Middle Holocene intensification and domestication of camelids in north Argentina, as tracked by zooarchaeology and lithics

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Using a detailed excavated sequence and a broad range of south Andean sites, the authors show that changes in the bones of camelids and in the lithic assemblages offer an account of how animals were intensively exploited and ultimately domesticated between the sixth and fourth millennia BP.

Keywords: Argentina, Andes, Middle Holocene, sixth–fourth millennia BP, domestication, camelids, lithics

Introduction

Two topics that have captured the global interest of the scientific community are the processes of intensification and domestication, issues that necessitate consideration of the evidence at local and regional scales (Dincauze 2000). This article presents a case study of a specific region of the Andean highlands, Pastos Grandes, in north-west Argentina (Figure 1). Pastos Grandes is situated in the puna of Salta, a high altitude desert biome located above 3500m asl. Macro-geographically the region belongs to the south-central Andes and is a habitat demanding particular human adaptations.

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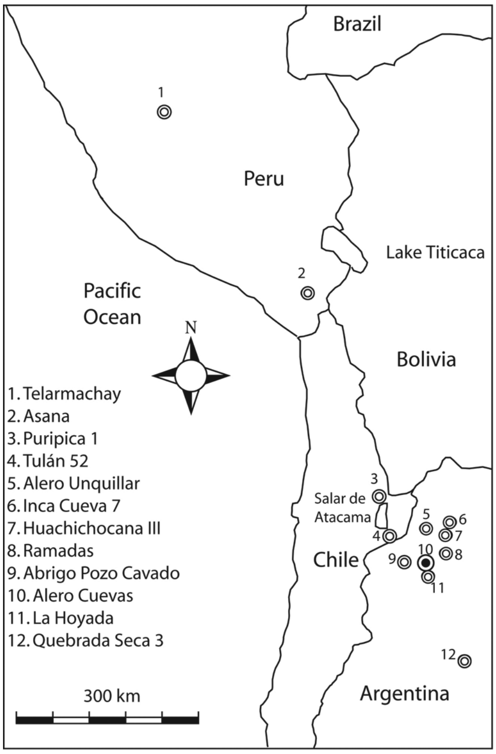

Figure 1. Andean archaeological sites with contextual evidence for intensification and domestication (c. 5500–3500 BP). The Pastos Grandes Basin coincides with the cluster of numbered sites in north-west Argentina. The Alero Cuevas site is n° 10.

We focus specifically on the intensification and domestication of camelids, animals native to the Andes. At present there are four camelid species in South America: llama (*Lama glama*) and alpaca (*Lama pacos*), both domesticated, and vicuña (*Vicugna vicugna*) and guanaco (*Lama guanicoe*), both wild. Currently there are some regions of the Andean area, including the Argentine puna, that are not inhabited by the alpaca. Likewise there is no strong evidence to suggest its presence in this area in the pre-Hispanic period (Olivera 1997; cf. Lavallée *et al.* 1997).

In this study we also connect lithic blade technology and, more specifically, the use of blades, with the maximising of camelid use, in turn a sign of intensification, reflecting increasing energetic demand due to population density and pressure on space. These changes are archaeologically visible towards the end of the Middle Holocene and the beginning of the Late Holocene (*c.* 5500–3500 BP), but only become evident by taking into account wider chronological parameters. For this reason, we also discuss the situation in the Early Holocene (*c.* 10000–8500 BP) and the Later Holocene (after *c.* 3000 BP).

Theoretical aspects

The theoretical framework that guides this article emphasises ecological and social variability in specific habitats. As such we are referring to human behavioural ecology, a branch of evolutionary ecology, which examines the adaptation of the human phenotype to specific habitats (Smith & Winterhalder 1992). The Middle Holocene in the Andean highlands saw a relative synchronic climatic change implying aridity and higher temperatures, especially in the lower latitudes (Aldenderfer 1998). In the case of the south-central Andes, the Middle Holocene was characterised by a change towards more arid conditions, a determining factor in the extreme fragmentation of this habitat into *patches* of specific resources. This meant that in certain local habitats humid conditions persisted and this permitted human occupation, whilst other areas became unsuitable for habitation (Núñez *et al.* 2005; Yacobaccio & Morales 2005).

The Middle Holocene, as opposed to the Early Holocene, was a period of extremely variable climatic conditions. These ecological changes generated the necessary conditions for human spatial competition and aggregation, which led in turn to an increase in group size (Aschero 1994; López 2008). This process is in keeping with the accepted models of human behavioural ecology such as 'optimal group size' (Boone 1992). Under these conditions we expect intensification and domestication that include, in turn, technological change.

Intensification is defined as the search for an increase in productivity, that is to say, a higher energetic input per unit of space or resource (Broughton 1999). In the south-central Andes, Yacobaccio (2001) proposed a process of intensification in the use of camelids that ultimately led to their domestication. This process was accompanied by the parallel development of certain traits within the complexity of puna hunters. Such an increase in complexity is seen in other areas of the world. Examples include Chinchorro along the northern coast of Chile (Arriaza 1995), the Natufians in the Levantine corridor of the Near East (Bar-Yosef 1986), the Jomon of Japan (Imamura 1996) and the Ertebølle of circum-Baltic Europe (Zvelebil 1996).

The first studies into the *domestication* of camelids were undertaken in the central Andes, and took account of distinct lines of evidence such as osteometry, age profiles and dental morphology (Kent 1982; Moore 1989; Wheeler 1998). At the site of Telarmachay in the puna of Junín, Peru, it was possible to note changes related to the domestication of camelids occurring as early as 6000 BP (Wheeler 1998). Nevertheless, at other sites in the south-central Andes (see Figure 1), the domestication of camelids generally occurred between 5000 and 3500 BP (Mengoni Goñalons & Yacobaccio 2006). This is backed by osteometric and alometric data from sites such as Inca Cueva 7, Huachichocana III and Alero Unquillar, in the puna of Jujuy, Argentina (Yacobaccio 2001), and Tulán 52 and Puripica 1, in northern Chile (Núñez *et al.* 2005). Similarly, in the Osmore basin, in southern Peru, investigators have proposed changes related to domestication, especially on the basis of the evidence at Asana (Aldenderfer 1998).

At present there is wide consensus that the llama is a species derived from the process of domestication of the Andean guanaco (Mengoni Goñalons & Yacobaccio 2006). This process would have required intensification in the use of guanaco, captivity of groups of guanacos and ultimately their domestication (Yacobaccio 2001). The south central Andes has been put forward as an independent centre of llama domestication (Yacobaccio 2001).

Intensification and technological change: emergence, spread and decline of blades

The process of intensification in the use of camelids that led to domestication had to be accompanied by technological changes within the context of increasing energetic demand. The available technology can increase or, on the contrary, restrict the rate of return (Bousman 1993). In the south-central Andes towards the end of the Middle Holocene we refer specifically to changes in blade technology.

Blade technology demands specialised and complex skills to achieve the desired result (i.e. standardised pieces, long edges, etc.). It involves the preparation of cores, a sequence of planned reduction and better knapping precision (Boëda 1997). In theoretical terms, and following Boyd and Richerson's (1985) theory of cultural transmission, the expectation is that larger group sizes and higher population density will see an increase in the transmission of specific cultural knowledge.

It is also possible that the development of more complex technology itself required mechanisms for the transmission of specific cultural knowledge. This in turn would minimise the risk of replication errors as the population grew (Bettinger & Eerkens 1997; Fitzhugh 2001; Muscio 2004). Therefore, during processes of intensification and domestication, blade technology allowed greater efficiency in order to maximise resource yield, in a context of increasing energetic demand.

This trend towards greater use of blades in line with demographic increase, human aggregation, increased sedentism and a change in food production has been noted in other parts of the world. For example, in the Pre-Pottery Neolithic of the southern Levant, highly standardised blades made from prepared cores (Naviform cores) are seen as a response to the intensification of food production and the nucleation of a growing population (Quintero & Wilke 1995). Conversely, decline in the use of this technology occurred when people dispersed into smaller groups in the Pottery Neolithic period (*ibid.*). This example shows that the emergence, spread and decline of certain technologies relate to given social and ecological contexts. There is evidence of this same pattern emerging in the puna of Salta as will be seen below.

The regional context of the site of Alero Cuevas

The study area was the target of meso-scale archaeological fieldwork (as defined by Dincauze 2000: 19) and covered the Pastos Grandes basin, puna of Salta, north-western Argentina. The site of Alero Cuevas is notable for being the baseline chronological referent for the area (Figure 1, n° 10; Figure 2). This site is located in a highland ravine, situated at 4400m asl, with access to resources critical for subsistence. The stratification permitted the recording of distinct layers relating to different periods (López 2008). Layer F4 provided dates from the Early Holocene, layer F3 included a discrete occupation of the Middle Holocene, layer F2 was dated to the end of the Middle Holocene and the beginning of the Late Holocene, and layers C1 and X spanned the period *c*. 2000–600 BP. These periods are traditionally characterised by the development of food production in the puna (see Figure 3).

Layer F2, which provided dates of 5106±68 BP and 4210±70 BP (López 2012), represents a crucial moment in the process of intensification and domestication of camelids in the puna. There were significant differences between F2 and other layers, particularly layer F4, dated to the Early Holocene (*c*. 9600–8500 BP). These changes were reflected in the archaeofaunal and lithic assemblage, examined below.

Analysis

Animal bones

The archaeofaunal assemblages were analysed using an osteometric approach with the object of detecting interspecies variation in the camelid population (Von den Driesch

Figure 2. The archaeological site of Alero Cuevas, Pastos Grandes (puna of Salta, Argentina), taken from the ravine bottom.

1976; Kent 1982; Elkin 1996). Osteometry has previously been used to study the process of intensification and domestication of camelids in the central and south-central Andes (Wheeler 1998; Mengoni Goñalons & Yacobaccio 2006). Although it is well known that osteometric results are not conclusive in distinguishing between species, the method is useful in providing an initial approximation, especially when other more direct indicators are lacking. In north-western Argentina the size gradation for the different camelid species from smaller to larger is vicuña–guanaco–llama. Therefore, the smallest scale measurements would signify vicuña (given the absence of alpaca in the Argentine puna) whilst larger scale measurements would signify guanaco and llama. A high variability in size among guanaco and llama corresponds to overlapping of the two species, making them indistinguishable from each other in most cases.

Another important indicator was the age profile analysis of the camelids. The underlying assumption of this study is that changes in age at slaughter of a given population may be related to processes of intensification and domestication. Species diversity, seasonal tendencies in the presence of camelids and contextual information have also been considered as indirect indicators of the processes of intensification and domestication (Mengoni Goñalons & Yacobaccio 2006). Unfortunately we do not have other indicators such as well-preserved fibres or dental morphology to support this analysis.

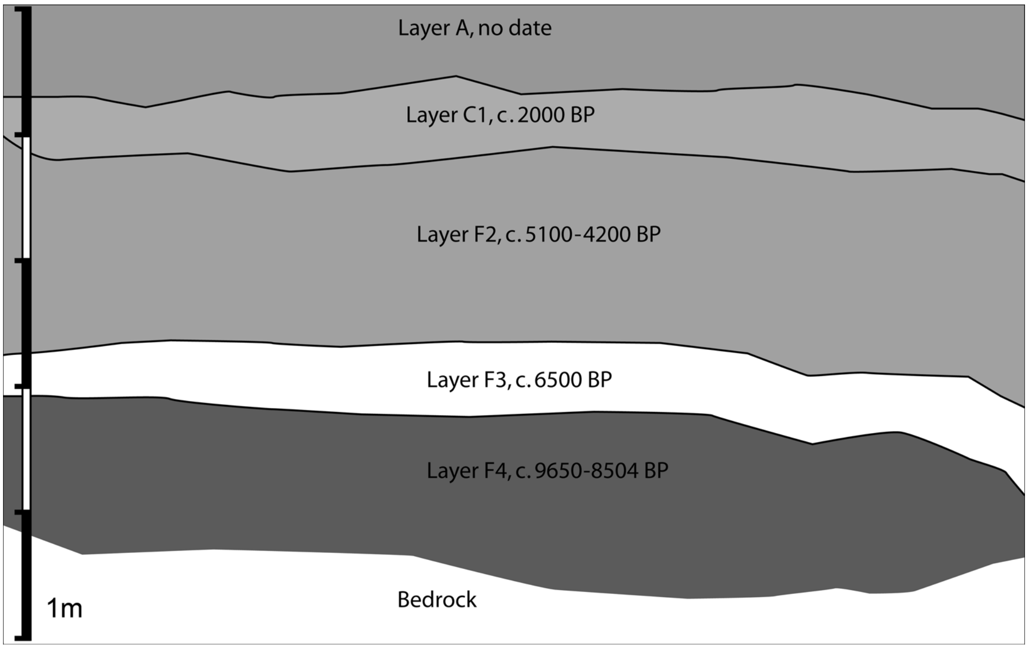

Figure 3. Stratigraphy of the Alero Cuevas site, detail of the north profile, Grid Square 7.

The Alero Cuevas archaeofaunal assemblage had a good general state of preservation (for more details see López 2008). A sample of 7553 specimens was analysed. As can be seen in Figure 4, the site of Alero Cuevas always tended towards a consumption of camelids that surpassed 90 per cent of the total assemblage. This figure holds true for the Early Holocene as well as for the end of the Middle Holocene. Nevertheless, at a regional level, variability in consumption patterns seems to have been higher in the Early Holocene, with a marked tendency towards predominately camelid consumption from the Middle Holocene onwards (Yacobaccio 2001).

The relative size of camelid species was estimated by measuring the width of the first proximal phalange, following Meadow (1987). The average proximal widths recorded in layers F2–4 are compared in Figure 5, which also shows the average width at the later site of Abrigo Pozo Cavado in Pocitos, dated to *c.* 4000 BP (see below). The positive values furthest to the right of the *y*-axis (this axis denotes the mean size of modern-day guanacos) indicate the largest sized individuals, whilst those to the left of this line probably correspond to vicuñas. When considering the Early Holocene, the higher values are interpreted as guanacos bigger than those found today. Evidence indicating a size reduction in some wild species throughout the Holocene has been demonstrated in certain cases (Mengoni Goñalons & Yacobaccio 2006). The case for changes in larger sized individuals in layer F2 of Alero Cuevas and in layer 4 from Abrigo Pozo Cavado could be earmarking camelids in the process of domestication and/or already domesticated. Even so it should be noted that there is a lack of guanaco comparative samples for the south Andean region, and there are difficulties in checking intra- and interspecies variability within the larger camelid group

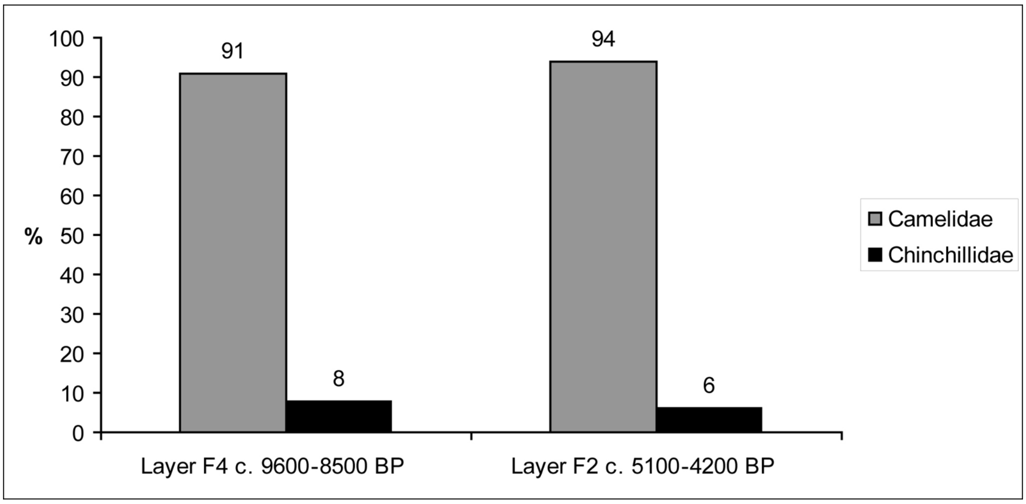

Figure 4. Faunal assemblages: comparative NISP% from layers F2 and F4 from Alero Cuevas (the remaining 1% from layer F4 belong to cervidae*).*

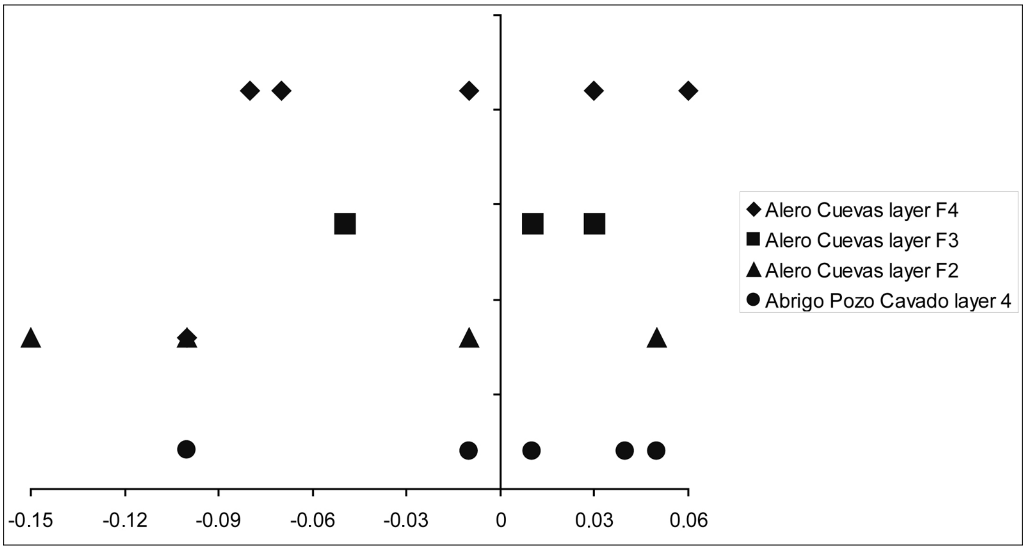

Figure 5. Camelid osteometry of the proximal width of the first phalange from different layers from Alero Cuevas and from layer 4 from Abrigo Pozo Cavado (method used = logarithmic differences [Meadow 1987]).

(llamas and guanaco). These two factors constitute problems common to the south-central Andes (Mengoni Goñalons & Yacobaccio 2006).

Another noticeable change in layer F2 of Alero Cuevas is that of the presence of fused and unfused bone specimens. There is a marked tendency in this layer towards the presence of unfused bones compared to earlier layers (Figure 6). The use and consumption of

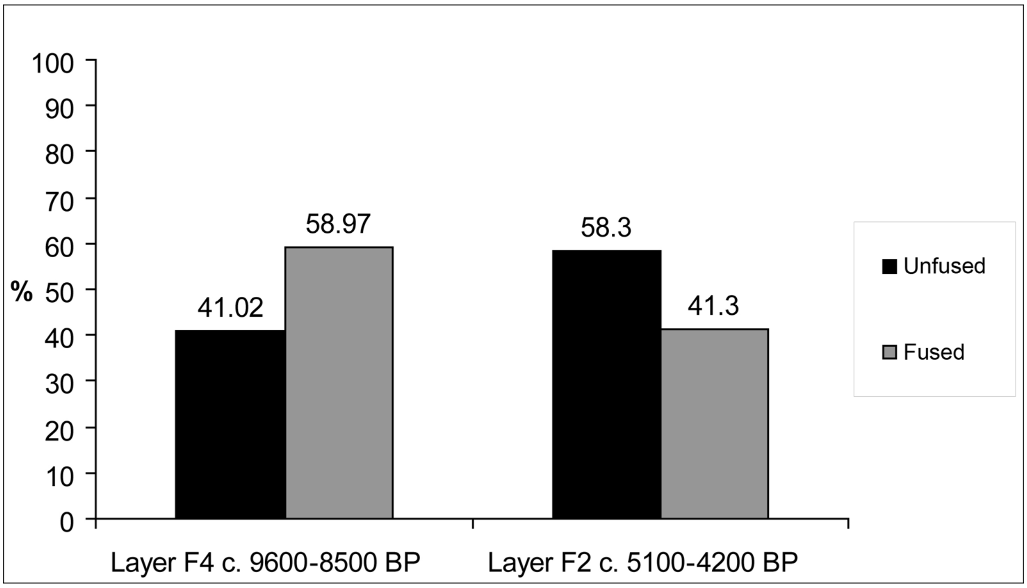

Figure 6. Fused and unfused camelid specimens from layers F2 and F4 from Alero Cuevas.

sub-adults in this type of context has already been observed by different scholars in the central and south-central Andes (Hesse 1982; Wheeler 1998). This same trend was detected at Abrigo Pozo Cavado, with a similar chronology. Similarly, it is important to note the rise during the end of the Middle Holocene and beginning of the Late Holocene in cut marks on camelid assemblages from Alero Cuevas and Abrigo Pozo Cavado (López 2012). We even registered the presence of cut marks on camelid neonate specimens.

Lithics

For the lithic analysis, we selected indicators that demonstrated a trend towards maximising strategies in resource yield (Nelson 1991; Bousman 1993; Escola 2004), indicators that are consistent with the process of intensification and domestication of camelids. On this basis we analysed tools, debitage and cores, classifying them according to different general criteria such as raw material, edge and face shaping, and blank.

The analysed assemblage totalled 2139 specimens from layers F4 and F2. A salient difference between the lithic assemblage in F4 and F2 is the emergence of a new type of artefact known as 'unifacial lanceolate', manufactured from blades (Figure 7). A general characteristic of these tools is the presence of partial retouching on the ventral face, probably as a means of reducing the width of the percussion bulb to facilitate hafting. These unifacial lanceolate tools are distributed across a large area that includes the puna of Salta and the puna of Jujuy. At Pastos Grandes this tool is frequently found on the surface as well as within stratified deposits. In other areas of the Argentine puna, such as Catamarca, located to the south of Salta, these artefacts are practically absent.

*Figure 7. Detail of unifacial lanceolate tools and associated blade core from layer F2 (*c. *5100–4200 BP) at Alero Cuevas.*

Studies by Fernández Distel (1978) in the puna of Jujuy have designated the association between unifacial lanceolate artefacts and blade cores as 'Saladillense' industry. This same association has been noted in other areas of the puna of Salta, such as at San Antonio de los Cobres, located 60km to the north-east of Pastos Grandes. Similarly, the site of Ramadas presents surface artefact concentrations as well as significant archaeological material in stratified layers with a date of 5210±40 BP (Muscio 2004). In this sense, there is a re-occurrence of open-air sites with archaeological material both in layers and on the surface dating to the end of the Middle Holocene (Fernández 1984; Muscio 2004). These sites were interpreted as relating to a process of higher population density, human aggregation and a reduction in residential mobility (Muscio 2004; López 2008). Also, in the Pocitos basin, located 60km to the west of Pastos Grandes, a number of open-air and rockshelter sites have been found with archaeological material dated to the same period. Amongst them we should recall the site of Abrigo Pozo Cavado, dated to 3884±59 BP (López 2012). Blades were also found in the Tulán and Puripica ravines in northern Chile, dating towards the end of the Middle Holocene (*c*. 5000–4000 BP) (Núñez *et al*. 2005) together with a high investment in architectural construction.

Although only one core was recovered at Alero Cuevas, it is important as it demonstrates a clear association between the extraction of blades and unifacial lanceolate tools made from blade blanks (see Figure 7). This association has also been noted at other sites in the region, such as La Hoyada, an open-air site located on the edge of the Salar de Pastos Grandes. Apart from the core and tools, unmodified blades were also found among the debitage.

In layer F2, dated to the end of the Middle Holocene and beginning of the Late Holocene (*c*. 5100–4200 BP), there is a notable predominance of unifacial lanceolate tools, which contrasts with their absence from layer F4 which dates to the Early Holocene (*c*. 9600–8500 BP). In Figure 8 we can see a high presence of blades towards the end of the Middle Holocene, which serves to demonstrate the emergence and proliferation of this technology within a given chronological context. Figure 8 also includes a comparison with Layer C1 from Alero Cuevas, dated to *c*. 2000 BP, which shows a decline in the use of blades during the Late Holocene. Insofar as they indicate a specific chronology, the lanceolate unifacial tools made using blade blanks have become 'time sensitive artefacts'. Across the area, both on the surface and in stratigraphic layers, more than 100 of these tools have been recovered.

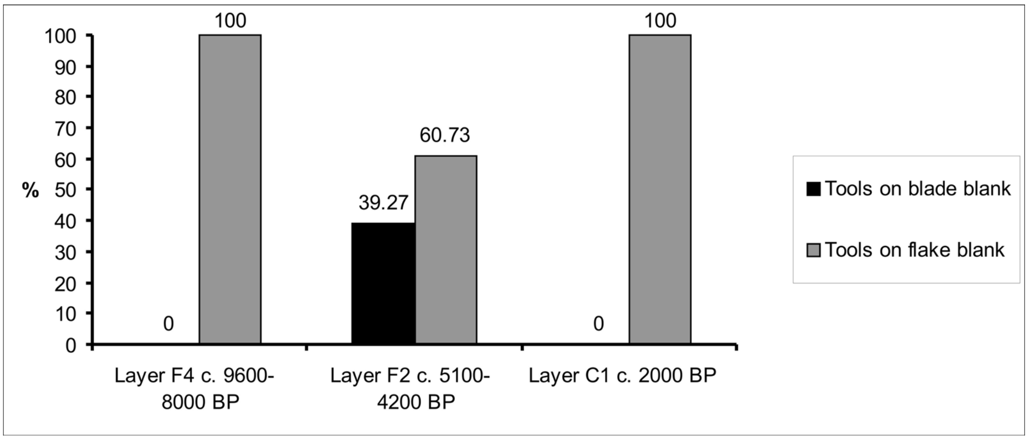

Figure 8. Emergence, spread and decline of blades over the Early, end of the Middle and Late Holocene from the Alero Cuevas site (N = 98).

Unifacial lanceolate artefacts show evidence of morphological and metric standardisation. In all these cases, starting from a blank, the knappers sought to create parallel or sub-parallel edges. At a metric level, the least variation is found across the width and in the width/length index (see López 2008). This standardisation might be related to hafting, since a standardised width means that lost or obsolete lithic artefacts would have been easier to replace in the valuable shafts (wood being rare on the puna). This then describes another of the properties of blade technology, namely the possibility of obtaining standardised and easily replaceable products.

The raw materials used for the manufacture of these unifacial lanceolate tools are local (within a radius of no more than 15km of the Pastos Grandes basin). These include Andesite from the open-air site of Picadero, 10km away. Another important source of raw material, given its frequency in the archaeological record, is obsidian from Quirón, located *c.* 40km from Alero Cuevas. Given these facts, it is noteworthy that layer F2 represents a general technological change in respect to the other layers, because of the spread of blade use as well as a greater dependence on local raw material sources that occured during the preceding Early Holocene (Figure 9).

Finally, in the layers chronologically later than F2, blade technology, especially that of unifacial lanceolate tools, disappears (Figure 8) from food production contexts (*c.* 2000 BP). We hypothesise that this decline in blade technology was related to particular Late Holocene ecological and social conditions.

Discussion

The process of intensification and domestication of camelids occurring in the Andean region can be approached from different scales of analysis. It is important to consider the micro- and meso-scale so as to have a clearer understanding of the regional, i.e. the macro-scale (Dincauze 2000).

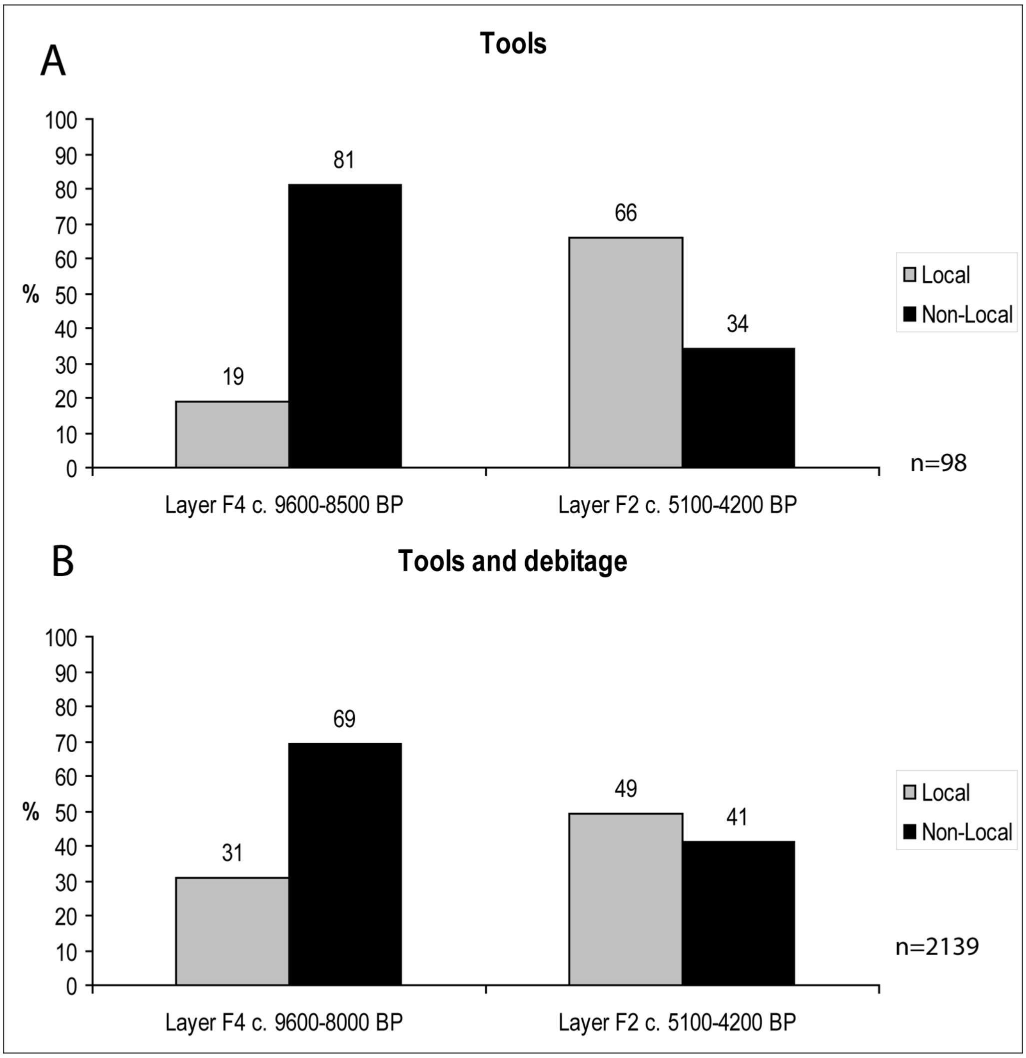

Figure 9. Comparison of raw material percentages from tools (A), and from tools and debitage (B) during the Early Holocene and the end of the Middle Holocene. In the case of layer F2 the remaining percentage (10%) belongs to indeterminate debitage.

As mentioned earlier, higher population density and complex technology favour the increase of social learning (Bettinger & Eerkens 1997). This is the case with blade technologies that required a high degree of planning and learning. As a working hypothesis, we suggest that it is precisely these contexts that are ideal for the development of technologies more efficient in the processing of resources given a higher energetic demand. As a consequence, the technological strategy would have been orientated towards the maximisation of resource yield as a form of intensification.

Blade technology is one response to this demand, as it allows for standardisation of specimens, which are easily replaceable and have edges with a potentially high rate of use (see Nelson 1991). In our case study, blade technology would have maximised yield in the processing of camelids, allowing intensification of their consumption. In sum, a change in technological strategy may be interpreted as an adaptive response to a context of intensification and the initial domestication of camelids during the Middle Holocene.

Moreover, the *absence* of blade technology and unifacial lanceolate tools in other puna regions, such as Antofagasta de la Sierra in Catamarca, implies the possibility of variations in the use of space at the end of the Middle Holocene. This is in keeping with the recurrent use of raw materials local to each of the different regions. For instance, the decline in use of non-local stone and the increase in local stone use could well be an indication of a reduction in mobility (Kelly 1992). Figure 9 clearly demonstrates this trend.

The archaeofaunal evidence from Alero Cuevas can be viewed in the light of these changes. The notable increase in the number of unfused bone specimens in the layer dated to the end of the Middle Holocene is consistent with the intensified use of camelids due to population pressure (e.g. Broughton 1999). Likewise, changes in age profile characteristics (towards younger animals) have been interpreted in other areas of the Andes as evidence for an initial domestication (e.g. Hesse 1982; Wheeler 1998). Both these lines of evidence are mutually supporting, since increased pressure on hunting resources could have led to an initial domestication of camelids.

The relative size of the camelids is less conclusive. The osteometry shows certain changes in the size of various specimens at a regional level in this chronological context, and these values tend to be metrically comparable to those of llamas. The osteometry from the central Andes as well as northern Chile and the Argentine puna reflects trends that could be related to camelid domestication (Wheeler 1998; Núñez *et al.* 2005; Mengoni Goñalons & Yacobaccio 2006). The evidence from Alero Cuevas and Abrigo Pozo Cavado is consistent with changes that relate to this wider regional context. Even so, the widening of this study in these sites and in other sites along the puna would permit us a more conclusive and generalised account of which species of animal was being exploited.

From the Late Holocene (*c*. 3000 BP) onwards, camelid domestication led to a profound change in the extant niche economy, resulting in the establishment of herding as the predominant economic strategy for many areas of the Andean region. In turn, an economic niche based on herding and hunting helped diversify the subsistence base, minimised risk and reorganised groups into smaller domestic units (López 2008). This has been observed in modern-day pastoralist groups across different areas of the Argentine puna (Göbel 2001). As population density and energy demand decreased, high-cost technologies such as blades became less efficient.

Conclusion

The different strands of evidence—archaeofaunal and lithic—attest to the process of intensification and domestication in the southern Andes between the sixth and fourth millennia BP. Intensification is evidenced through the use of blade technology in conjunction with changes in slaughter profiles and osteometry. There is no evidence to suggest the existence of alternative options, for example a diversification of diet through the exploitation of lower ranking species or through an abandonment of the region (López 2012). Even so, more evidence at a meso- and macro-scale, and the development of new lines of investigation will permit us to deepen our understanding of these widely encountered processes.

Acknowledgements

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