South American Extinctions, a case study:
the Rodrigo Botet Collection of the Museum of Natural Science
in Valencia, Spain

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This paper aims to discuss the Pleistocene-Holocene South American megafauna extinctions, taking into account the evidence of bones exhibiting cut marks, identified in the Rodrigo Botet Collection of Valencia, Spain, donated by Rodrigo Botet at the end of the 19th century. Due to the amount of material present and the completeness of some specimens, this Collection is often considered the most important assemblage of South American megafauna fossils housed in Europe. Pleistocene-Holocene mammal extinction is quite a controversial topic and a variety of explanatory arguments have been put forward over the last 30 years. In South America, the loss of such a considerable amount of native fauna, in particular the megafauna, coincided with two important events: Homo sapiens’ expansion onto the continent and the rise of the temperatures, both of which affected the transition. In order to contribute to current understanding of this event, a taphonomical analysis was performed on the Rodrigo Botet Collection and these data were then contextualised with palaeoecological information. The taphonomic appraisal of this archived material was useful in order to identify bones with anthropic cut marks and, thus to provide new data for the debate on the South American megafauna extinction during the Pleistocene-Holocene transition.

Keywords: extinction, megafauna, South America, taphonomical analysis, palaeoecological relationships, zooarchaeology

Introduction

A taphonomical analysis was undertaken on the Rodrigo Botet fossil megafauna collection, which comes from the northeast of the Pampean region in Argentina (Figure 1). This research was conducted in order to add new data to the debate on the megafauna extinction of the Pleistocene-Holocene transition (Chichkoyan 2011). This event is widely discussed in archaeological literature (cf. Barnosky et al. 2004; Cione et al. 2003, 2009; Gutiérrez and Martinez 2008: 62, 63; Koch and Barnosky 2006; Martin 1975, 1984; Sodhi et al. 2009) as it coincided with the rise of the temperatures and the expansion of Homo sapiens into the continent. The southern portion of South America provides an excellent case study to evaluate the influence of humans on these animals, as this is the last region where humans migrated and where an autochthonous fauna developed. The last factor was the result of the previous isolation of this continent, until 3 MA when South America connected with North America. These native fauna, unique in the world, were characterised by their size, i.e., >1000 kg for megamammals or 44-999 kg for macro-mammals, and survived until Pleistocene-Holocene transition, when humans appeared in the region (Cione et al. 2003, 2009).

Taphonomical analyses were conducted in order to differentiate between anthropic traces or cut marks, and non-anthropic agencies (e.g., carnivores, wind or water erosion, plant growth, etc.). The analysis was performed using magnifying glasses and stereoscopic microscopes. This methodological approach is critical for analysing non-stratigraphic museum material where context data has been lost. The examination of a bone surface is useful to distinguish any kind of anthropic intervention and to obtain evidence of human exploitation of different fauna. Consequently, these data can be used in the discussion of megafauna extinction in order to understand humans’ impact upon the native palaeoenvironment during the Pleistocene-Holocene transition in South America. Prior to discussing this argument in full, it is important to provide a brief history of the Collection as well as the background of the material.

History of the Collection

The collection of material was gifted to Valencia City in 1889 by the engineer Jose Rodrigo Botet who obtained it from the collector, Enrique de Carles (Belinchón et al. 2009: 31 to 41). De Carles was a naturalist from the Museum of Natural Science of
Buenos Aires and undertook excavations including those in De La Plata, Salado and Samborombon Rivers and Samborombon Bay in the northern part of the Pampean region, Argentina (Figure 1).

All of the macromammals Darwin recognised in the Beagle's historical journey appear in the Rodrigo Botet Collection (Belinchón et al. 2009). The Collection held in Valencia, considered the first European palaeontological museum (Belinchón et al. 2009), and, although most of the material requires taxonomic re-identification, at least six orders of mammals and megamammals are conclusively present: Carnivora, Notoungulata, Litopterna, Perissodactyla, Proboscidea and Xenarthra (Martel San Gil and Aguirre Enríquez 1964). When this material was originally excavated, the methodology of fossil extraction was markedly different from that of today. There was no stratigraphical control, no systematic recording materials found in each stratum, or even a detailed description of the site and the surrounding area. At the present time, these kinds of procedures are de rigueur, and it is impossible to do an excavation without a strict protocol. Further, every detail is taken into account, registered and processed in the analysis of the materials. At times it can be difficult to understand the utility of analysing bones housed in museums that lack context. For this research, a different point of perspective was necessary, in which museums are considered the first essential part of an investigation. Although partial, the information recollected here is not only useful because it provides additional data contributing to current discussions, but also aids in creating new research lines for the future. Lastly, in the case of bones with cut marks, these materials can be subjected to radio-carbon dating, allowing for a chronological framework of human intervention to be obtained.

Antecedents of the region

Argentina is located in southern South America, one of the biggest land masses in the Southern Hemisphere. The country has two distinct geographical areas: the lowlands to the east, with different vegetation mosaics, and the Andean Mountain range to the west, with marked altitudes (Figure 1). Due to Argentina's unusual shape, it has a great diversity of biomes and climates that allows for different adaptations to the environment (Argollo 2006). During most of the Cenozoic, this continent was an island, until 3 MA when it joined with North America through an intercontinental bridge, the Parana Isthmus. This occurrence was one of the largest biogeographical events in the Americas. This event led to what was called the Great American Faunal Interchange, when various species, from both continents, migrated north and south (Patterson and Pascual 1968; Potts and Behrensmayer 1992: 462, 463; Webb 1978).

The previous isolation of South America allowed the development of an indigenous fauna of great variety, quite different in shape and size to what had emerged on other continents. Among these fauna were the Xenarthra, one of the earliest American orders of placental mammals that during the Great American Faunal Interchange, extended to the north, while many carnivores, such as ursids and felids, entered into the south (Potts and Behrensmayer 1992: 462, 463). Some skeletons of these native species can be seen in Figure 2, while Figures 3, 4 and 5 depict ideal reconstructions of these native fauna.
Within this complex migratory event, Argentina was located in a critical sector, amongst the Guayano-Brazilian and Andean-Patagonian sub-regions, which were home to a variety of fauna (Morrone 2004). The key area within this system was the Pampean region (see Figure 1), a transitional area between these two great biomes. Thus, this region has always been particularly susceptible to changes, in both flora and fauna, which tend to expand and contract in relation to the fluctuating climate (Prado and Alberdi 2010).

The Pampean region is crucial not only because of its location, but also because it has the best known South American faunal records, which have defined the stratigraphy for the whole continent (Patterson and Pascual 1968). This material, accumulated under arid or semi-arid environmental conditions, accompanied the deposition of sediments during much of the Quaternary (Prado and Alberdi 2010). Further, this region is characterised by having some of the earliest evidence of human-megafauna interaction.

Figure 2 Skeletons on display in the Museum of Natural Science of Valencia: A. Macrauchenia patachonica, B. Megatherium americanum, C. A type of Mylodontidae, D. A type of Glyptodontidae (photographs by Chichkoyan).
Existing evidence of Human-Megaflauna interaction

Megafauna bones, in association with human activities or with evidence of anthropic intervention, have been found in various sites in southern Province of Buenos Aires, located to the southeast of the Pampean region (see Figure 1). For the purposes of this article a selection of these sites are described below:

La Moderna: Located on the banks of Azul Creek and dated between 7500 to 7000 BP (Gutiérrez and Martinez 2008). Hunting and processing of *Doedicurus clavicaudatus* took place here, as inferred by the association between lithic instruments and the remains of the animal (Politis and Gutiérrez 1998). The animal would have been quartered here and the front and rear quarters would have been transported elsewhere. Some axial remains, i.e., the skull and the shell, were left in the site. This evidence corresponds to a ‘Kill Butchery Stage’ (Lyman 1994: 300) in which there is a brief human occupation and restricted butchery activities take place on site.

Arroyo Seco 2: Located to the south of La Moderna and dated between 12150 to 11200 BP, based upon multiple determinations from megafauna bones (Steele and Politis 2009). In the lower layers of this archaeological site, there was evidence of human exploitation of *Megatherium americanum* as well as two types of horses: *Equus neogeus* and *Hippidion sp.* The front and rear quarters from these animals as well as bones with possible traces of human intervention were found at the site (Politis 1989).

Campo Laborde: Located along the banks of Talapaque River and dated between 8700 to 7750 BP (Gutiérrez and Martínez 2008). This site was interpreted as being the location of hunting and primary processing (i.e., evidence of rib bones with cut marks) of *Megatherium americanum* (Gutiérrez and Martínez 2008). Following processing, only meat and viscera were taken away, leaving the majority of animals’ bones on site (Politis and Messineo 2008).

Paso Otero 5: Located at the right margin of the Quequen River and dated from 10450 to 10200 BP (Gutiérrez and Martínez 2008). At this site burned bones of *Megatherium americanum* and *Hemiauchenia sp.* were found and interpreted as fuel material.

Cueva Tixi: Located in the Tandilia Mountain System, 40 km from the Atlantic coast and
dated between 10,400 and 10,000 BP (Gutiérrez and Martínez 2008). Three phalanxes and six osteoderms of *Eutatus seguini* were found in association with lithic tools and a hearth. This association of material was interpreted as evidence of an anthropic intervention over this species (Mazzanti and Quintana 1997; Politis and Gutiérrez 1998).

The date range for these sites is indicative of a 3000-4000 year period of coexistence for *Homo sapiens* and the native South American fauna (Politis and Messineo 2008: 111). Although there is some evidence of exploitation of megafauna in the south of the Pampean region, the small guanaco (*Lama guanicoe*) is still considered to have been the most important animal resource (Cione et al. 2009; Politis et al. 2004). This scenario is different to what happens in Patagonia for example. In this region an opportunistic behaviour was defined in relation to the exploitation of the megafauna (Borrero and Franco 1997). The analysis of bones housed in museums can contribute new evidence to evaluate, clarify, and specify the sort of impacts that human populations would have introduced. *Homo sapiens* must be seen as a new invader species (Lanata et al. 2008), that dispersed into the American palaeoenvironments, which were not used to this novel predator (Cione et al. 2009).

### Methodology

Taphonomical analysis of the Rodrigo Botet Collection was undertaken to examine the fossil bones. These analyses allow for the identification of cut marks in animal bones (i.e., from human and non-human agents), as well as the detection of weathering by multiple factors, which can be indicative of the palaeo- and post-depositional environment (Bonnichsen 1989; Lyman 2008).

Much has been written on how to identify cuts of human origin and to what part of the butchery process they correspond (Binford 1981; Lyman 1994; Shipman 1981; Walker and Long 1977). For the purposes of this study human traces (full methodology details in Chichkoyan 2011) were classified as cut marks for simple cuts, percussion when the trace was more profound, and tools for objects potentially fashioned by humans.

Bone material larger than 2cm of size was selected for observation with magnifying glass, and binocular microscopy, utilising an Olympus SZ-PT. Full taxonomic and anatomical identification was not always provided for the material and the degree of identification available has been categorised as follows:

- **Identified**: material was assigned to a definite taxa and anatomical level;
- **ID**: material identified at anatomical level but taxonomical identification below class not possible; or
- **II**: material neither identified at anatomical nor taxonomic level.

### General Results

In total, 11,466 bone elements were analysed: 4,474 elements were identified at species, genus, family or order level, 693 elements were identified only by anatomical level (i.e. ID) and 6,299 fragments were unidentifiable (i.e. II) (Figure 6).

![Figure 6 Percentage of the material analysed.](image)

At least 19 bone elements, 0.17% of the total, exhibited evidence of human intervention elements (see Table 1). Of the 52.6% of bone elements that were taxonomically identified, five taxa are represented: *Eutatus*, Glyptodontidae (Figure 7), *Macrauchenia patachonica* (Figure 14), *Megatherium* (Figure 13), and Mylodontidae (Figures 8, 9, 10, 11, & 12). The rest of the material is distributed among three ID elements: one rib fragment, one shaft, and one fragment of mandible from a non-identified species, and six II elements. Three observations can be highlighted: the relative age of cut marks (i.e., in relation to other evidence of weathering on the fragments), the taxonomical identification of the bone upon which cut marks were detected, and the anatomical identification of the bone upon which cut marks were noted.
First, this analysis aids in considering a broad ‘taphonomic history’ of these fossils (i.e., a chronology of the agents that affected the bones). Examination revealed that cut marks detected were inflicted before the intervention of other non-human agents (e.g., roots or trampling). The Mylodontidae atlas (see Figures 9 & 10) displays evidence of latter intervention by non-human agents. The same can be said regarding the Glyptodontidae osteoderm (Figure 7), which exhibits manganese spots that are evidence of post-depositional chemical processes which altered two continual walls that were already affected by human intervention. The Macrauchenia patachonica ribs (see Figure 14), the Mylodontidae rib (see Figure 8) and metatarsal (see Figure 12), as well as the ID and II fragments, both the bone and cut marks were observed to have the same superficial colouration. This colouration can be interpreted as evidence of a post-depositional environment that uniformly affected the material. This information gives greater weight to the interpretation of the marks being the result of pre-depositional human intervention upon the bone. Further, this makes the possibility that these marks occurred during transfer, manipulation, or archival of the material post-excavation, very unlikely (Chichkoyan 2011; Chichkoyan et al. 2013).

Table 1 Bones with evidence of anthropic intervention.

<table>
<thead>
<tr>
<th>Species</th>
<th>Bone Type</th>
<th>Types of Human Intervention</th>
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<td>Mylodontidae</td>
<td>Scapula</td>
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<td>Megatherium sp.</td>
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<tr>
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<td>Mandible</td>
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<tr>
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<td>Rib</td>
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<tr>
<td>Undetermined</td>
<td>Shaft</td>
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<td>1</td>
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<tr>
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<tr>
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<tr>
<td>Eutatus sp.</td>
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<tr>
<td>Eutatus punctatus</td>
<td>Osteoderm</td>
<td>1</td>
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<tr>
<td><strong>TOTALS</strong></td>
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Figure 7 Glyptodontidae (left) and Eutatus (right) osteoderms (photograph by Chichkoyan).
Figure 8 Mylodontidae rib with three percussions (photographs by Chichkoyan).

Figure 9 Mylodontidae scapula with percussion (photographs by Chichkoyan).

Figure 10 Mylodontidae atlas (dorsal face). The circled areas are where cut marks were found (photographs by Chichkoyan).

Figure 11 Detail of Figure 10: Mylodontidae atlas (photographs by Chichkoyan).
Figure 12 Mylodontidae metatarsal with cut marks in the distal epiphysis (photographs by Chichkoyan).

Figure 13 Megatherium sp. rib with the detail of the distal part where there are percussion marks (photographs by Chichkoyan).

Figure 14 Two Macrauchenia patagonica ribs with cut marks (photographs by Chichkoyan).
Second, the bones with anthropic intervention found in the Rodrigo Botet Collection are a representative sample of different megafauna species which became extinct at the time of the Pleistocene-Holocene transition; excepting Eutatus, which became extinct during the middle Holocene (Krmpotic and Scillato-Yane 2007; Krmpotic et al. 2009). Not surprisingly, most of the material exhibiting signs of human intervention belongs to Mylodontidae, because this family was one of the best represented in the Collection (i.e., 25.12% or NISP of 1124), as well as the Pampean region on the whole (Miño-Boilini and Carlini 2009). Megatherium sp. (see Figure 13, rib), Macrauchenia patachonica (see Figure 14, ribs), and Glyptodontidae (see Figure 7, osteoderms) represent other taxa abundant during the Pleistocene that did not survive beyond the initial Holocene and which displayed indications of human intervention. Megatherium americanum is considered to be the most exploited species south of the Pampean region, as is evidenced by finds at sites such as Arroyo Seco (Steele and Politis 2009), Campo Laborde (Gutiérrez and Martínez 2008), and Paso Otero 5 (Gutiérrez and Martínez 2008). There is markedly less evidence of prehistoric consumption of Macrauchenia patachonica. Thus the identification of cut marks on fossils of this species within the Rodrigo Botet Collection provides compelling evidence of Macrauchenia patachonica interaction with Homo sapiens. Examination of the Glyptodontidae osteoderms revealed fine striation marks on the walls. These marks were interpreted as evidence of human intervention as this kind of work must be done on fresh material, as post-mortem the bones rapidly lose collagen becoming brittle. Despite these observations, more information is necessary in order to interpret and understand how osteoderms were manipulated by humans (Chichkoyan 2011; Chichkoyan et al. 2013).

Finally, we can focus on the anatomical elements in which these anthropic traces were found. The axial skeleton is the most abundant group within the sample, and included five ribs and one atlas. The appendicular skeleton is represented by one indeterminate shaft and a Mylodontidae metatarsal. A fragment of Mylodontidae scapula and a mandible fragment of unknown taxon were also found. The rest of the material corresponds to the six II fragments mentioned before and to the three osteoderms previously described (see Figure 7). It can be supposed that bones from the axial skeleton more commonly display cut marks as they represent those parts closest to the skin. Consequently, the chances of a lithic cutting these bones in the process of butchering are noticeably greater. Additionally, the ribs and atlas are related to the first steps in butchering, in which the separation of the skull from the rest of the body generally leaves marks over the atlas, and the evisceration process is related to the marks on the ribs (Binford 1981). At the site of La Moderna, the ribs and skull were left after the initial carcass processing was complete (Politis and Gutiérrez 1998). Additionally, the site of Campo Laborde revealed a rib of Megatherium americanum with what has been interpreted as an anthropic cut mark (Gutiérrez and Martinez 2008). When butchering large animals, often the initial goal is to cut and transport ‘clean muscles’ to another locale, leaving as many bones as possible where the animal was slaughtered. Though a great deal of cutting can be involved in dismembering, the long bones of the appendicular skeleton are covered by a significantly larger amount muscle mass which offers up fewer possibilities for the lithics to come in contact with the bones (Borrero and Martin 2012). The presence of cut marks on the metatarsal of Mylodontidae (see Figure 12) and on one indeterminate shaft can be related to the size of the animal and to the near impossibility of moving the front and the rear quarters without further butchering. The percussive marks on the scapula from Mylodontidae (see Figure 9) can also be related to the detachment of limbs from the rest of the body.

It is worth noting something about the probability of scavenging of animals hunted by other carnivores. The faunal population of the Pampean region was characterised as unbalanced, with greater variation in and quantities of herbivores than carnivores (Fariña 1996). Due to the size of the native herbivorous fauna, only the carnivorous Smilodon populator, and later Panthera onca, Puma concolor, and Canis nehringi, were considered capable of preying upon them (Prevosti and Vizcaíno 2006). The size of these herbivorous megafauna made them particularly unattractive for hunting by carnivores, and consequently there were fewer chances for them to be attacked. Thus, the possibility for humans to have scavenged over previously hunted animals is reduced. Lastly, there are notably no identifiable bones of carnivores within the Rodrigo Botet Collection.
Discussion

The evidence found in the analysis of the Rodrigo Botet Collection is significant as it indicates human populations might have had substantial access to megafauna in the Pampean region. However, in order to understand the importance of these findings, it is necessary to consider them within the context of human-megafauna interaction. It is essential to take into account the general palaeoecological conditions and relationships that developed during the Pleistocene-Holocene transition, and how *Homo sapiens*’ incursion into this region played out.

The South American megafauna were predominantly K-selection strategy species (MacArthur and Wilson 1967), characterised by low population density, few offspring per individual, late sexual maturity and long gestation periods. K-strategists tend to have few newborns with low survival rates, making their populations especially vulnerable during times of palaeoclimatic fluctuation (i.e., the Pleistocene-Holocene transition) (Cione et al. 2009). In light of these characteristics, human predation upon these animals might have noticeably affected the density of native megafauna populations. Effects need not be immediate however; as there is also evidence, as noted previously, that *Homo sapiens* and native fauna coexisted for at least 3000-4000 years. Nevertheless, the palaeoenvironmental changes for the region combined with some utilisation of megafauna by humans might have eventually negatively impacted the native fauna.

It is important to note that these animals were not subjected to human predation or technology when they evolved on the South American continent. As is commonly witnessed in alien-native interactions (Kondoh 2006), the megafauna probably were slow to develop defensive or evasive behaviours in order to adapt to a new threat. The megafauna, which lumbered across the landscape, were an easy target for the new human population, equipped with lithic technology (Cione et al. 2009; Gutiérrez and Martinez 2008; Patterson and Pascual 1968: 447). The majority of taxa identified in the Rodrigo Botet Collection fit the K-strategist paradigm (i.e., Mylodontidae, Macrauchenia patachonica, Megatherium sp., and Glyptodontidae). In contrast, *Eutatus*, although a Pampean species exploited by humans, perhaps could have survived for a greater period of time as it was not a K-strategist. *Eutatus*’ reduced size, weighing less than 50 kg (Krmpotic et al. 2009), and the possibility of a high reproductive rate, could have influenced the fact that this animal survived well into the Holocene like the previously mentioned guanaco.

The South American megafauna were adapted to live in open areas with cold environments, as were characteristic of the Pampean region during the Pleistocene. A series of interglacial and glacial periods demonstrated the ability of these animals to adapt to changing environmental conditions as the habitats of these animals contracted and expanded along with the fluctuating climatic conditions. Yet, the arrival of *Homo sapiens* during the last interglacial could have unbalanced the natural adaptive strategies of megafauna. Upon arrival, humans found different megafauna species isolated in shrinking biomes, serving as ecological shelters, due to rising temperatures. The area from where the Collection comes could have acted as an ecological shelter. The Pampean region was an open space which maintained the arid climatic conditions of the Pleistocene that facilitated the survival of these megamammals. When the human population arrived, they most likely found this native fauna already reduced to their minimal viable number for survival. Humans might have incorporated them as a novel resource and though exploitation might have been sporadic, this new predator probably had a negative impact on the natural survival adaptations of the megafauna.

The invasive character (sensu Lanata et al. 2008) of the *Homo sapiens* populations in the different palaeoenvironments implies a differential usage of the diverse resources in the process of dispersion through the isolated biomes. In this way, the Rodrigo Botet Collection can be compared to evidence from south of the Pampean region. In general, similarities with the exploitation of *Megatherium* and *Eutatus* can be detected; the former was consumed in Arroyo Seco (Politis 1989) and Campo Laborde (Gutierrez and Martinez 2008), and utilised for fuel in Paso Otero 5 (Gutierrez and Martinez 2008); while *Eutatus* was recorded at Cueva Tixi (Gutierrez and Martinez 2008). Only Campo Laborde presents clear evidence of cut marks on a *Megatherium* rib. Though megafauna were utilised in both regions, in the south, *Megatherium* was the most exploited animal; however, to the north, Mylodontidae was the most important taxon as evidenced by the Rodrigo Botet Collection. In contrast to what happened in the Pampean region, in Patagonia a lower encounter rate for humans and megafauna was postulated. The archaeological
record of megafauna and human interaction is scarce and some assemblages do have carnivore marks. It is proposed that the megafauna were opportunistically scavenged by humans (Borrero and Franco 1997; Borrero and Martin 2012). Consequently, it is important to take into consideration the diverse impacts that Homo sapiens could have produced over the populations of native fauna. Homo sapiens' distribution and diversity might have been related to the characteristics of the different palaeoecological patches, and this would have influenced human actions within each of them. For example, it can be seen that there are some similar trends in both areas of the Pampean region, although the variability of the species consumed probably depends on the different abundance of the native population in each patch. In contrast, in Patagonia, fewer relations between humans and megafauna were registered overall. This trend can be connected to the different palaeoenvironments of the regions as well as the environmental niches of the particular taxa.

The material found in the Rodrigo Botet Collection adds weight to the premise that Homo sapiens influenced the survival of the South American native megafauna in the Pampean region in a negative way. This impact could have been facilitated by the shrinking ecological niches of these species as well as by the climatic fluctuations of the period. The exploitation of some animals in a population that was already in decline due to climatic changes was potentially enough to lead them to extinction. The possibility of scavenging by humans is temporarily rejected due to the lack of evidence of carnivores in the Rodrigo Botet Collection.

**Conclusion**

The causes of megafauna extinction are far from clear. Positions as to whether extinction was caused by humans and/or climatic fluctuations are prevalent in the literature (Borrero and Franco 1997; Brook and Bowman 2004; Cannon and Meltzer 2004; Fiedel and Haynes 2004; Grayson and Meltzer 2003; Haynes 2007; Koch and Barnosky 2006). According to the position taken in this investigation, the South American megafauna would have been declining when Homo sapiens arrived in the Pampean region. Climatic fluctuations already detrimentally affected the reproduction and development of megafauna species during the Pleistocene. Thus, when human populations entered the region, they found a native fauna under different types of stress, probably grouped in regions more favourable for their survival (e.g., the Pampean area). In the Pampean region, cold and dry conditions allowed large animals to survive and be exploited by humans.

The exact role Homo sapiens played in the extinction of South American megafauna should be investigated further. One of the key issues is the dearth of human traces on bones, which is the most direct way to assess the degree of anthropic exploitation. Most conclusions have been made by cultural association in controlled excavations. The limited evidence of cut marks may be a result of the massive size of these animals or due to the carcasses subsequent usage as fuel.

It is evident that the climate of the Pleistocene-Holocene transition played an important role in the distribution and depletion of these animals. Megafauna populations would have been at minimal viable numbers when human groups entered the Pampean region. Further, the different regions of the landscape would have allowed a heterogenic rate of invasiveness of humans onto the continent, according to the diversity of resources present in each ecological patch.

For the future, regional studies are necessary in order to amass a body of comparative data from palynological, sedimentological, and archaeological studies. Further zooarchaeological analyses must be undertaken to understand the processing chain of these megamammals. When the extinction of South American mammals is analysed, it is important to consider and account for the differences between genera and species involved and their distribution over the landscape. It can no longer be postulated that the whole process did not have palaeoregions and species differentiation.

The discussion of megafauna extinction at the Pleistocene-Holocene transition is still not finished. Further research must be done in the Pampean and in surrounding regions to delve into all aspects of the consumption of the megafauna. A more detailed comprehension of landscape changes due to Homo sapiens intervention will be obtained in this way.
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