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DESCRIPTION AND INTERPRETATION OF A *MEGATHERIUM AMERICANUM* ATLAS WITH EVIDENCE OF HUMAN INTERVENTION

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Abstract. This paper discusses a *Megatherium americanum* atlas from the Pampas region of Argentina, which is currently housed at the Museo di Storia Naturale di Firenze, Italy. Traces of anthropic cut marks were found on the dorsal and ventral faces of the posterior part, in articulation with the axis. This is the first time that this type of evidence has been documented on this element of this species. The position of these marks suggests that they resulted from the act of separating the head from the postcranial skeleton. They were therefore most likely made in an effort to exploit the contents of the head. Current research focusing on museum collections employing modern methods can provide new and valuable information, despite the general lack of contextualization of these pieces. In the case studied here, these methods have allowed us to delve deeper into the first dispersal of *Homo sapiens* and their interaction with the native fauna in the South American Southern Cone.

INTRODUCTION

Early human dispersal in the Americas is a much debated topic. The routes of entry, the regions humans moved into, the kind of demographic growth they experienced, the resources they used and the impact they had on the environment have been extensively discussed in recent decades (Martin 1973; Graham & Lundelius 1984; Anderson & Gillian 2000; Barnosky et al. 2004; Brook & Bowman 2004; Koch & Barnosky 2006; Lanata et al. 2008; Cione et al. 2009; Lanata 2011; Pitblado 2011; Borrero & Martin 2012; Fariña et al. 2014; Abramson et al. 2015; Grayson & Meltzer 2015; Monjeau et al. 2015; Goldberg et al. 2016; among others).

Human impact seems of singular importance due both to the profound changes in the landscape since the mid-19th century (Grusin 2015) and the characteristic distinctiveness of Quaternary American environments. In fact, unlike other land masses, this continent remained virtually isolated except during certain periods when North America and Eurasia were connected. South America remained separated from North America until approximately 3 million years ago (Fariña et al. 2013). This particular feature gave rise to a unique pace in the evolution of life, such as the development of a native paleo-environment that did not interact with our species after the last glacial maximum, when *Homo sapiens* came onto the stage (Martin 1973; Cione et al. 2009; Lanata 2011; but see also Toledo 2005; Azcuy et al. 2011; Boëda et al. 2014; Fariña et al. 2014; for discussions of earlier human entries). Megafauna weighing more than 44 kg were the masters of this landscape and particularly species weighing over 1000 kg. These had unique and diverse biological characteristics and particularities different to northern or Holarctic fauna and they disappeared after the Pleistocene-Holocene transition (Cione et al. 2009; Fariña et al. 2013). Thus, current American

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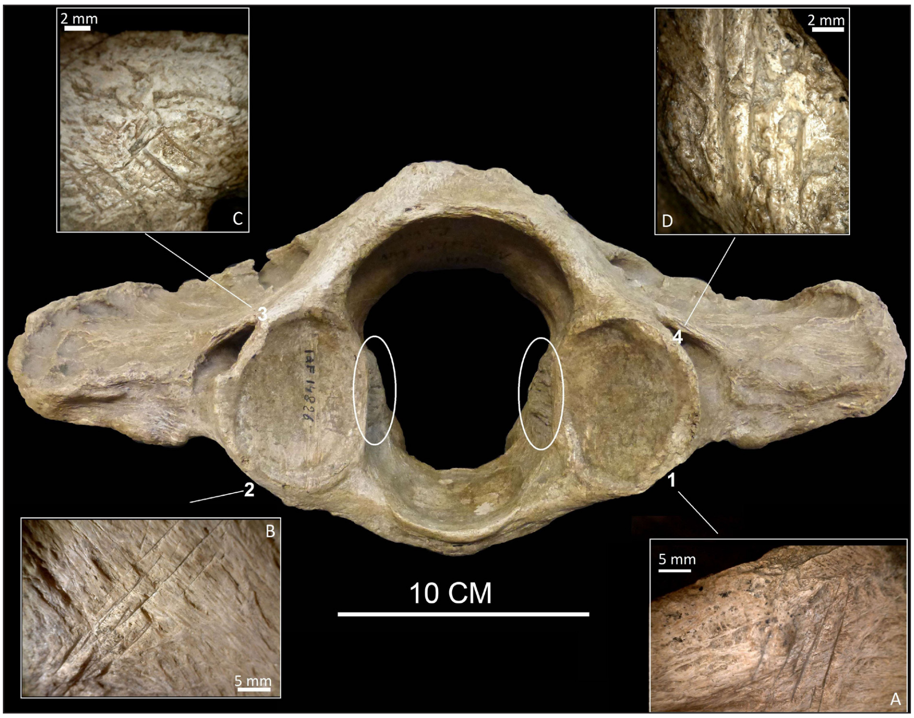


Fig. 1 - Atlas of *Megatherium americanum* (IGF 14826). The position of the numbers indicates the position of the different groups of anthropic cut marks described in the text. In the circles, the bony regrowth.

environments exhibit a stark contrast to the paleobiological development this continent underwent in the past (Cione et al. 2009).

As a result, South America is a paradigmatic case in understanding the evolution of native species and in appreciating how anatomically modern humans interacted with them. The dispersal of *Homo sapiens* coincides with the climate fluctuations characteristic of the Pleistocene-Holocene transition. Because of this, the debate has generally focused on analyzing the extent to which human intervention could have affected megafauna extinction during this period (Graham & Lundelius 1984; Barnosky et al. 2004; Koch & Barnosky 2006; Politis & Messineo 2008; Cione et al. 2009; Lanata 2011; Borrero & Martin 2012; Martínez et al. 2013; Fariña et al. 2014; Grayson & Meltzer 2015; Monjeau et al. 2015; among others). The scarcity of early archaeological sites and slight and weak association with or direct evidence of native fauna predation would suggest that human intervention on these species was minor and opportunistic (Arribas et al. 2001; Borrero & Martin 2012; Hubbe et al. 2013; Grayson & Meltzer 2015). However, from a paleontological point of view, humans seem to have been a considerable biological factor in the demise of megafauna (Cione et al. 2009).

In the Pampas region, different archaeological sites have yielded evidence of megafauna exploitation, in what are currently the countries of Uruguay and Argentina (Steele & Politis 2009; Suárez & Santos 2010; Martínez et al. 2013; Fariña et al. 2014; among others). Research in different parts of the world has started to incorporate paleontological collections and collections from old excavations housed in various museums (Prous 1986; Saunders & Daeschler 1994; Labarca 2003; Perez et al. 2005; Martin 2008; Fisher 2009; Toledo 2009; Krasinski 2010; Redmond et al. 2012; Chichkoyan et al. 2015; Dowd & Carden 2016). The biological interventions (either carnivore or human) that may have affected bone surfaces can potentially provide information to help advance our understanding of paleoecological relationships between different species (Chichkoyan et al. 2015).

To this end, this paper discusses an atlas from a *Megatherium americanum* (IGF 14826) bearing anthropic cut marks, which is currently housed in the Museo di Storia Naturale di Firenze (MSNF) (Fig. 1). This is part of a research project that is reviewing 19th century collections to find evidence of biological interventions on different elements of native fauna (Chichkoyan et al. 2015; Chichkoyan 2016). The MSNF collection has only 30 bone elements

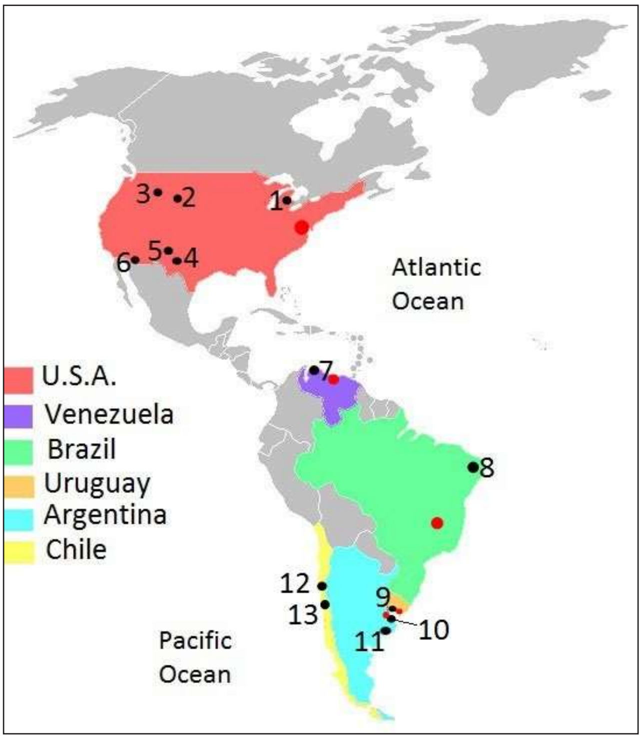


Fig. 2 - Principal American sites named in the text: 1 - Pleasant Lake and Sheathelm, 2 - Lange/ Ferguson, 3 - Colby, 4 - Lubbok Lake, 5 - Blackwater Draw, 6 - Murray Springs, 7 - Taima Taima and El Vano, 8 - Poço Redondo, 9 - Arroyo del Vizcaino, 10 - Río de la Plata, 11 - Arroyo Seco, Campo Laborde and Paso Otero, 12 - Quereo II, 13 - Tagua Tagua. Red points indicate Capital Cities of each country (Modified from Wikimedia Commons).

from this species, making it one of the smaller collections of this type in Europe. Nevertheless, this atlas is one of the most diagnostic elements with evidence of anthropic intervention found. It is the first time that these types of traces have been detected on an atlas of this species. By reviewing collections housed in museums, new information can be obtained, and these materials can regain their investigative value for inclusion in current research topics.

In the coming sections, we will delineate the regional context as well as the materials and methods used in this analysis, followed by a precise description of the traces on the atlas. In order to discuss this evidence, we will compare this case with other American sites in which the heads of megafauna have been exploited. This will offer insight into the possible purpose of the marks on the piece under study. We will also briefly discuss types of access. Finally, in the conclusions, we will mention the usefulness of undertaking this type of work with museum collections.

Regional Setting and Materials

The collection housed at the MSNF comes from the Pampas region, Río de La Plata, Buenos Aires province, Argentina (Fig. 2, number 10). The Pampas region is a vast plain composed of different subunits differentiated by geomorphology, soils, vegetation, and drainage, among other characteristics. The area that lies along the Río de la Plata is part of the northern rim of the geological region called the Salado Basin. The area was subject to various different marine regression and transgression events (Cavallotto 2002), and one such event occurring after the Last Glacial Maximum was particularly important in terms of sediment deposition. Different paleoclimatic pulses and eolian and fluvial contributions point to complex geological processes at the end of the Pleistocene (Cavallotto 2002; Toledo 2005; Cione et al. 2009; Zárate et al. 2009).

The discovery of the *Megatherium americanum* in 1787 at the Luján River and Darwin's visit to the region revealed the novelty of South American fauna to the scientific community. Consequently, during the 19th century, a complex fossil trafficking network developed between Argentina and different European countries like England, France, Spain or Italy. This was related to European colonization and expansion policies, as well as to Argentina's need to be involved in this new economic and political system (Podgorny 2001).

In this context, the MSNF's Pampas collection belongs to the museum's former collections. According to the historical catalogue currently housed in the Museo di Storia Naturale La Specola, the Megatheriidae collection was bought in 1850. In 1871 some Glyptodontidae remains (labeled "near Buenos Aires") were added. The museum was opened to the public in 1775 by Granduca Pietro Leopoldo of Tuscany before Firenze became the capital of Italy (from 1866 to 1871). Thus during the first half of 19th century this museum, as the ones in Paris and London, was pioneer in the development of natural scientific research (Cioppi & Dominici 2010). The acronym IGF before the catalogue numbers stands for Instituto Geologico di Firenze, today the MSNF.

This material was not extracted in the way that methodological excavations are completed today. Although some general information about locality and stratigraphic position was sometimes re-

Fig. 3 - Right *Megatherium americanum* clavicle (IGF 14824). Bony regrowth can be seen in the scapular end.

corded, the specific position and associated context was not always documented. This was the way that excavations were done in the 19th century, when the procurement and description of the most complete skeletons was the ultimate objective (Turvey & Cooper 2009).

The collection is mainly made up of appendicular bones (one tibia, two humeri, one femur, one ulna, one radius and five bones from the foot). From the axial skeleton, in addition to the atlas, there are 12 caudal vertebrae and three fused dorsal vertebrae with exostosis. The presence of three clavicles with bony regrowth on the scapular end indicates the presence of at least two individuals in this collection. The clavicle IGF 14824 (Fig. 3) was sent for AMS ^{14}C dating to the University of Berkeley (California) but it did not contain collagen. Besides the *Megatherium americanum*, the Pampas collection consists of four fragments of Glyptodontidae plates. Restoration activities at the time of recovery were not clearly documented. Some bones have minimal restoration or reconstruction material with gypsum, and only old glue was applied. Macroscopically, the whole collection appears similar to the atlas, which will be described in detail below.

Megatherium americanum belongs to the Xenarthra order, a diversified South American native order. It is part of the Megatheriidae family that evolved in the Middle Miocene (Brandoni et al. 2008). It is characterized by its enormity, with weights ranging from four to six tons. Like most of the extinct families of this order, it has no current-day counterpart (Fariña et al. 2013). It had a cylindrical skull and a mandible with a prominent bulge to accommodate the hypsodont and bilophodont teeth. It had a browsing diet but also ate moderate to soft tough foods and it may have been an occasional carrion feeder (Bargo 2001; Fariña et al. 2013). Its anatomical configuration would have allowed it to stand on its hind limbs (Fariña et al. 2013). From a biostratigraphic point of view, this taxon first appeared in the region in the *Megatherium americanum* biozone that starts at 0.4 MA and it was last recorded in the *Equus (Amerhippus) neogaeus* biozone that extended until 8000 yr BP (Tonni 2009).

METHODS

Different surface modifications have been documented including non-biological activity, and non-human and human biological interventions (Tab. 1). The former were useful to analyze what general processes had affected the bone and to partially reconstruct the lost context of the bony elements. Furthermore, they were useful in ruling out any type of activity that might have mimicked cut marks, and thus allowed us to distinguish between non-biological activity and biological intervention. Several studies have been conducted in this field over the past few decades, but due to spatial constraints, only some of the most significant and classical of these works are mentioned here (Tab. 1).

Non-biological activity. The non-biological activity considered included: 1) postdepositional fracture, which is produced when the bone has already lost its organic content (Shipman 1981; Gifford-González 1989); 2) presence of original sediment or concretions, as this is sometimes attached to bones (Lyman 1994); 3) fluvial erosion, which scrapes the surface and, in the long term can cause rounding to the bones (Shipman 1981; Fernández-Jalvo & Andrews 2003); 4) trampling, which occurs when sediments scrape the bones. Trampling often leaves signs that can be confused with cut marks; however, one basic difference is that trampling marks are generally random and undulating (Binford 1981; Olsen & Shipman 1988; Lyman 1994); 5) degree of weathering, caused by exposure to en-

Tab. 1 - Classification of the different surface modification and some of the most important works that explain them.

SURFACE MODIFICATIONS		BIBLIOGRAPHY
NON- BIOLOGICAL ACTIVITY	Post depositional fracture	Shipman 1981; Gifford-González 1989
	Sediment/Concretions	Lyman 1994
	Fluvial intervention	Shipman 1981; Fernández-Jalvo & Andrews 2003
	Trampling	Binford 1981; Olsen & Shipman 1988; Lyman 1994
	Weathering	Behrensmeyer 1978
	Roots	Lyman 1994
	Manganese spots	López-González et al. 2006
	Burning	Lyman 1994; Hanson & Cain 2007
NON-HUMAN BIOLOGICAL INTERVENTION	Insects	Shipman 1981; Lyman 1994; Pomi & Tonni 2011
	Rodents	Binford 1981; Lyman 1994
	Carnivores	Haynes 1980; Binford 1981; Shipman 1981; Gifford-González 1989; Lyman 1994; Martín 2008
HUMAN BIOLOGICAL INTERVENTION	Ancient/ primeval Fractures	Binford 1981; Shipman 1981; Gifford-González 1989; Lyman 1994
	Ancient/ primeval Cut Marks	Binford 1981;Shipman 1981; Olsen & Shipman 1988; Gifford-González 1989; Lyman 1994; Bello & Soligo 2008
	Recent marks or fractures	Shipman 1981; Labarca 2003
	Restoration	Shipman 1981; Labarca 2003

vironmental conditions, which can give an approximate idea of the time of burial (Behrensmeyer 1978); 6) presence of roots (Lyman 1994); 7) presence of manganese spots (López-González et al. 2006); 8) and burned bones due to exposure to fire (Lyman 1994; Hanson & Cain 2007).

Non-human biological intervention. Insect perforation, rodent and carnivore marks were considered among possible types of non-human biological intervention (Binford 1981; Shipman 1981; Lyman 1994; Pomi & Tonni 2011). It is especially important to identify carnivore marks in order to determine whether any type of non-human carnivore may have exploited the carcasses of these animals. Imprints, grooves, perforations, castings and fractures were taken into account (Haynes 1980; Binford 1981; Shipman 1981; Lyman 1994; Gifford-González 1989; Martin 2008).

Human biological intervention. In examining museum pieces, the extraction methods used in the past and the manner in which the museums handled or restored the objects have to be considered. These processes can cause marks or fractures, both at the time of excavation and in the reconstruction and restoration of the fossils in the lab (Shipman 1981; Labarca 2003). Two differences distinguish these fresh traces from the original marks on the piece: fresh cut marks are the color of the subcortical bone and they interrupt postdepositional factors, such as weathering fissures, manganese or trampling (Labarca 2003; Perez et al. 2005; Toledo 2009; Redmond et al. 2012; Dowd & Carden 2016). As these marks are made during and after excavation, they are not subject to postdepositional factors that affected the bone in the past. This explains the different color of newer cut marks and their interruption of past non-biological activity imprinted on the cortical surface.

The definition and differentiation of all these type of processes allows us to identify and determine ancient or primeval human anthropic actions on bones. The cut marks must exhibit the general classical features compiled by different researchers over the years (Binford 1981; Shipman 1981; Olsen & Shipman 1988; Gifford-González 1989; Lyman 1994; Bello & Soligo 2008; among others): they must be elongated with a transversal or longitudinal orientation, have a V-shaped cross-section, and feature parallel striations on their walls. The types of cut marks are related to the amount of force applied, the quantity of remaining meat, the presence of tendons, ligaments or skin, and the instruments used. They are also associated with the anatomical features related to the butchering of the animal (Binford 1981; Gifford-González 1989; Borrero & Martin 2012; Redmond et al. 2012). Once cut marks are identified, they can be related to different butchering stages during the processing of the animal (Binford 1981; Lyman 1994), which allowed the humans to manipulate and access the different organs and pockets of meat inside the animals (Bunn et al. 1988; Lyman 1994).

The material was reviewed with the naked eye and with magnifying glasses (3.5 X and 12 X). A Dinolite microscope 4113 model with magnifications of 20x to 200x and its software (Dinolite 2.0) was also used. This instrument is useful for detecting details and photographing microstriations and cut shapes as well as for taking small measurements. A caliper was used to take general measurements. A Panasonic Lumix DMC-TZ35 camera up to 20x Full HD was used for general photographs.

Fig. 4 - Magnification of excavation mark located on the left articulate axis facet of the atlas. The circle indicates the interruption of the manganese spot. 50 x magnifications.

Results

Non-biological activity. The atlas measures 30.5 x 13 x 11 cm. It belongs to an old individual, as evidenced by osteolith regrowth in the foramen (Fig. 1). The atlas bears minor postdepositional fractures, and is well conserved with no adhered concretions or fluvial erosion. Its level of weathering is 1 on the Behresmeyer scale with minimum weathering fissures (1978). This reflects fast burial after the animal's death. There is no evidence of modifications caused by roots or trampling, and only a few manganese spots were found.

Non-human biological intervention. No carnivore or any other kind of non-human biological intervention was detected.

Human biological intervention. The atlas exhibits excavation marks in the left articulation facet. What is relevant about these marks is that they are lighter in color than the surrounding bone and they crosscut manganese spots (Fig. 4). Thus, they must have been made when the material was excavated or during handling at the museum.

The ancient human traces are distributed in four groups, comprised of three to six cuts each. Two are situated on the ventral face and two on the dorsal face, surrounding the facets that articulate with the axis, the second cervical vertebra. They are transversally oriented to the sagittal plane. The groups were numbered from 1 to 4 (Fig. 1).

Group 1 (Fig. 1A, Fig. 5) is on the right part of the ventral face. It is comprised of five marks, two of them measuring approximately 2 cm and the other three between 0.5 and 1 cm. Some weathering fissures and manganese spots cross these cut marks. Thus the marks where made before deposition (Fig. 5A). Near the largest marks, some Hertzian cones were observed as well as internal microstriations (Fig. 5A and B). These marks are deeper than those in group 2, on the left side of the same face (Fig. 1B, Fig. 6). Here, at least three main, more superficial cut marks were counted. One of these measures 3 cm and the others 2 cm in length. Smaller cut marks were detected parallel to these or partially crossing the main marks (Fig. 6A). They are especially abundant near the articular facet and are separated by 0.2 to 0.3 cm. Manganese spots crossing the marks were also documented (Fig. 6B). The traces in these two groups run parallel to one another.

Groups 3 and 4 are situated on the dorsal face, on the left and right side, respectively. In these cases, the marks extend between the border of the articular surface and the posterior alar foramen, which allows the passage of the second spinal nerve (Owen 1861). Group 3 (Fig. 1C, Fig. 7) is made up of 6 main marks measuring approximately 1 cm, oriented parallel to one another and separated by 0.2 cm. They are situated in the medial section of

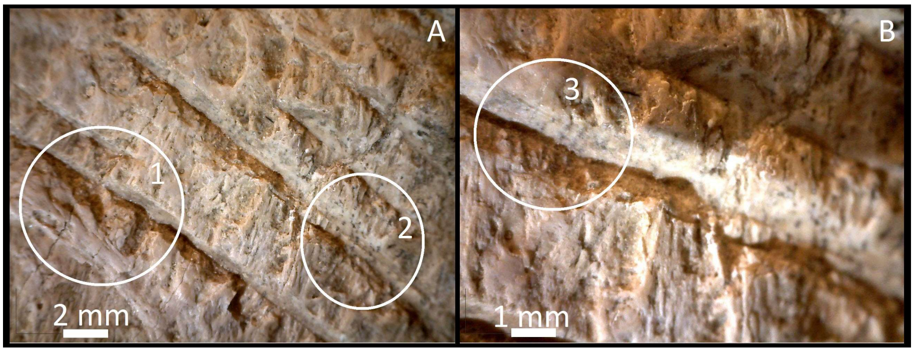
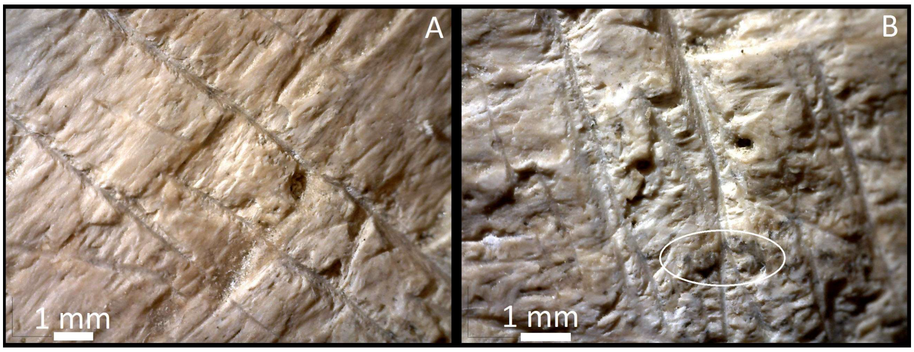


Fig. 5 - Magnification of cut-mark group 1. A - Circle 1 indicates weathering fissures crossing several cut marks and a possible Hertzian cone, circle 2 indicates manganese spots crossing several cut marks. 20 x magnifications. B - Circle 3 indicates internal microstriations. 40 x magnifications.

Fig. 6 - Magnification of cut-mark group 2. A - Detail of long and short marks. 35x magnifications. B - Detail of another section of the marks. In the circle, manganese spots crossing several cut marks. 45 x magnifications.



the posterior alar foramen. At a distance of 2 cm from this group, on the dorsal face, two additional cut marks were documented, measuring approximately 1 cm. These cuts lie next to the posterior alar foramen, which allows the occipital artery to pass (Owen 1861). Group 4 consists of six marks (Fig. 1D, Fig. 8), deeper than those in group 3. They also measure approximately 1 cm with a separation of 0.2 cm between them. They appear slightly more perpendicular in relation to the sagittal plane than the rest of the groups. There are manganese spots both on the bone surface and the cut marks. In this case, two additional marks cross between the two foramens and are parallel to the sagittal plane of the bone.

Discussion

General examinations of the marks. We documented a general regularity in the location of the marks, which surround the facets of articulation with the second vertebra both on the dorsal and ventral faces. Only on the dorsal surface were some additional traces detected farther from the facets, but in these cases, they were near the posterior alar foramen which leaves a passage for the occipital artery. They exhibit the same type of fossilization as the rest of the bone, with manganese and weathering fissures that, in some cases, cross these marks. This implies that they were already present befo-

Fig. 7 - Group number 3 of cut marks, dorsal view.

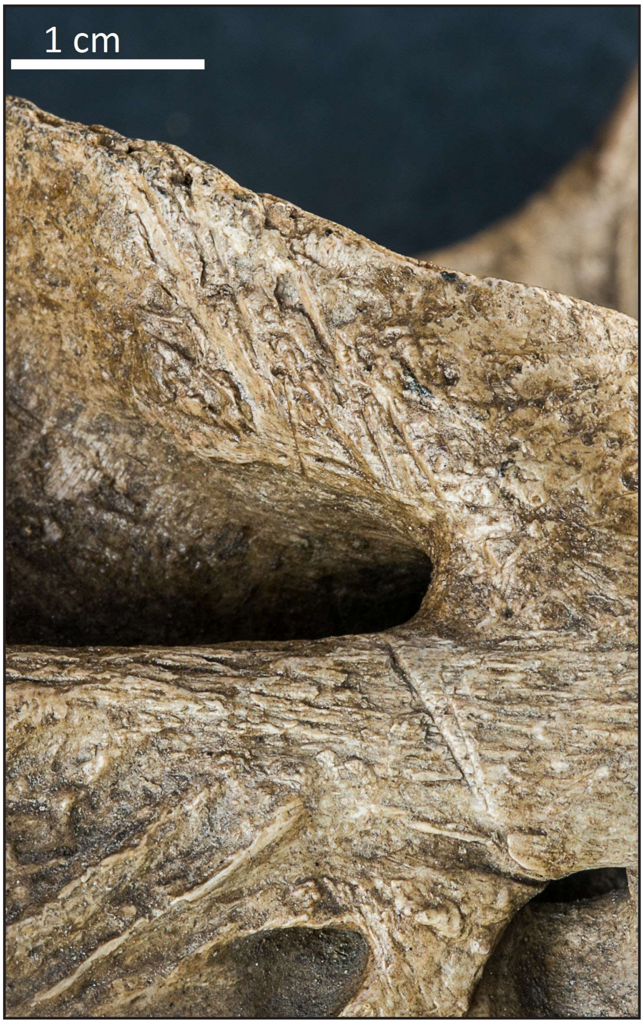


Fig. 8 - Group number 4 of cut marks, dorsal view.

REGION	SITE NAME	LOCATION/ COUNTRY	SPECIE	DESCRIPTION	REFERENCES
NORTH AMERICAN SITES	Blackwater Draw	Clovis, Roosvelt, New Mexico/ USA	*Mammuthus columbi*	Scavenging of the head in 2 mammoths	Saunders & Daeschler 1994
	Colby	Wyoming/ USA	*Mammuthus columbi*	Probable intentional anthropical transportation of skulls	Jones 1991
	Lange/Ferguson	South Dakota/ USA	*Mammuthus columbi*	Separation of the head between 4th and 5th cervical vertebra	Hannus 1989; Jaimes Quero 2005
	Lubbok Lake	Yellowhouse Draw, tributary of Brazos River/ USA	*Mammuthus columbi*	Cut marks and fracture on an immature mandible for probable exploitation of marrow and tongue	Johnson 1976
	Murray Springs	San Pedro River, Arizona/ USA	*Mammuthus columbi*	Possible consumption of brain and tongue in Area 3 (one cranium collapsed and disarticulation of the mandible. Absence of hyoid arch)	Hemmings 2007
	Pleasant Lake	Washtenaw County, Michigan/USA	*Mammut americanum*	Separation of the head by presence of cut marks between atlas and axis	Fischer 1984
	Quagaman	Michigan/USA	*Mammut* sp.	Only head	Fischer 2009
	Sheathelm	Michigan/USA	*Mammut* sp.	Only head	Fischer 2009
	St. Johns	Michigan/USA	*Mammut* sp.	Palate with upper cheek tooth dentition and basicranium	Fischer 2009
SOUTH AMERICAN SITES	Quereo II	Los Vilos/ Chile	*Cuvieronius hyodon*	Cut marks in the occipital condyle of the atlas	Labarca 2003
	Tagua Tagua 1	San Vicente de Tagua Tagua/ Chile	*Cuvieronius hyodon*	Presence of basal cranium for probable brain consumption	Jackson et al. 2011
	Tagua Tagua 2	San Vicente de Tagua Tagua, Chile	*Cuvieronius hyodon*	Ten broken skulls for probable brain consumption	Nuñez et al. 1994
	Taima Taima	Paraguana Peninsula,State of Falcon/ Venezuela	*Stegomastodon waringi*	Transportation of the head with cervical vertebrae for brain consumption/ Processing of the mandible near the site to extract the tongue	Casamiquela 1979
	El Vano	Barbacoas Mountain Range,State of Lara/ Venezuela	*Eremotherium rusconi*	One right mandible with cut marks in the buco lingual region	Jaimes Quero 2005
	Arroyo del Vizcaíno	Canelones/ Uruguay	*Lestodon armatus*	Stylohyal bone with cut marks for consumption of the tongue	Tambusso et al. 2015
	-	Poço Redondo, State of Sergipe/ Brazil	*Eremotherium laurillardi*	Polished tooth with anthropogenic marks and triangular shape	Dantas Trindade et al. 2014
PAMPEAN REGION SITES	Arroyo Seco 2	Tres Arroyos, Buenos Aires/ Argentina	*Megatherium americanum*	Tibia with helical fracture	Steele & Politis 2009
	Campo Laborde	Olavarria, Buenos Aires/ Argentina	*Megatherium americanum*	One rib with cut marks, one rib helically fractured, one rib transformed into informal tool	Politis & Messineo 2008
	Paso Otero 5	Necochea, Buenos Aires/ Argentina	*Megatherium americanum*	Burned bone used as fuel	Martínez et al. 2013

Tab. 2 - Sites named in the text.

re laboratory handling. They are thin and elongated and present internal microstriations or possible Hertzian cones. These marks also form groups with similar numbers of marks and similar separation distances between them. The systematic localization and orientation of the four groups of marks does not correspond to random trampling marks.

Group 1 on the ventral face and group 4 on the dorsal face of the right side are slightly deeper than those situated on the left side. This implies that a more forceful cutting motion was used on the right side. Although this might be discussed in terms of the presence of attached muscles and ligaments, the fact that the same anatomical features are present on the left side rules out this explanation. The evidence here does not allow inferences to be drawn about this difference. However, it might be suggested that the position of the animal at the time of the butchering or the sharpness of the instrument involved in the task could have influenced the different pressure applied when cutting the right and the left side of the vertebra. Although little can be said about the tools involved in this task, some of the instruments associated with megafauna recorded at other sites in the region include flakes, tools such as knives or scrapers and fishtail projectile points. Among the most commonly used raw materials were orthoquartzite, quartz and silicified sandstone (Suárez & Santos 2010; Fariña et al. 2014; Messineo 2015). Therefore, these types of materials might well have been used to process this vertebra.

The marks on the ventral face are longer than those on the dorsal face. This may be related to the presence of the posterior alar foramen on the latter. Additionally, these marks may be related to the act of cutting the arteries and the nerves that pass through these foramens. The presence of additional cut marks near the posterior alar foramen on the dorsal face supports this hypothesis. The cut marks on the ventral side may be longer because no foramens are present on this part of the bone.

Consequently, the four groups of cut marks surrounding the articular facets and the additional dorsal cut marks can be related to one of the dismembering stages that separate the different parts of the animal (Binford 1981; Lyman 1994). They would have been made to separate the first cervical vertebra from the second, with the intention of splitting the head from the postcranial skeleton (Binford 1981). This separation would have been oriented to process the various contents of the head. The most exploited organ here is the brain (Stiner 1991). However, the head also contains other exploitable tissues, such as the tongue and the marrow, or even the teeth, as observed at other American sites with evidence of megamammal exploitation (Tab. 2), which we will briefly discuss below.

American sites for comparison. In order to appreciate the different resources that can be obtained from the exploitation of the head, some of the most significant American sites with this type of evidence were selected for comparison (Tab. 2 and Fig. 2). Sites where the authors suggest any kind of human activity in the head, either based on direct cut marks or contextual interpretation, were taken into account. At North American and South American sites, the most abundant extinct megafauna remains of a size similar to *Megatherium americanum* are the Proboscidea (*Mammuthus*, *Mammut* and Gomphotheriidae), but evidence of *Eremotherium* and *Lestodon armatus* in South America was also examined. The former belonged to the same family as *Megatherium americanum* (Megatheriidae) and the latter, *Lestodon armatus,* belongs to Mylodontidae. We also considered three important sites in Argentina that present evidence of *Megatherium americanum* exploitation, although none directly related to the consumption of the head.

Different types of references to head exploitation can be seen in Tab. 2, either because of the general pattern of the site, or through direct evidence such as cut marks or fractures. The first case can be observed in Blackwater, Colby and Taima Taima where interpretations were oriented to either the scavenging of the skull in situ (Blackwater), or to the transportation of the element to another location (Colby and Taima Taima) (Casamiquela 1979; Jones 1991; Saunders & Daeschler 1994). In this regard, Fisher (2009) suggests that findings of isolated heads or basicrania, like at Sheathelm, Quagaman and St. Johns, may have resulted from human activity.

Other sites provide insight into how butchering may have been done. This is the case of Lange-Ferguson (separation of the head from the cervical vertebra four and five) (Hannus 1989; Jaimes Quero 2005), Pleasant Lake (cut marks on the first and second vertebrae) (Fisher 1984), and Quereo II, where Labarca (2003) studied old collections from Quereo and found cut marks on the anterior part of an atlas. It should also be mentioned that in Taima Taima the last cervical vertebra must have been separated from the thoracic vertebra, as no cervical vertebra was found (Casamiquela 1979).

In addition, cut marks can be associated with the consumption of the tongue and the marrow, as suggested at Lubbock Lake (Johnson 1976), the cut marks found on mandibles at El Vano (Jaimes Quero 2005) and Taima Taima (Casamiquela 1979), and the hyoid cut mark at Arroyo del Vizcaíno. In this last site, the cut would have been made in order to extract the 10 kg tongue of a *Lestodon armatus* (Tambusso et al. 2015). At Taima Taima, only the mandible was found near the site, which might be due to the process of extracting the tongue (Casamiquela 1979). In other cases, the skulls were crushed to extract the brain, like at Tagua Tagua 1 and 2 (Nuñez et al. 1994; Jackson et al. 2011). Meanwhile, at Murray Springs, one cranium was found crushed for brain consumption and the mandible was disarticulated to better access the tongue (Hemmings 2007). Finally, in Poço Redondo, Brazil, another type of evidence was found: A polished, triangular shaped tooth of *Eremotherium laurillardi* suggests that not only were the tissues of the head exploited, but the teeth may also have been sought out as a raw material (Dantas Trindade et al. 2014).

In Argentina, exploitation of *Megatherium americanum* has been documented at three sites. At Arroyo Seco 2, exploitation of this taxon included one helically fractured tibia (Steele & Politis 2009), while at Campo Laborde, three ribs exhibit evidence of human intervention in the form of cut marks or bone technology (Politis & Messineo 2008). In Paso Otero bones of this species and others were used as fuel (Steele & Politis 2009; Martínez et al. 2013).

Purpose of the marks and access scenarios. These different American sites show that the contents of the head were deemed useful throughout the continent. Considering all of the above examples, the most plausible explanation for the described cut marks is that they were made to remove the head and possibly exploit the contents of the head of an old *Megatherium americanum* individual. The brain and tongue may have been the most sought after organs. The brain of a *Megatherium americanum* was half the size of a modern-day elephant's (Owen 1861), which weighs approximately 4 kg

(Agam & Barkai 2016). On the other hand, like the *Lestodon armatus*, these animals also had voluminous tongues that could have been consumed. It is also possible that marrow and even teeth may have been resources extracted from the head. In the Pampas region, this species was not only a source of edible tissues, but the bones were also used for tool production or even fuel (Politis & Messineo 2008; Martínez et al. 2013). Hence, the high processing cost can be compensated by the complete use of the animal's skeleton.

The head contents of this animal could have been exploited in a primary or secondary access scenario.

Primary access can imply either hunting or early access to an animal that died of natural causes. Binford (1981) refers to the separation of the head as one of the first processing actions taken when dismembering an animal. This can be done between the occipital condyles and the first vertebra, between the first and the second vertebra, or from the consecutive cervical vertebrae (Binford 1981; Bunn et al. 1988; O'Connell et al. 1990; Lupo 1994). The separation of the head, at least at the sites reviewed here, can be done in other ways as well, as at times the first cervical vertebrae was involved and at other times the last vertebrae were cut to separate the head and the neck. In the case presented here, the position of the four groups of cut marks implies that in this *Megatherium americanum* individual, the separation of the exploited head also included the first vertebra. This skeletal component is sometimes transported or may be eaten at the kill spot, depending on the animal, the number of people in the carrying party, and the distance from the base camp, among other factors (Binford 1981; Bunn et al. 1988; O'Connell 1990). In the vertebra studied here, the lack of context does not allow us to determine whether transportation occurred. Among the above-cited American sites, transportation was only detected at Colby and Taima Taima (Casamiquela 1979; Jones 1991).

The head contents may have been exploited in a secondary access scenario. In this case, the exploitation of the head would have been related to scavenging (Blumenschine 1986; Stiner 1991). It was recently noted, however, that the use of the head is not always related to a marginal scavenging tendency. Although hard and heavy, the rich protein content of the head justifies its intentional transport and high processing costs (Agam & Barkai 2016), especially when the head contains all the tissues intact, as the fleshy parts of the head can be eaten faster than the brain because the skull is difficult to break for carnivores (Blumenschine 1986; Haynes 1988). However, as proposed earlier, if the cut marks described above were made for the purpose of exploiting the various contents of the head, this would imply that no part of the head had previously been consumed by carnivores. As suggested by the presence of elephant heads in Paleolithic sites (Agam & Barkai 2016), this could have been an intentional behavior, even in a scavenging scenario. Consequently, the human scavenging of megafauna carrion would have been added to an already existing scavenging niche in the Pampas region. Direct evidence of megafauna exploitation by carnivores in the region is scarce. Although one cf. *Eosclerocalyptus lineatus* (Hoplophorini) neurapophysis from the Pliocene was scavenged by *Chapalmalania* (Procyonidae) (de los Reyes et al. 2013). Therefore, as observed in European and African environments, the wide array of megafauna in the region would have been exploited by different types of carnivores, including humans (Blumenschine 1986; Stiner 1991; Arribas & Palmqvist 1999; Fariña et al. 2013, among others).

CONCLUSION

The atlas from a *Megatherium americanum* individual housed at the MSNF presented anthropic cut marks. They comprise four groups of traces on the ventral and dorsal faces, surrounding the facets that articulate the axis. The aim of the action that created these marks would have been to separate the head from the postcranial skeleton in an old *Megatherium americanum* individual. This action may have occurred in a primary or secondary access scenario, possibly to exploit the various different resources contained in the head. This is the first time that this type of human intervention has been documented on this element of this species.

This research, like similar studies carried out on museum collections all over the world (Prous 1986; Saunders & Daeschler 1994; Labarca 2003; Perez et al. 2005; Martin 2008; Fisher 2009; Toledo 2009; Krasinski 2010; Redmond et al. 2012; Chichkoyan et al. 2015; Dowd & Carden 2016), constitutes a complementary, but very useful way to search for new information. The discovery of biological marks (left by both humans and carnivores) on material collected during the 19th century means that these collections potentially harbor important information to be investigated. Though there is neither contextualization nor association with other materials, the application of new techniques developed in these last decades combined with an interdisciplinary perspective allows researchers to maximize the information obtained. It also allows us to integrate and compare this new data from an interdisciplinary point of view and at a coarse-grained level with information from other sites in order to better interpret the evidence. Consequently, the study of these old collections provides new information regarding the behavior of early human populations and their paleoecological relationships with fauna (Chichkoyan et al. 2015).

This makes old museum collections a complementary resource to information obtained from archaeological records coming from stratigraphically controlled excavations. Archaeological data is a non-renewable resource (Pérez de Micou 1998), so looking for new sources of information like that considered here is a productive way to obtain new information. It reduces research costs and the anthropogenic modification of the landscape (Pérez de Micou 1998). But to work with these kinds of samples, the researcher must also bear in mind that this material is part of a biased record, in which only certain bones and species, or only the most visible pieces, would have been chosen (Turvey & Cooper 2009). When these types of caveats are taken into account, bone remains recovered in museum collections constitute a significant contribution. Research at other museums will allow more information like this to be recovered. The dating of that material will help to establish a referential chronology of when these interactions occurred. This information can be combined with current research programs to develop new axes of study.

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