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Thermal alteration of small mammal from El Guanaco 2 site (Argentina): an experimental approach on armadillos bone remains (Cingulata, Dasypodidae)

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ABSTRACT

The thermo-altered Dasypodidae bone remains from El Guanaco 2 site (ca. 9000–6000 YBP, Pampean Region, Argentina) were analyzed through an experimental study. The experimentation involved the cooking of three individuals of *Chaetophractus villosus* and the burring of three carapaces under the hearth, in order to recognize the degrees of burning damage on osteoderms according to the time of heat exposure and the burring depth in sediments. The results showed similarities between archaeological and actualistic assemblages, including the non-uniform burning damage and scarce endoskeleton thermal modification, but the armors buried didn't show evidence of burning damage. Based on these comparative results, it is suggested that the Dasypodidae assemblages of El Guanaco 2 site derive from hunter gatherers butchering, cooking and consumption of armadillos.

1. Introduction

Small prey handling has been archaeologically and ethnographically recorded for hunter-gatherers inhabiting different environments (Blasco, 2008; Dewar et al., 2006; Escosteguy and Salemme, 2012; González, 2005; Jones, 2006; Kelly, 1995; Laroulandie, 2001, 2005; Loponte, 2007; Lupo and Schmitt, 2005; Medina et al., 2012; Quintana et al., 2002; Quintana and Mazzanti, 2010; Santiago, 2004; Stiner, 1993; Stiner et al., 2000; Stoessel, 2012; among others). Dasypodidae is one of the small-sized families frequently recovered in archaeological sites from the Argentinean Pampean Region and requires detailed analysis of both the natural or cultural agents involved in their deposition and on the evidence of human handling (Frontini and Deschamps, 2007; Frontini and Escoteguy, 2012; Mello Araujo and Marcelino, 2003). Ethnographic and historic records describe the consumption of several species of armadillos. These animals were captured along with other species both in collective (Armaignac, [1874–1877] 1974: 125; Claraz, [1865–1866] 1988: 68, 71; Cox [1862–1863] 2006: 186; Mendoza, [1865–1866] 1965: 64; among others) and individual (Azara, [1781–1801] 1923, T. II: 21; Barne, [1753] 1910: 540; Claraz, [1865–1866] 1988: 51, 55, 117; Falkner, [1745] 1957: 150; Hux, [1875] 1979: 129; Lista, [1894] 2006: 121; Parchappe, [1828] 1945: 597 and 620; among others) hunting parties. Such observations were also confirmed by ethnographers from the 20th century in Patagonia (Aguerre, 2000: 127; Perea, 1989: 60). In several archaeological contexts the thermal alteration shown by armadillo bone remains could suggest human cooking of Dasypodidae (Bayón et al., 2010; Frontini, 2010; Quintana and Mazzanti, 2001; Salemme, 1987).

In an archaeological context different attributes are considered in order to determine the anthropic origin of the small animals' remains: cut marks, fractures, thermal modification, anatomical representation, minimum number of individuals, among others. While cut marks, fractures and MNI have been studied thoroughly, burning damage is not typically considered as anthropic evidence and has not been extensively analyzed from an experimental perspective (Laroulandie, 2001; Lloveras et al., 2009; Medina et al., 2012; Stiner, 2005). Burning damage can be the result of intentional activities such as cooking, the discarding of food wastes in the fire and the use of bones as fuel or for cremation. On the other hand, they can be the result of accidental or unintended actions such as proximity to a hearth. Also, modifications can result from natural causes such as naturally occurring fires (Bennett, 1999; Buikstra and Swegle, 1989; Clark and Ligouis, 2010; Costamagno et al., 2005; David, 1990; James, 1989; Lyman, 1994; Stiner et al., 1995). Considering that the faunal remains can be thermally altered

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through different processes, it is essential to determine the origin of the burning damage in order to reach an accurate interpretation of the assemblages. Since small prey handling requires specific procedures depending on the size, number of individuals, way of cooking, sources obtained (meat, leather, bones, feathers), it is necessary to create frameworks appropriate for the specificity of each practice (Kent, 1993; O′ Connell and Marshall, 1989; Quintana and Mazzanti, 2001; Yellen, 1977).

The aim of this article is to contribute to the recognition of material correlate of small-sized prey handling through the experimental analysis of thermal alteration on *Chaetophractus villosus* (Cingulata, Dasypodidae), a South American type of armadillo. The burning damage pattern obtained was used to identify reliable cooking evidences in the Dasypodidae remains recovered from El Guanaco 2 site (Pampean Region, Argentina).

2. Materials and methods

2.1. Experimental sample

Experimental analyses were carried out on six carcasses of *C. villosus* (Mammalia, Dasypodidae). An average adult individual weights approximately 2.5 kg and is 0.50 m long (Fig. 1B) (Abba et al., 2010; Redford, 1985). The species is characterized by a dorsal shield consisted of thick fix and movable osteoderms, arranged in transverse lines, and additional shields covering the top of the head. It also has a long tail covered with bony dermal scutes (Fig. 1A) (Cabrera and Yepes, 1940; Olrog and Lucero, 1981). The osteoderms have a specific ornamentation on the exposed surface, which allows its taxonomic identification (Fig. 1C) (Soibelzon et al., 2013; Vizcaíno et al., 1995).

The experimental study involved two procedures: the cooking of hairy armadillo carcasses and the burial of hairy armadillo carapaces in a hearth. Three individuals (two females and one male) were completely cooked in an experimental hearth specially built for this purpose in the Área de Metalurgia at Universidad Nacional del Sur. The experimental procedures included the complete cooking of the prey lying over its carapace, with hot-rocks inside two of the carcasses. The techniques used replicated historical observations of cooking processes of Dasypodidae, which describes that once the entrails were removed, the animal was cooked using its armor as a natural container, directly on the fire. Then the cavities were filled with hot-rocks (Beerbohm, [1877] 2004: 54; Hux, [1875] 1979: 36; Prichard, [1900–1901] 2003: 55). This culinary practice was described as follows: “They are (…) usually cooked in the shell on the fire, the entrails, &c., being taken out, and the cavity filled with heated stones. When they are in their best condition, one leg is sufficient for a man, as there is about an inch of yellow fat on them” (Musters, [1869–1870] 1871: 190).

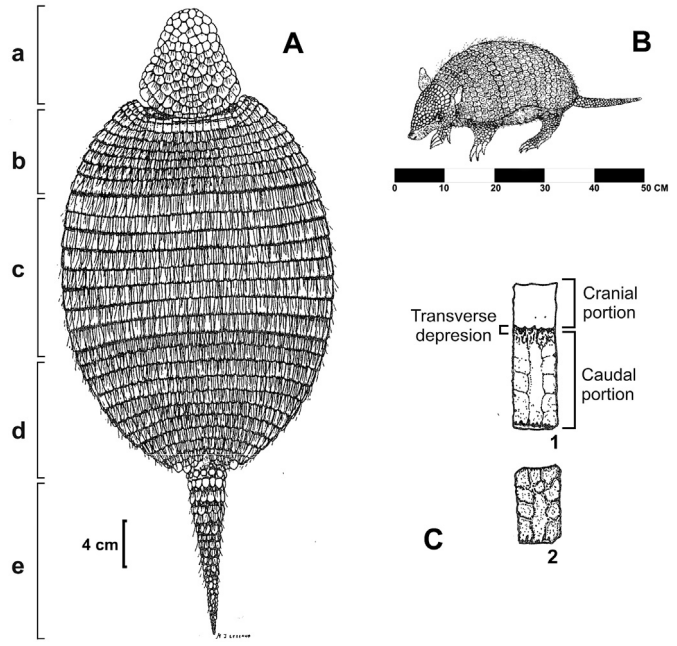

Fig. 1. A: Dorsal view of *Chaetophractus villosus* armor; a: head shield; b: scapular shield; c: mobile band; d: pelvic shield (taken from Vizcaino and Bargo, 1993:439); B: Specimen of *Chaetophractus villosus* (taken from Olrog and Lucero, 1981); C: 1 mobile osteoderm and its sections; b, fix osteoderm (taken from Vizcaino and Bargo, 1993 and from Soibelzon et al., 2013).

The stone used in the experiment were metaquartzite pebbles from secondary deposits of the Sauce Grande River and *tosca* stone (caliche), which outcrops extensively during the Holocene in the South of Buenos Aires province.

Individuals 1 and 3 were cooked under direct fire and individual 2 was barbecued with charcoal. The fuel used consisted of *Condalia microphylla* (piquillín) wood, an autochthonous species corresponding to the *Espinal* province of the South of Buenos Aires province (Cabrera, 1968). The type of wood is relevant since it is related to the maximum temperature reached and, consequently, to its effects on the remains (Nicholson, 1993; Pupio and Cattáneo personal communication, 2013).

The carapace was divided schematically in five sectors, following Vizcaino and Bargo (1993) and Soibelzon et al. (2013) in order to record the modifications (Fig. 1A). During the cooking events, the following aspects were recorded:

a. Temperature at 1-min intervals, with three thermocouples located (1) at fire level, (2) over the armor shell; (3) over the meat.
b. The degree of thermal alteration of the scutes at 5-min intervals. This was carried out macroscopically during the cooking, without extracting the prey from the hearth.
c. The total cooking time.
d. The degree of thermal alteration in the bones. The meat was removed from the bones once the carcasses were cooked.

The burning damage of each individual osteoderm was described in the laboratory after the cooking. Four-color categories correlated with burning damage were considered (De Nigris, 2004; Lyman, 1994; Mengoni Goñalons, 1999; Nicholson, 1993). A cream tone was considered as unburned; brown was considered as burned; black was considered as carbonized, and blue-gray and white as calcined. Eight analytical categories of burning damage were applied considering the osteoderm surface affected (dorsal or internal), the percentage of surface affected and the intensity of the burning damage: 1- Only carbonized externally; 2- Carbonized externally and burned internally; 3- Partially carbonized on both surfaces; 4- Completely carbonized on both surfaces; 5- Calcined on the external surface, carbonized internally; 6-Carbonized externally and calcined internally; 7- Partially calcined on both surfaces; 8- Completely calcined on both surfaces. The description of the movable osteoderms affected area was performed following the Soibelzon et al. (2013: 3) scheme. It was possible to observe the presence or absence of burning evidence across the cranial portion of the movable osteoderms.

A second experience consisted in the study of three *C. villosus* buried carapaces below the experimental hearths, because the thermal alteration of buried remains has been suggested as a plausible explanation for certain assemblages (Bennett, 1999). The carapaces used were donated by a researcher who had already

separated them from the animals' bodies. The carapaces were buried 5, 10 and 15 cm in order to analyze burning damage when bones were buried in the sandy sedimentary matrix. The carapaces remained buried throughout the entire experimental cooking of the armadillos.

For the buried armors, the following parameters were recorded:

a. The temperature reached by carapaces with a thermocouple positioned over the armors.
b. The degree of thermal alteration of the armors once the experimental cooking was finished.

All observations made after concluding the experimentation were carried out macroscopically.

2.2. Archaeological sample

El Guanaco 2 site (38° 41′S and 59° 39′W) is located in the south of Buenos Aires province at 11 km from the Atlantic coast, north of a small lake (Fig. 2). It is in a sandy eolian deposit corresponding to a dune environment formed by deflation of the neighboring lake (Flegenheimer et al., 2010; Zárate et al., 2009).

In this location, it was possible to recover stone tools, human and faunal remains, and record early and middle Holocene (from 9140 ± 120 YBP to 6415 ± 69 YBP) occupations (Flegenheimer et al., 2010; Zárate et al., 2009). Due to the characteristics of the deposit, the different levels of occupation cannot be isolated, so the whole deposit is considered as a sole unit. The occupations are interpreted as representing a residential camp where *Lama guanicoe* (guanaco), *Ozotoceros bezoarticus* (pampean deer), *Rhea americana* (ñandú), *C. villosus* (peludo) and other Dasypodidae where butchered and consumed (Frontini, 2012; Frontini and Picasso, 2010; Vecchi et al., 2007). Six percent of the remains are thermo-altered, affecting guanaco, vizcacha, armadillo and Rheidae eggshell elements (Frontini, 2012; Frontini and Picasso, 2010). A detailed study of the stratigraphical sequence, chronology, lithic artifacts, faunal assemblage and landscapes from El Guanaco 2 site can be found in Flegenheimer et al. (2010); Frontini, 2010, 2012, Frontini and Picasso, 2010; Mazzia, in press; Vecchi, 2010 and Zárate et al., 2009.

This paper considers the 529 armadillo bone remains obtained during excavations carried out in a 12 m^2 area (Frontini, 2012). They are concentrated between 15 and 30 cm deep and stand in association with all the above mentioned species. Ninety seven percent of the assemblage (NISP = 513) corresponds to dermal scutes, and the rest are bones, mainly from the appendicular skeleton. Thirty-two bone remains correspond to *C. villosus*, the rest (NISP = 497) could not be determined to a deeper taxonomic level due to the poor degree of conservation and fragmentation state. Cut marks on a *C. villosus* metapodial were registered (Frontini, 2012).

3. Results

3.1. The experimental cooking

The time necessary for the complete cooking of individual 1 and 2 was 40 min, while that of individual 3 was 35 min. Throughout the experiment, different temperatures were registered according to the way of cooking (direct fire or on hot charcoal) (Table 1). The highest meat temperatures were registered on individuals 1 and 3, which were cooked by direct fire. Moreover, there were variations in the temperature due to the location of thermocouples. For example, in the individual 3, the flame movements affected the thermocouple. Regarding the individual cooked by hot charcoal, the temperatures registered were the lowest.

Each carapace region was affected at different moments during the process, depending on the cooking method applied. In the two carcasses exposed to direct fire (1 and 3), the scapular shield and the pelvic shield were the first parts affected, after 5 min of exposure, and the carapace was completely thermo-altered after 10 min. On the contrary, in the sample burned with hot charcoal, the movable osteoderms zone was the first to be affected, and the time registered for the complete alteration was 20 min.

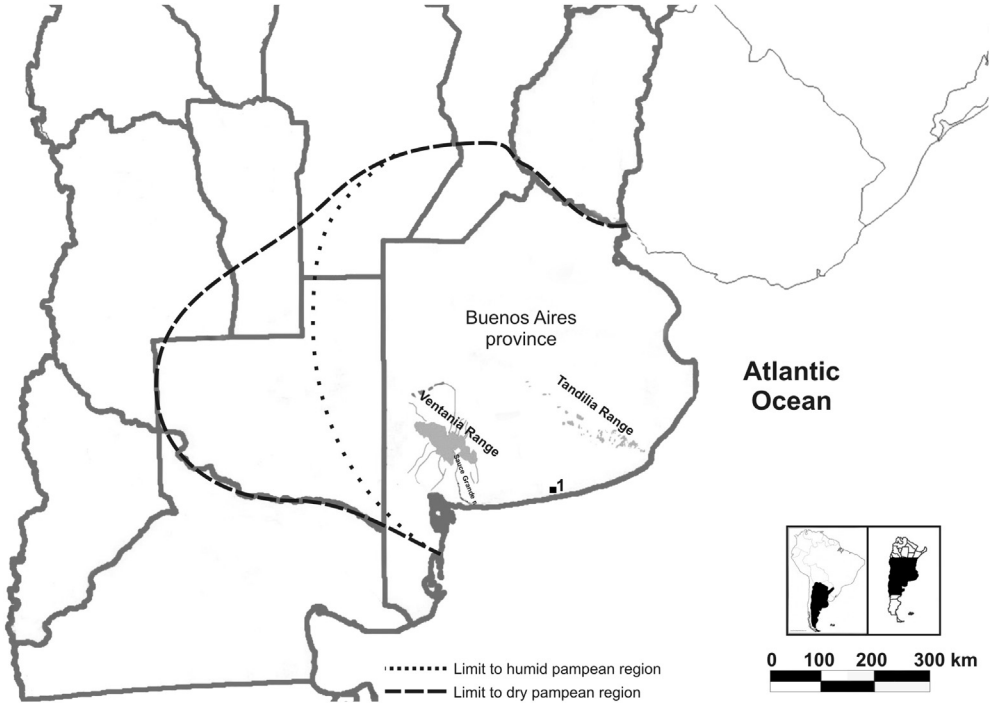

Fig. 2. Map showing Pampean Region and El Guanaco 2 site location (1).

Table 1
Thermal alterations and temperatures recorded during experimental cooking of *Chaetophractus villosus*. References: b: burned; car: carbonized; ch: calcined; n/a: no alteration. 1: right sector; 2 central sector; 3 left sector of the armor shell. A: head shield; B: scapular shield; C: mobile bands; D: pelvic shield.

Individual/time	Individual 1 (direct fire)					Individual 2 (hot charcoal)					Individual 3 (direct fire)				
	T° meat	Scutes condition				T° armor	Scutes condition				T° meat	Scutes condition			
5′	17.7		1	2	3	18.2		1	2	3	95.00		1	2	3
		A	n/a				A	n/a				A	car		
		B	car	car	car		B	n/a	n/a	n/a		B	car	car	car
		C	n/a	n/a	n/a		C	car	car	car		C	n/a	car	car
		D	b	car	b		D	n/a	n/a	n/a		D	car	car	car
10′	14.7		1	2	3	18.4		1	2	3	99.83		1	2	3
		A	car				A	n/a				A	car		
		B	car	car	car		B	n/a	car	n/a		B	car	car	car
		C	b	b	b		C	car	car	car		C	car	car	car
		D	car	car	car		D	n/a	car	n/a		D	car	car	car
15′	32.6		1	2	3	7.2		1	2	3	203.91		1	2	3
		A	car				A	car				A	car		
		B	car	car	car		B	n/a	car	n/a		B	car	car	car
		C	b	car	b		C	car	car	car		C	car	cl	car
		D	car	car	car		D	n/a	car	n/a		D	car	cl	car
20′	94.3		1	2	3	76.52		1	2	3	152.90		1	2	3
		A	car				A	car				A	car		
		B	car	car	car		B	car	car	car		B	car	car	car
		C	b	car	b		C	car	car	car		C	car	cl	car
		D	car	car	car		D	car	car	car		D	car	cl	car
25′	201.5		1	2	3	35.8		1	2	3	325.56		1	2	3
		A	car				A	car				A	car		
		B	car	car	car		B	car	car	car		B	car	cl	car
		C	b	car	b		C	car	car	car		C	car		car
		D	car	car	car		D	car	car	car		D	cl		car
30′	189.1		1	2	3	39.8		1	2	3	438.7		1	2	3
		A	car				A	car				A	car		
		B	car	car	car		B	car	car	car		B	car		car
		C	b	car	b		C	car	car	car		C	cl		cl
		D	car	car	car		D	car	car	car		D	cl		cl
35′	134.1		1	2	3	50.5		1	2	3	509.60		1	2	3
		A	car				A	car				A	car		
		B	car	car	car		B	car	car	car		B	car		car
		C	b	car	b		C	car	car	car		C	cl		cl
		D	car	car	car		D	car	car	car		D	cl		cl
40′	101.9		1	2	3	57.2		1	2	3	–	–			
		A	car				A	car							
		B	car	car	car		B	car	car	car					
		C	b	car	b		C	car	car	car					
		D	cl	cl	cl		D	car	car	car					

The detachment of the bony dermal scutes during cooking occurred exclusively in the samples exposed to direct fire. In individual 1, the scapular and pelvic shields osteoderms were detached after 35 min of exposure, while in individual 3 the movable osteoderms and bony dermal scutes from the pelvic shield started detaching at 15 min and fell into the fire after 25 min. One hundred and ten scutes were recovered from the ashes in a calcined condition. In turn, the carcass burned with charcoal (individual 2) did not lose any osteoderm during cooking, but many were detached when the prey was manipulated and removed from the fire to be placed on different surface.

The post-cooking analysis was developed considering the osteoderms which remained in the carapaces together with those recovered from the ashes. The analysis allowed to recognize that the thermal alteration was not homogeneous among the different bony dermal scutes. It was possible to observe a range of variation from 0 to 36% of unburned osteoderms, considering each individual separately. Macroscopically, these osteoderms did not show any alterations by fire (Table 2). Between 65% and 100% of the total osteoderms showed modifications by fire (Table 2, Fig. 3). A considerable number of the osteoderms (66%) showed both dorsal and internal surfaces affected, in different intensities (categories 2–8); only in the 34% of the cases did the alterations occur exclusively on the dorsal surface (category 1) (Table 3). No osteoderm presented alteration solely on the internal surface.

Among the osteoderms showing alterations both in the dorsal and the internal surfaces, different burning damage intensities were identified (Table 3). The predominant feature (39, 50%) was osteoderms completely carbonized in both surfaces (category 4). Among the partially carbonized osteoderms (category 3), it is worth mentioning that in movable osteoderms, the thermo-alteration was restricted to the distal part, and the embedding area remained

Table 2
Number of osteoderms per specimen with and without thermal alteration.

Osteoderms state	Individual 1		Individual 2		Individual 3		Total	
	N	%	*N*	%	*N*	%	*N*	%
With thermal alteration	399	100	332	93	268	64.27	999	84.66
Without thermal alteration	0	0	25	7	149	35.73	181	15.34
Total	**399**	**100**	**357**	**100**	**417**	**100**	**1180**	**100**

Fig. 3. Experimental thermo-altered osteoderms. a. Dorsal surface; b. Internal surface. 1. Only carbonized externally; 2. Carbonized externally and burned internally; 3. Partially carbonized on both surfaces; 4. Completely carbonized on both surfaces; 5. Carbonized externally and calcined internally; 6. Calcined on the external surface, carbonized internally; 7. Partly calcined on both surfaces; 8. Completely calcined on both surfaces.

unburned, showing that the bony dermal scute remained attached to the carapace during their exposure to fire.

In categories 2 and 5, showing two different intensities of alteration, it was evident that the external zone always presented a more intense damage. This occurred with those osteoderms carbonized on the dorsal region and burned internally as well as on those calcined on the dorsal region and carbonized internally (Table 3). This could be related to the position of the prey during cooking, a condition that determines which external surface will be affected first and more intensively.

Regarding endoskeletal elements, scarce evidence of burning damage was observed. Only the right scapula and the sacrum of individual 1 show burning marks. In the scapula, it was possible to observe that a portion of the coracoid apophyses was carbonized. Regarding the sacrum, a carbonized area in the external sector was registered. In both cases, the extension of the damage represents less than 5% of the total surface. In individual 1, it was also possible to identify a fracture on the left pelvis and on the scapula. These fractures could be associated with the capture method or also with the handling of the prey for cooking.

3.2. Buried armors

The maximum temperature recorded in the sedimentary matrix under the hearth was 44.56 °C. Once the cooking of the armadillos was finished (after 40 min), the armors were removed from the matrix. They did not show any burning damage or macroscopic structural modifications. This may have been due to the low temperature reached, which could be caused by two factors: the short time of exposure or the scarce thermal conductivity of sand. It is expected that thermal modifications on buried elements occur after a longer period of fire activity than the cooking of the carcasses requires. This aspect shows the need for further experimental cases, in order to determine the effects during longer heat exposure. In that sense, the experiment carried out by Bennett (1999) recorded bone thermal alterations on modern and archaeological bones after 40 h of continuous fire. It is also necessary to consider the effects in different types of sediment, since the thermal conductivity of sand led to low temperatures.

3.3. El Guanaco 2 site thermo-altered Dasypodidae bone remains

Burning damage was observed on 11, 72% of the Dasypodidae assemblage. Fifty-four osteoderms are thermally modified, showing variations in the burning intensity (Table 4). Most of them are burned mainly on its external face (55, 56 %NISP); in second place, carbonization was recorded both on external surface (14, 81 %NISP) and on external and internal surfaces (14, 81 %NISP); only one osteoderm is calcined. As regards the area affected, thermo-altered osteoderms show diverse conditions. Most of the scutes are partially affected (72%, NISP = 39), specially on their external surface (NISP = 32). The elements showing complete alteration mainly show a carbonization stage (NISP = 14) (Table 4).

C. villosus thermo-altered bones were also recovered. They correspond to two caudal vertebrae, a proximal scapula, a femur, three metapodials and a phalanx.

4. Discussion

4.1. Experimental pattern of thermally modified Dasypodidae remains

Experimentally cooked armadillos show clear macroscopic burning damage caused by exposure to heat. It can be suggested that the two cooking methods employed -direct fire and charcoal- cannot be differentiated by their material derivate. The only difference that can be stated among the cooking methods corresponds to the osteoderms detachment during the procedures. Only in the carcasses exposed directly to the fire did the bony dermal scutes fall into the fire and became more intensely affected showing a calcinated state on the osteoderm dorsal and internal regions. However, this condition (osteoderm with calcinate degree) was not a reliable indicator of the cooking method applied, due to an equifinality problem, by which the same material derivate could be obtained by discarding behaviors.

Once the burning affects the whole prey the material correlates regarding intensity and burning damage are indistinguishable, considering that the three carcasses show an important diversity of burning situations (categories 1–5). In the endoskeleton, bones were affected to a much lesser extent and it was possible to register

Table 3
Number of osteoderms per specimen and according to the type of alteration.

Type of alteration on osteoderms	Individual 1		Individual 2		Individual 3		Total	
	N	%	*N*	%	*N*	%	*N*	%
1. Only carbonized externally	140	35.09	139	41.87	118	27.38	397	34.17
2. Carbonized externally and burned internally	0	0	14	4.22	0	0	14	1.20
3. Partially carbonized on both surfaces.	72	18.05	0	0	62	14.38	134	11.53
4. Completely carbonized on both surfaces.	167	41.85	172	51.81	120	27.84	459	39.50
5. Calcined on the external surface, carbonized internally	20	5.01	7	2.11	10	2.32	37	3.18
6. Carbonized externally and calcined internally[a]	0	0	0	0	11	2.55	11	0.95
7. Partially calcined on both surfaces[a]	0	0	0	0	51	11.83	51	4.39
8. Completely calcined on both surfaces[a]	0	0	0	0	59	13.70	59	5.08
Total	399	100	332	100	431	100	1162	100

[a] These scutes were recovered in the hearth.

burning damage only in two elements of a unique prey from the three cooked.

The pattern derived from cooking experiments shows diverse burning damage on the osteoderms' external surface along with the absence of internal bone thermo-alteration. Moreover, when both external and internal osteoderms surfaces are affected, the internal region shows less damage intensity. This pattern results mainly from the armadillos' position in the fire and determines material derivate for identifying cooking actions and techniques in archaeological sites.

The results of the burring experiments evidenced a significant difference to the cooked preys. Carapaces buried in sandy soils did not suffer any thermo-alteration, so it can stated that sub-surface osteoderms do not get altered if the fire lasts 40 min or less in that substrate. Ethno-archaeological data taken from the Hazda indicates that they make different types of fires ranging from 15 min to 4 months of use, depending on the function assigned (Mallol et al., 2007). This indicates that there may be a wide variety of situations to consider when making interpretations of sub-surface thermal alteration of the buried remains. Therefore, the experience developed may be useful to interpret cases of short duration fires developed for a specific purpose, but it should be expanded to longer-duration fires or many fire events.

4.2. Archaeological case: El Guanaco 2 site Dasypodidae assemblage

Experimental and archaeological armadillo assemblages presented several similarities. Firstly, thermo-alteration was mostly registered in the osteoderms. Secondly, different thermo-alteration degrees were recorded in both the archaeological and the actualistic material. It is important to remark that the cooking of a single individual may yield this varied material record. In the archaeological assemblage the scutes are mainly affected on their external region, showing that the carapace was exposed to heat from one side. In addition, it is possible to infer that scutes did not become detached from the armor during the exposure to heat because the embedding region of movable osteoderms was no affected.

From the above statements, it was interpreted that the origin of the archaeological thermo-altered scutes is anthropic and may derive from the cooking of the prey. While there are several characteristics in common between the archaeological and the actualistic cooked carapaces, there are no material similarities between the assemblage and the experimental buried armors. Based on these results, the present work suggests that the Dasypodidae assemblage of El Guanaco 2 site derives from human butchery, cooking and consumption activities.

However, the experimental analogy may not fully contemplate the past human burning-related behaviors despite similarities (O'Connell, 1995). For example, the archaeological assemblage showed prevalence of a lower burning damage-stage, which was not present in the experimental remains. Additionally, in the archaeological sample, calcined osteoderms are scarce, while in the experimental sample they comprise *ca.* 10%. The calcined osteoderms' high susceptibility to disintegration would explain this bias. Furthermore, it can be stated that the numerous burned-stage osteoderms, together with the virtual absence of calcined-stage osteoderms, would be due to the use of a different type of fuel which reached a lower temperature, as well as to a shorter exposure time.

The burned endoskeletal bones of El Guanaco 2 site includes elements that were unburned during the experiment, such as metapodial and vertebrae. This may suggest that they do not derive from the cooking of armadillos as a whole carcass. In the experimental assemblage the legs stay far away from the heat source and the vertebral column was not affected because of the presence of the armor. Their presence in the assemblage could be explained by other causes, such cleaning activities in residential areas or surrounding campfires, as well as by other cooking techniques used on Dasypodidae that may include the carcass segmentation before cooking.

It is necessary to take further considerations in relation to this point, since the resolution of archaeological sites is not of fine grain, and generally includes multiple deposition events from thousands of years averaging human behaviors and multiple post-depositional processes. So, the patterns obtained from short-term observation of modern events may not fully describe the long-term processes (Borrero, 1991; Stiner, 1994).

Table 4
Thermo-altered Dasypodidae osteoderms from El Guanaco 2 site.

Type of alteration on the osteoderms	NISP	%NISP
Only burned externally	30	55.56
Partially burned on both surfaces	4	7.41
1. Only carbonized externally	8	14.81
2. Carbonized externally and burned internally	1	1.85
3. Partially carbonized on both surfaces.	2	3.70
4. Completely carbonized on both surfaces.	8	14.81
5. Calcined on the external surface, carbonized internally	0	0.00
6. Carbonized externally and calcined internally	0	0.00
7. Partially calcined on both surfaces	0	0.00
8. Completely calcined on both surfaces	1	1.85
Total	**54**	**100**

6. Conclusions

The cooking experiment presented here represents a relevant methodological tool to establish material derivates from

Dasypodidae cooking activities, thus providing an essential background to interpret the formation process at El Guanaco 2 site.

The experimental cooking performed led to the interpretation that thermal alterations on dermal scutes constitute a primary indicator to identify culinary activities on armadillos. This interpretation also relies on the El Guanaco 2 site archaeofaunal context derived from domestic or base camp activities.

The future agenda includes several tasks destined to deepen current understanding of the taphonomic processes that affect the armor shells armadillos. It is important to consider new variables for experimental cooking, as the use of different fuels and time of cooking, among others factors. It is necessary to develop new methodological tools in order to contrast this hypothesis.

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