Morphometric analysis of camelid remains from the Alero Deodoro Roca (ADR) site (Córdoba, Argentina). An attempt to characterize 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 (ADR), 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 3 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 characterization of guanaco body size in the mountainous region of Córdoba.

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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 recognize processes in animal domestication (Albarella and Payne, 2005; Izeta, 2004, 2007; Izeta et al., 2009; 2012; Mengoni and Yacobaccio, 2006; von den Driesch, 1976; Zeder and 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, 1982; Cardich and Izeta, 1999-2000; Izeta et al., 2009, 2012; Mengoni and 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 characterization of body size in intraspecific populations (some exceptions include Kaufmann and L'Heureux, 2009; L'Heureux, 2005, 2010; and Yacobaccio, 2006). Consequently, defining morphotypes in wild animal populations is necessary, especially if we recognize that artiodactyl body size positively influences their resistance to environmental variation or restriction (Lindstedt and Boyce, 1985). Moreover, it directly affects relations with other species since the maximum speed reached by an individual also varies positively in relation to ungulate size (Calder, 1984). Thus, it seems important to characterize 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; *Vicugna pacos* and *Lama glama* as the domesticated species (Wheeler, 1995; Jimenez et al., 2010). These diurnal and gregarious herbivores can be found in arid and semi-arid environments (Canevari and Vaccaro; 2007). They also generally establish three basic social units, a territorial family harem, the non-reproductive male groups and the solitary males (González et al., 2006; Canevari and Vaccaro, 2007). Outside the breeding season, these social structures can vary according to environmental conditions (González et al., 2006; Canevari and Vaccaro, 2007).

It is also accepted that Camelidae family does not present a marked sexual dimorphism, fact that helps when trying to differentiate distinct taxa (Davis 1995; Kaufmann and L'Heureux, 2009; Izeta et al. 2012). Hence differences in the ungulates morphology (or in other animals), can be the result of two types of pressures: anthropogenic or/and natural. The first can be associated with human management of an isolated population (L'Heureux 2008; Yacobaccio and 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 and Boyce 1985; L'Heureux 2008).

Currently, the *guanaco* (*Lama 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*, Rio and 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 (Rio and Achával, 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 (*Lama glama*) had also related with human groups in Córdoba's province throughout the Holocene (Pascual, 1954; Berberián, 1984; Bixio et al., 2010; among others). Regarding *Lama 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 and Bonnin 2009, Costa, 2015). In contrast, Pascual (1954) inferred through bone morphology that *Vicugna vicugna* might be one of the species recovered by Menghin and González (1954) excavations in ADR site, even though the paleontologist never mentioned taking any measurement on the archaeofaunal remains. Recognizing 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 and collaborators (2014) recently attempted to differentiate interspecifically local populations (*Lama glama* from *Lama guanicoe*) using two measurement variables of proximal phalanges (maximum width and thickness of the proximal condyles). Based on their osteometric results, the authors recognized 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 which does not allow differentiating properly between different body sizes (Izeta, 2007; Izeta et al., 2009; Kent, 1982; Gasco et al., 2014). As a result, Medina et al. (2014) concluded that it is not possible to argue in favor of the existence of domesticated ungulates (*Lama 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 a inadequate methodological approach make their use ambiguous.

Recognizing the above and the lack of modern morphometric data comparable to Chaco's specimens (Izeta et al., 2009; Medina et al., 2014), this paper aims at adding new data for Late Holocene *Lama guanicoe*, in order to establish intraspecific body size variability which will help the interspecific differentiation of these ungulates in the Chaco´s mountainous[1] area known as *Sierras Pampeanas Australe*s.

Figure 1: Map showing the location of Ongamira Valley in the mountainous region of Córdoba with detail of the archaeological site of ADR.

Alero Deodoro Roca (ADR) 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 meters 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.

[1] The Chaco ecoregion in Cordoba comprises seven ecological areas (Cruzate et al. 2008) the area under study belongs to the Sierra Chaco District (Zak et al. 2008).

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

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

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 and Izeta, 1999-2000; Dantas, 2012; Gasco et al., 2014; Izeta et al., 2009, 2012; L'Heureux, 2005; Menegaz et al., 1989; Mengoni and Yacobaccio, 2006; among others). In this paper we use the osteometric variables proposed by Izeta et al. (2012) which comprise of fifteen 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: 1: maximum length, taken parallel to the major axis 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 BP1V177

Kent 1982; Gl von den Driesch 1976; PHF01 Izeta et al. 2012); 2: width of the proximal articular surface (FP1V2 and BP1V178 Kent 1982; BFP von den Driesch 1976; PHF05 Izeta et al. 2012); 3: height of the proximal articular surface (BP1V179 and FP1V3, Kent 1982; PHF07 Izeta et al. 2012); 4: width of the distal articular surface (FP1V4 and BP1V180 Kent 1982; BFd von den Driesch 1976; PHF13 Izeta et al. 2012); 5: height of the distal articular surface (BP1V181 and FP1V5 Kent 1982; PHF14 Izeta et al. 2012).

In addition, Izeta and collaborators (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 hindlimbs (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 (*Lama guanicoe*) and they show radiocarbon dates spanning from 1700-1400 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 40s and 50s (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, 5474) to ~3600 BP (1535, 1388).

As for the characterization of the rear and fore limbs, we followed the methodology described by Kent (1982). The author demonstrated that in *Lama 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).

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

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

Table1: Measurements (mm) from archaeological front and hind limb first phalanges.

Table 1 highlight 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 (UPGMA) and bivariate graphs were generated in order to characterize body size. In addition, the geometric means (GM) have been analyzed through the Mixture Analysis technique in order to study groupings based in the shape of the elements (Menegaz et al., 1989; Izeta, 2007; Izeta et al. 2009; L'Heureux, 2005; Yacobaccio, 2010; Grant 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 *Lama guanicoe* body size. Consequently, our analysis compares two species of wild camelids that could be interacting with the hunter-gatherer occupants of ADR, the smaller *Vicugna vicugna* with *Lama guanicoe*, since, 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) anterior and (b) posterior). However, when observing the specimens with bigger body size, it is possible to distinguish two groups for both phalanges.

The forelimb phalanges (Figure 3a) 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 y 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 rearlimb phalange group (Figure 3b) also displays two *“guanaco”* size groups even though the bigger/smaller specimens divide 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, 35 and OG 5).

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

Principal Component Analysis (PCA)

PCA also displayed a clear distinction between *Vicugna vicugna* (VSJ, VH, VO) and the *“guanaco”* size groups for both limbs, as demonstrated in Figure 4. Despite the clear interspecific 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 4a) shows some heterogeneity in the *“guanaco”* distribution. The diversity is expressed in the isolation of some specimens such as ADR 17, OG 13, 3871 and ADR 37 in the upper pole and 1357, one LgCOA and one GP in the opposite side of the graph. Figure 4b 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 GP’s and some ADR’s (16, 35, 43; 446). The other group assembles mostly north and central-western specimens (GC, GSJ, LgCOA) with the remaining elements from ADR (OG9, 17; ADR 20, 26; 1339, 3371, 3670, 5474).

Figure 4: Principal Component Analysis showing results for front (a) and rear (b) specimens.

Cluster Analysis (UPGMA)

Cluster analysis displayed the same intraspecific separation on front phalanges as the previous statistics (Figure 5a). However, the rear elements exhibited two specimens, one modern *Lama guanicoe* (GS) and one archaeological remain (ADR48), clustered with the *Vicugna vicugna* specimens (Figure 5b). 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 compared (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, GSJ) and smaller ones (GS, 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 hindlimbs). These results may suggest a high variability in the body size of Chaco's *Lama guanicoe*.

Figure 5: Cluster analysis for front (a) and hind (b) phalanges.

Mixture Analysis

In order to recognize shape albeit the size of the elements, we used Mixture analysis in the geometric means (GM) calculated values for the *Lama guanicoe* specimens measured for both, front and rear phalanges. By isolating the species, we aimed at observing the interspecific variation in the group since this kind of information can enlighten about 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 hindlimbs) 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 archaeological elements (n=20, ADR, OG and LgCOA) in conjunction with some modern elements from the low latitude areas nearby (n=5, GS y GC). Therefore, evidence suggests a high morphological heterogeneity in the archaeological specimens of the site since they occur in both assemblies.

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

Conclusion

South American camelids from archaeological sites have been extensively studied through the use of osteometric techniques (Miller, 1979; Kent, 1982; Cardich and Izeta, 1999-2000; Izeta et al., 2009, 2012; Mengoni and Yacobaccio, 2006; Cartajena, 2009; Aschero et al., 2014; Gasco et al., 2014; 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 and collaborators (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 *Lama 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.

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 *Lama 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 recognize that there is a "gray area" in the osteometric technique where *llamas* and *guanacos* can overlap (see Yacobaccio 2010:72).

Earlier attempts to differentiate local camelids interspecifically also recognized 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 characterizing the archaeofaunal remains in a more regional way, since our research demonstrates that, even though there is variability in the *guanaco* body size, most of the specimens analyzed 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 characterization 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 characterizing body size without a modern analogue for the area; as a result, this should be a starting point in order to fulfill 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 characterization of guanaco's body size in the mountainous region of Córdoba known as *Sierras Pampeanas Australes*. Therefore, we believe that the integration of the different statistical techniques applied here are complementary to each other in a way that permitted us contrasting first results between multiple analyses enabling a finer grain resolution.

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Table1: 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

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

Front elements	Group 1	Group 2	Max group	Rearelements	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

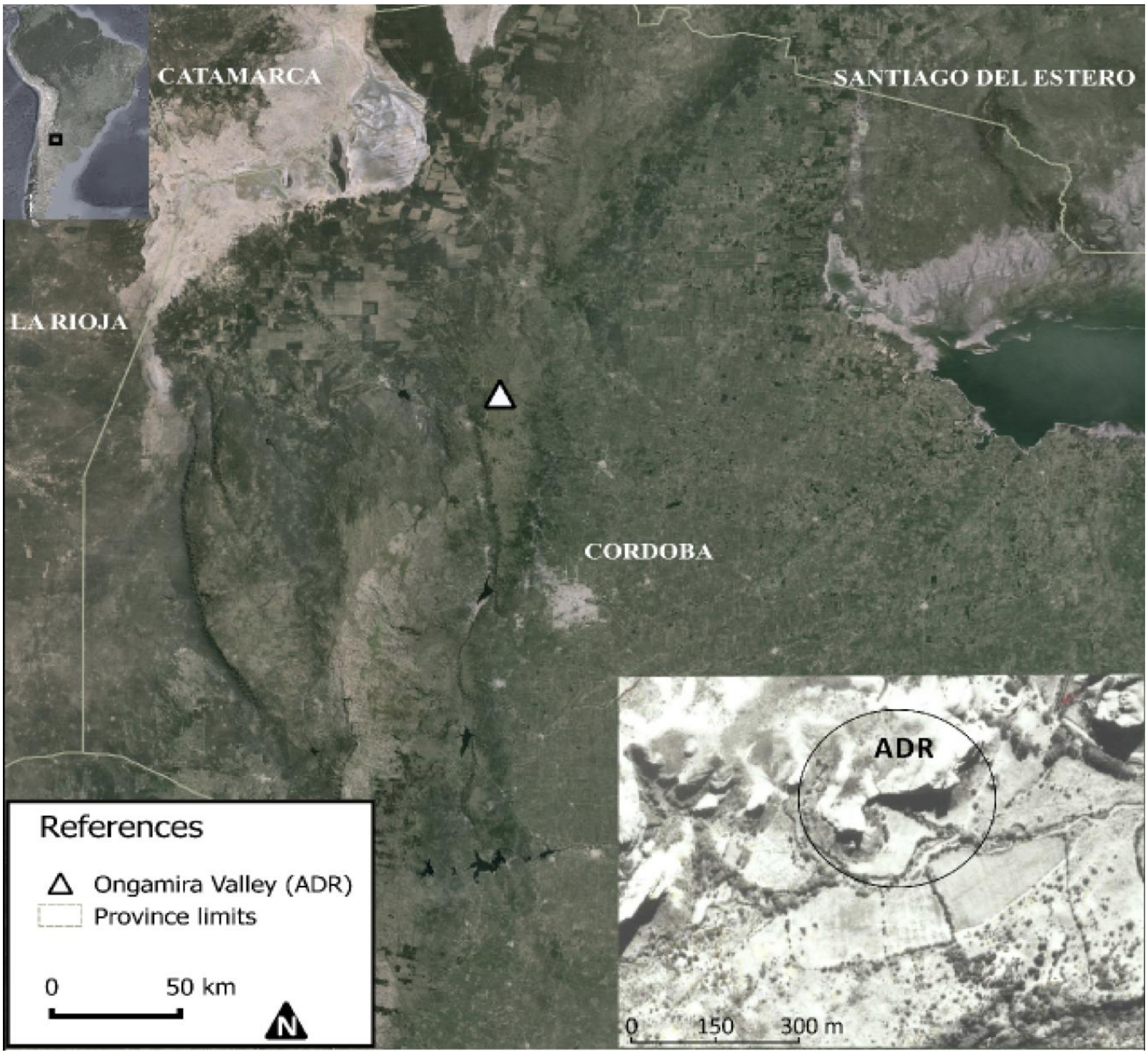

Figure 1: Map showing the location of Ongamira Valley in the mountainous region of Córdoba with detail of the archaeological site of ADR.

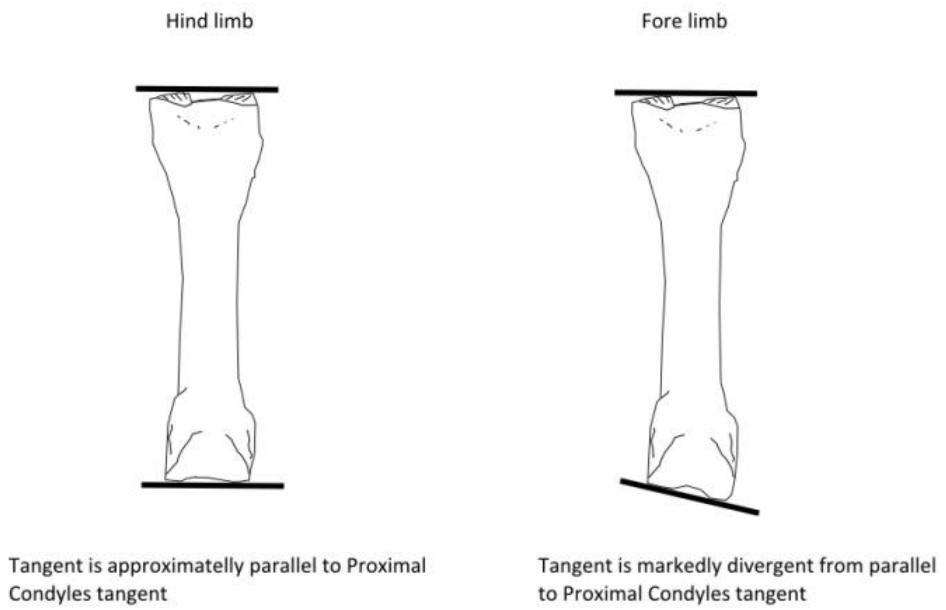

Figure 2: Characterization of the front and rear proximal phalanges (adapted from Kent 1982).

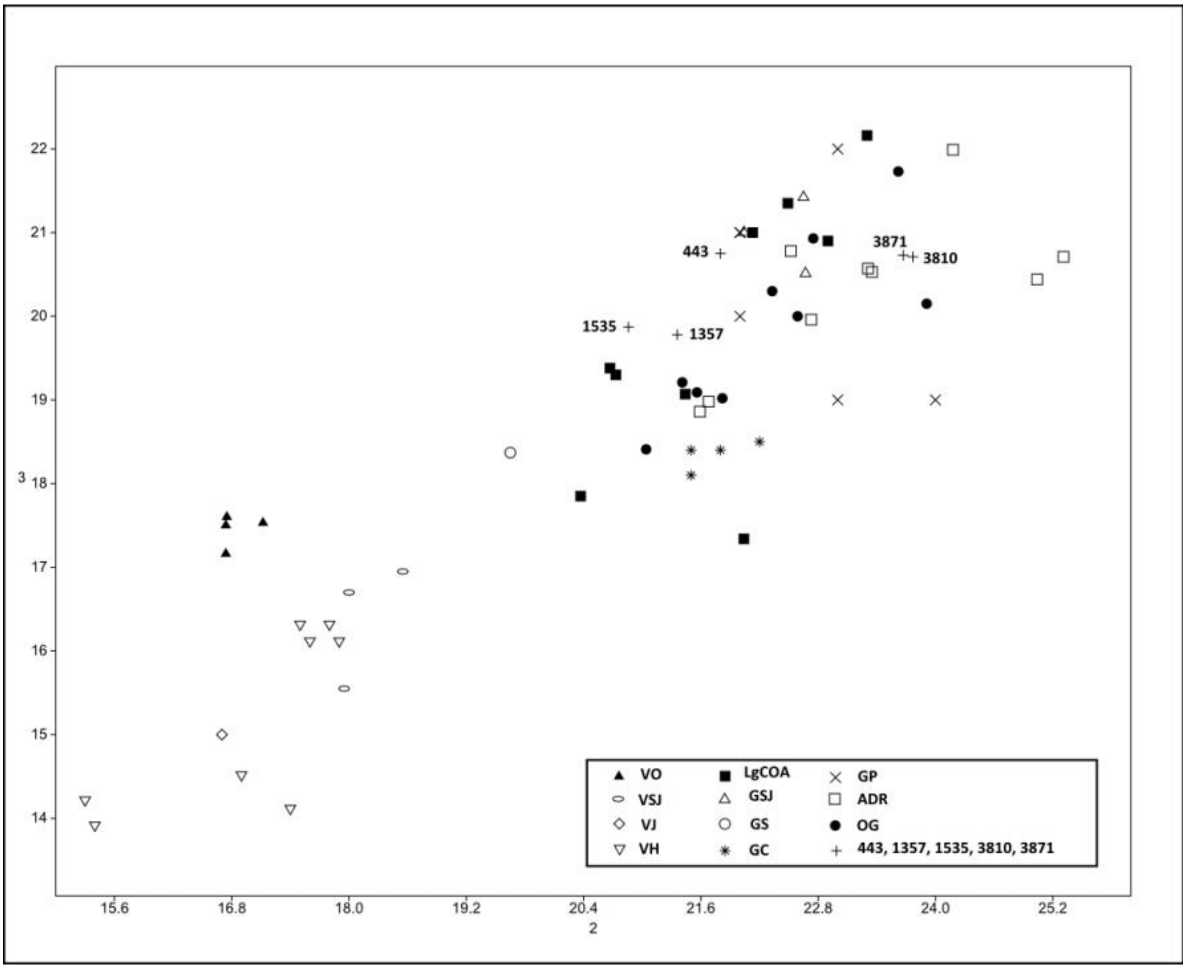

Figure 3: Biplot showing the relationship between variables 2 and 3 for front (a) phalanges.

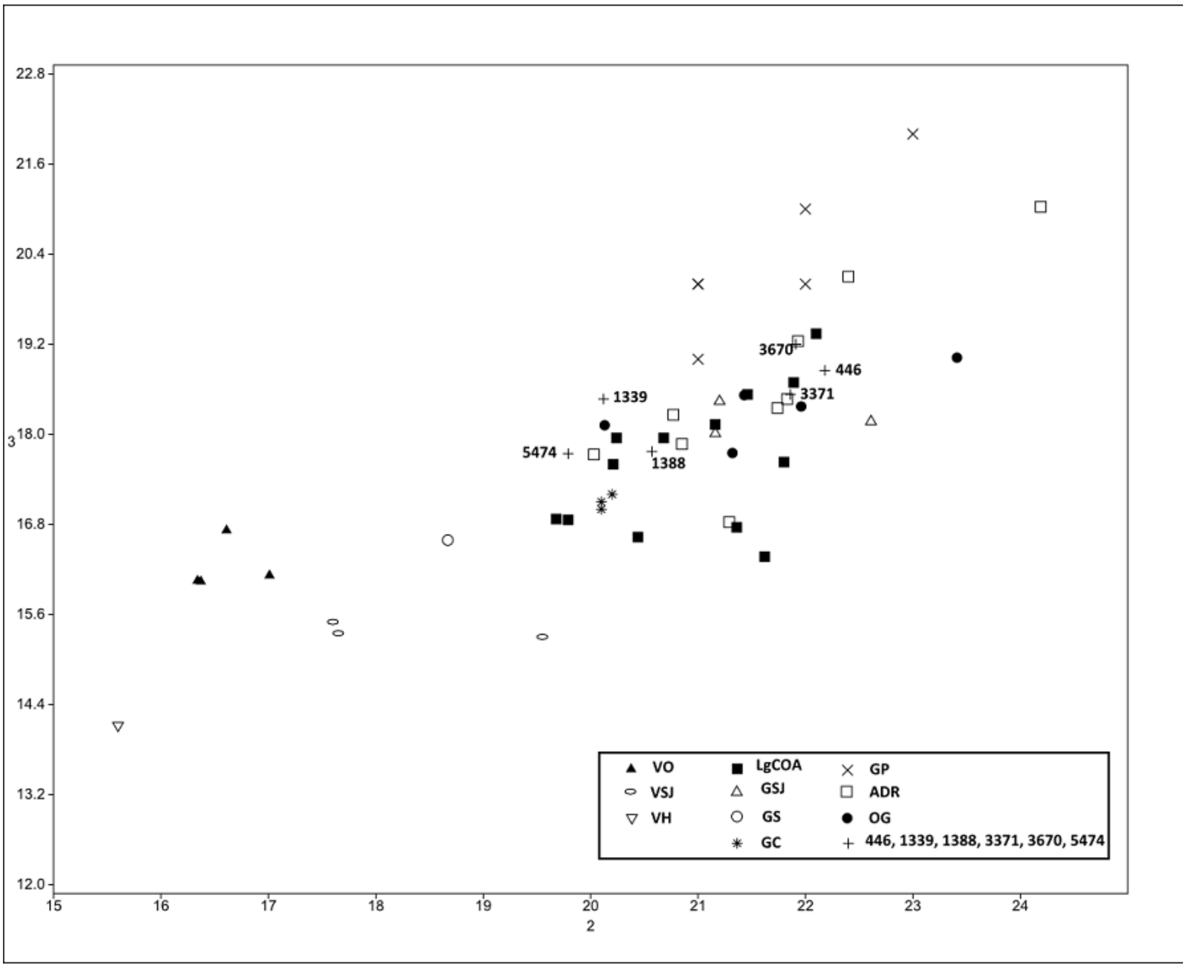

Figure 3: Biplot showing the relationship between variables 2 and 3 for hind (b) phalanges.

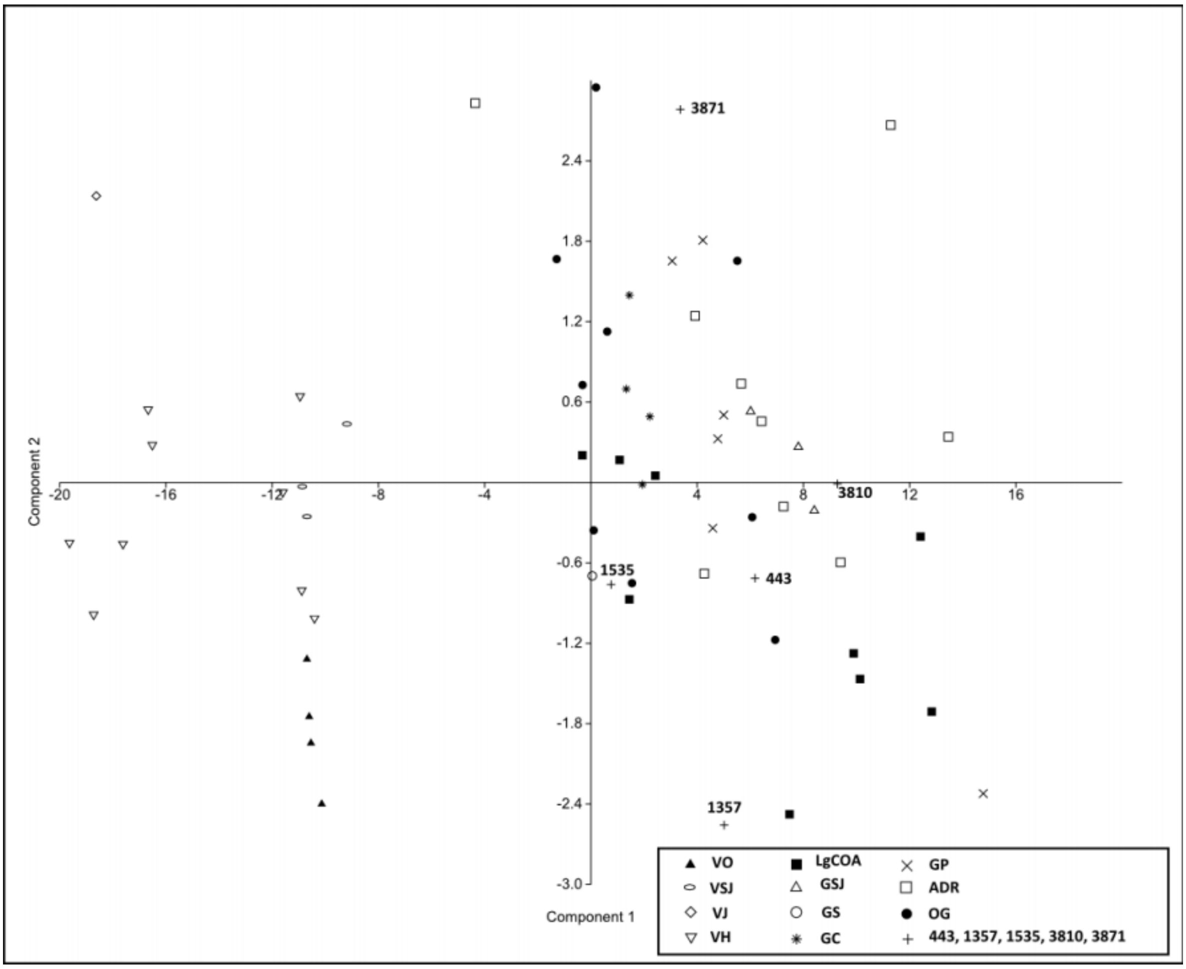

Figure 4: Principal Component Analysis showing results for front (a) specimens.

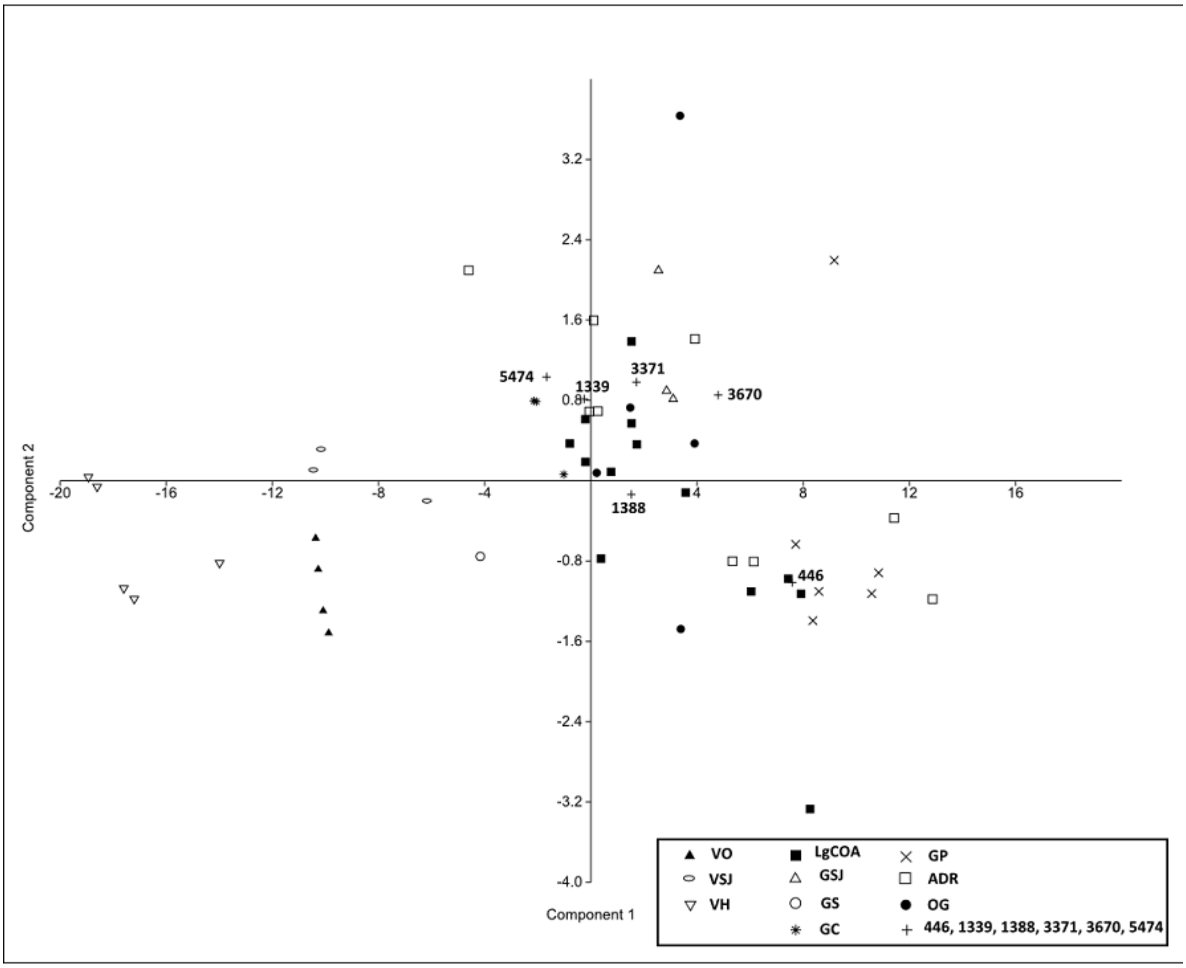

Figure 4: Principal Component Analysis showing results for rear (b) specimens.

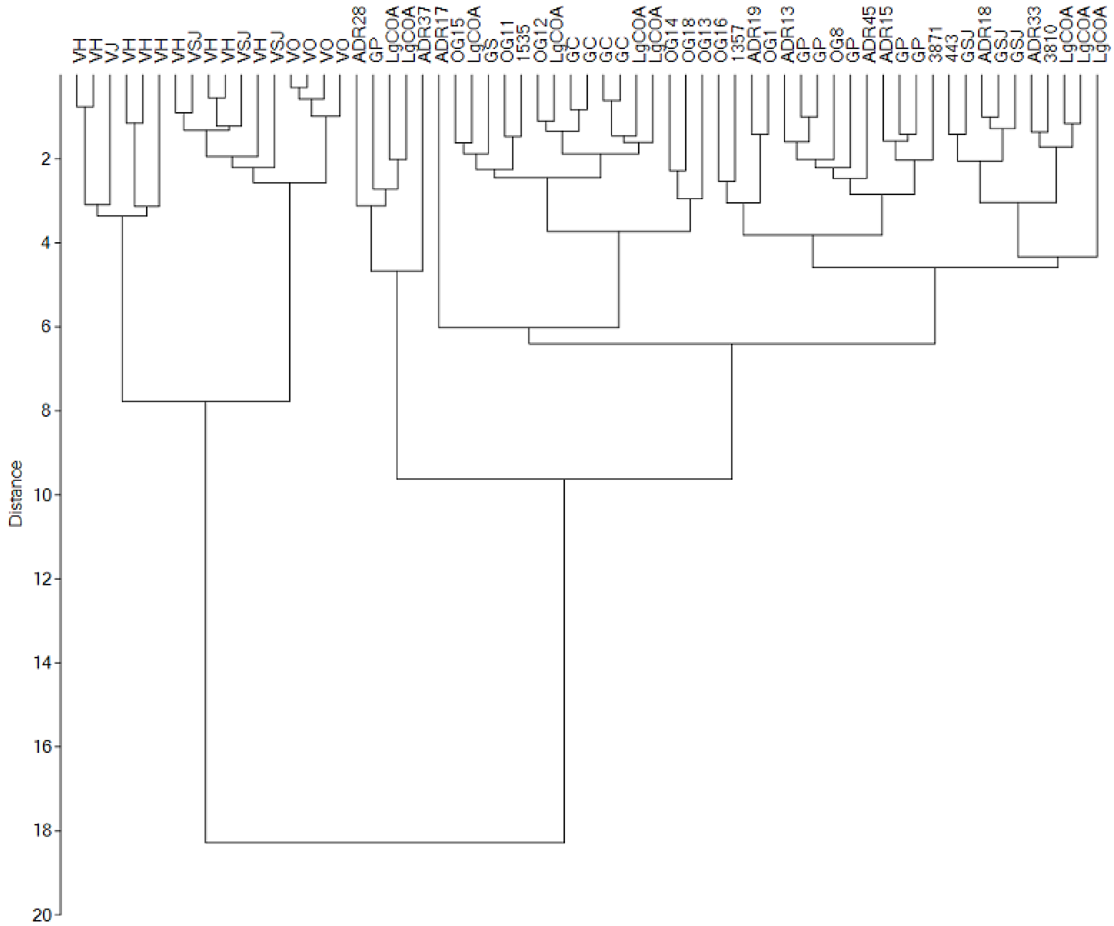

Figure 5: Cluster analysis for front (a) phalanges

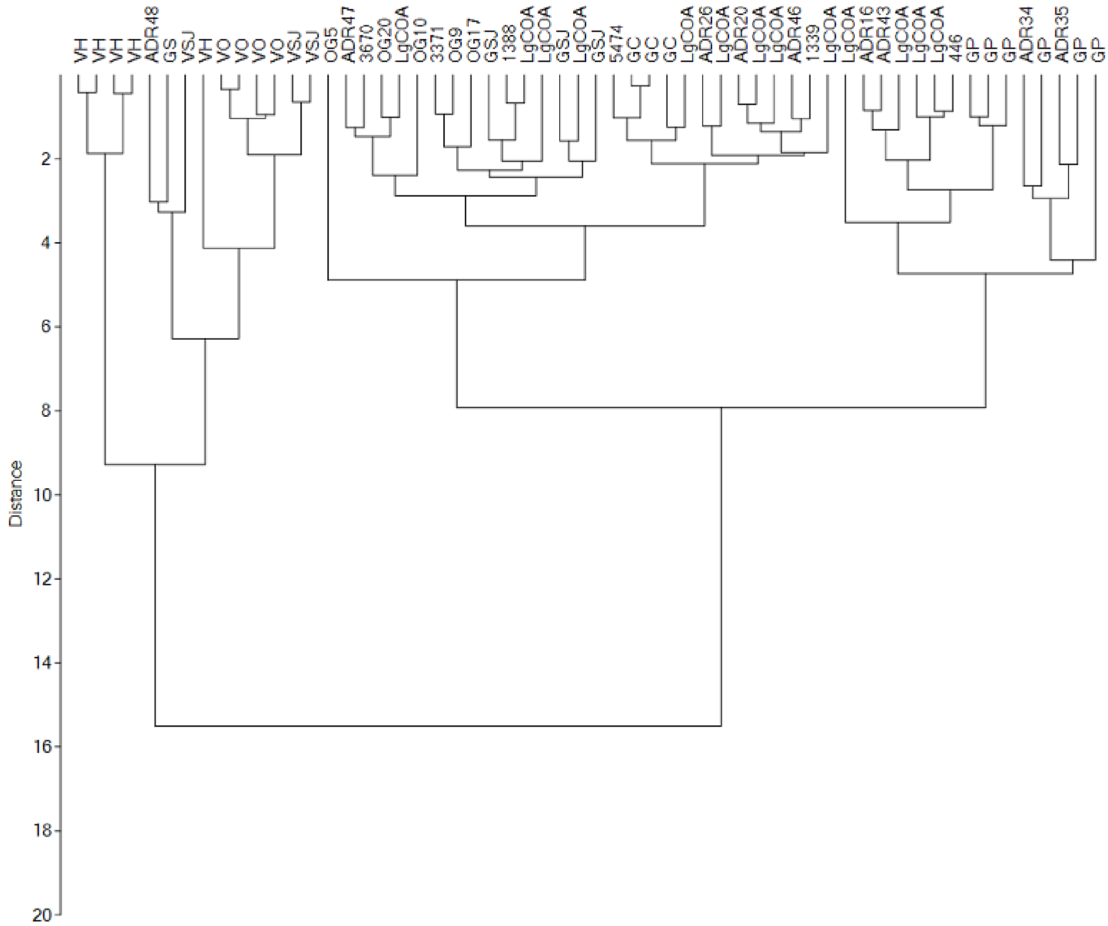

Figure 5: Cluster analysis for hind (b) phalanges