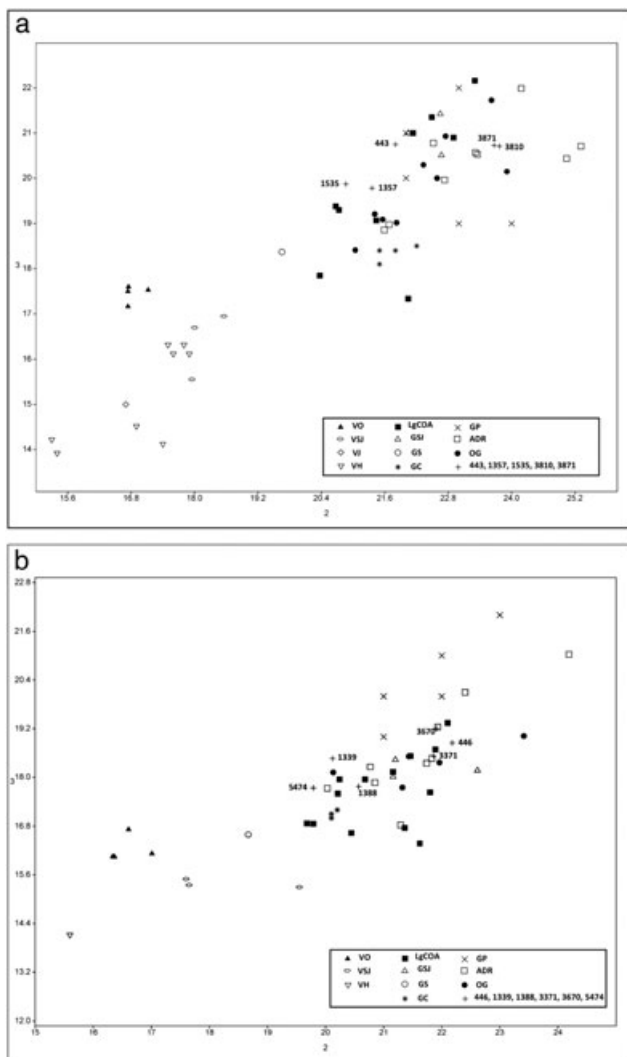


Figure 3. Biplot showing the relationship between variables 2 and 3 for front (a) and hind (b) phalanges.

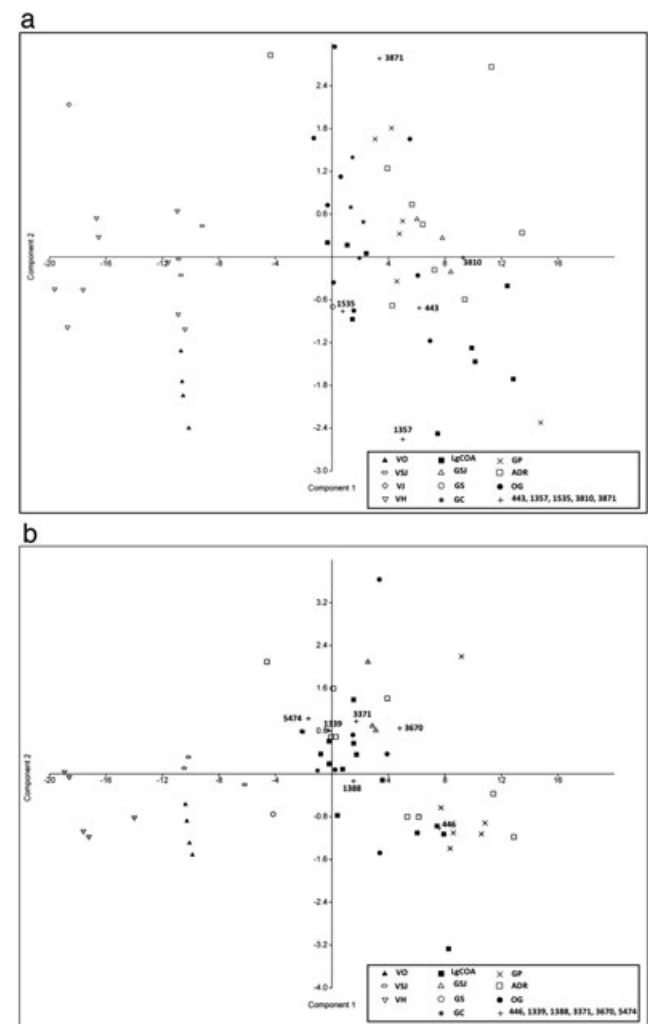


Figure 4. Principal component analysis showing results for front (a) and rear (b) specimens.

differentiation when it comes to intraspecific differences, PCA has not displayed a clear separation between the specimens for both front and rear phalanges. Accordingly, it is possible to note that the front limb graph [Figure 4(a)] shows some heterogeneity in the 'guanaco' distribution. The diversity is expressed in the isolation of some specimens such as ADR 17, OG 13 and 3871, ADR 37 in the upper pole and ADR 1357, one LgCOA and one GP in the opposite side of the graph. Figure 4(b) demonstrates that rear phalanges also display heterogeneous elements (OG5 upper side and LgCOA in the opposite side) among the most homogeneous ones. Thus, in the 'more homogeneous' elements, two groups seem to appear: one consisting of GPs and some ADRs (16, 35, 43 and 446). The other group assembles mostly north and central-western specimens (GC, GSJ and LgCOA) with the remaining elements from ADR (OG9 and 17; ADR 20 and 26; 1339, 3371, 3670 and 5474).

Cluster analysis (unweighted pair group method with arithmetic mean)

Cluster analysis displayed the same intraspecific separation on front phalanges as the previous statistics [Figure 5(a)]. However, the rear elements exhibited two specimens, one modern *L. guanicoe* (GS) and one archaeological remain (ADR48), clustered with the *V. vicugna* specimens [Figure 5(b)]. The elements mentioned have the smallest average measures, 25.17 mm to ADR 48 and 24.50 mm to GS, suggesting that their size influenced the results. Despite this, the specimen geometric mean is higher than that of the vicuñas (21.48 mm).

Considering the interspecific groups, both fore and rear elements recovered at ADR site were grouped with bigger size Patagonian guanacos (GP), medium-size central-western Argentina (LgCOA and GSJ) and smaller ones (GS and GC). Regardless of the association mentioned, most of the specimens recovered at the site exhibited a closer relationship between themselves ($n = 10$ on forelimb phalanges and $n = 9$ on hind limbs). These results may suggest a high variability in the body size of Chaco's *L. guanicoe*.

Mixture analysis

In order to recognise shape albeit the size of the elements, we used mixture analysis in the geometric means' calculated values for the *L. guanicoe* specimens measured for both front and rear phalanges. By isolating the species, we aimed at observing the interspecific variation

in the group because this kind of information can enlighten the life history of the elements.

The results of mixture analysis showed a division into two groups for both limbs (Table 2). Moreover, group 2 exhibited more specimens gathered ($n = 36$ forelimbs and $n = 32$ hind limbs) for both assemblages, front and rear phalanges. Assemblage 2 is also formed by a heterogeneous sample which includes elements from different latitudes, archaeological and modern ones. Alternatively, group 1 is constituted by a more homogeneous collection, with a higher incidence of

Table 2. Mixture analysis displaying results of front and rear specimens

Front elements	Group 1	Group 2	Max group	Rear elements	Group 1	Group 2	Max group
OG1	0.00	0.28	2	446	0.00	0.24	2
OG8	0.00	0.26	2	1388	0.23	0.17	1
OG11	0.39	0.08	1	ADR16	0.00	0.26	2
OG12	0.00	0.16	2	ADR20	0.27	0.16	1
OG13	0.00	0.26	2	ADR26	0.24	0.17	1
OG14	0.40	0.08	1	ADR34	0.00	0.08	2
OG15	0.18	0.05	1	ADR35	0.00	0.04	2
OG16	0.00	0.28	2	ADR43	0.00	0.25	2
OG18	0.30	0.09	1	ADR46	0.05	0.22	2
1357	0.15	0.11	1	ADR47	0.00	0.24	2
1535	0.36	0.07	1	ADR48	0.04	0.07	2
443	0.00	0.30	2	3670	0.00	0.23	2
ADR13	0.00	0.30	2	3371	0.02	0.23	2
ADR15	0.00	0.30	2	1339	0.21	0.18	1
ADR17	0.21	0.05	1	5474	0.27	0.13	1
ADR18	0.00	0.28	2	OG5	0.00	0.21	2
ADR19	0.00	0.30	2	OG9	0.11	0.20	2
ADR28	0.00	0.04	2	OG10	0.17	0.19	2
ADR33	0.00	0.25	2	OG17	0.25	0.12	1
ADR37	0.00	0.01	2	OG20	0.00	0.26	2
ADR45	0.00	0.21	2	GP	0.00	0.17	2
3871	0.00	0.28	2	GP	0.00	0.17	2
3810	0.00	0.21	2	GP	0.00	0.20	2
GP	0.00	0.30	2	GP	0.00	0.09	2
GP	0.00	0.29	2	GP	0.00	0.03	2
GP	0.00	0.28	2	GP	0.00	0.13	2
GP	0.00	0.08	2	GC	0.10	0.09	1
GP	0.00	0.30	2	GC	0.10	0.09	1
GP	0.00	0.26	2	GC	0.10	0.09	1
GC	0.03	0.13	2	GS	0.00	0.01	2
GC	0.00	0.15	2	GSJ	0.00	0.25	2
GC	0.01	0.20	2	GSJ	0.00	0.25	2
GC	0.09	0.18	2	GSJ	0.00	0.26	2
GS	0.18	0.05	1	LgCOA	0.16	0.19	2
GSJ	0.00	0.24	2	LgCOA	0.00	0.25	2
GSJ	0.00	0.28	2	LgCOA	0.00	0.26	2
GSJ	0.00	0.24	2	LgCOA	0.27	0.13	1
LgCOA	0.41	0.07	1	LgCOA	0.01	0.25	2
LgCOA	0.09	0.12	2	LgCOA	0.00	0.23	2
LgCOA	0.00	0.26	2	LgCOA	0.19	0.11	1
LgCOA	0.38	0.08	1	LgCOA	0.00	0.23	2
LgCOA	0.00	0.12	2	LgCOA	0.25	0.16	1
LgCOA	0.01	0.20	2	LgCOA	0.22	0.17	1
LgCOA	0.00	0.07	2	LgCOA	0.08	0.21	2
LgCOA	0.00	0.24	2	LgCOA	0.00	0.25	2
LgCOA	0.03	0.19	2	LgCOA	0.25	0.13	1

archaeological elements ($n=20$, ADR, OG and LgCOA) in conjunction with some modern elements from the low-latitude areas nearby ($n=5$, GS and GC). Therefore, evidence suggests a high morphological heterogeneity in the archaeological specimens of the site because they occur in both assemblies.

Conclusion

South American camelids from archaeological sites have been extensively studied through the use of osteometric techniques (Miller, 1979; Kent, 1982; Cardich & Izeta, 1999–2000; Izeta *et al.*, 2009, 2012; Mengoni Goñalons & Yacobaccio, 2006; Cartajena, 2009; Aschero *et al.*, 2014; Gasco *et al.*, 2014; del Papa, 2015 among others). Nevertheless, this paper adds to the sparse corpus of research on the area studied (Medina *et al.*, 2007, 2014; Costa *et al.*, 2011; Costa, 2015).

Therefore, the results of bivariate and multivariate analysis suggested that *guanacos* can be divided into three groups: small (GS and GC), medium (LgCOA and GSJ) and large (GP). This has been previously proposed by Izeta *et al.* (2009) and is useful when determining body size in an intraspecific manner. Thus, the specimens recovered at ADR site showed great variability in body size relating to different *L. guanicoe* groups, as suggested by our statistical results. Despite the body size differences expressed by bivariate and multivariate statistics, the specimens dated ~3000 and ~3600 BP seem to better associate with the medium-size *guanaco* group. The analyses also imply the absence of *vicuñas* in the site. The presence of the species had been proposed by Pascual (1954), even though no osteometric analysis had been presented by the author and as pointed earlier in this paper.

The mixture analysis results displayed differences in the shape of phalanges. Consequently, the analysis separated the specimens into two groups which presented slight differences in their morphology despite their size. This result provides a starting point for further research into the life history of these elements. Concerning the existence of *L. glama* in our assemblage, there is so far no evidence suggesting the presence of domesticated animals in the site. Thus, we considered that the species is absent during the hunter–gatherer's occupations that provided the evidence shown here, even though we recognise that there is a 'grey area' in the osteometric technique where *llamas* and *guanacos* can overlap (see Yacobaccio, 2010:72).

Earlier attempts to differentiate local camelids interspecifically also recognised the existence of a high

variability in population size during the Middle and Late Holocene (Medina *et al.*, 2014). Thus, it is important to add comparable information in order to start characterising the archaeofaunal remains in a more regional way because our research demonstrates that even though there is variability in the *guanaco* body size, most of the specimens analysed here appear to be medium or large. So, a more specific database urges when trying to separate wild from domesticated camelids regionally.

Therefore, the new data presented here will help in the characterisation of *guanaco*'s archaeological remains from the Chaco region (see also del Papa, 2015), an area that is being devastated at an alarming rate (Zak *et al.*, 2008), and as a consequence, the few *guanacos* that still persist in the region are isolated in the shrublands near the saline depressions (F. R. Barri personal communication, December 15, 2015). We also understand the difficulty of characterising body size without a modern analogue for the area; as a result, this should be a starting point in order to fulfil our research agenda, which includes the creation of a modern reference collection of Chaco's *guanacos*.

Finally, this paper aimed at establishing a first approach to the characterisation of *guanaco*'s body size in the mountainous region of Córdoba known as *Sierras Pampeanas Australes*. Therefore, we believe that the integrations of the different statistical techniques applied here are complementary to each other in a way that permitted us to contrast the first results between multiple analyses, enabling a finer grain resolution.

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