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Actualistic Study of a Dense Concentration of Bone Remains in the Central Plateau of Santa Cruz Province (Argentina)

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This work analyzes a modern bone concentration at Cueva 7, in Los Toldos archaeological locality, as part of the taphonomic studies that we have carried out in the northeast of the Central Plateau of Santa Cruz province (Argentina). The goal of this work is to identify the actualistic taphonomic patterns that can contribute to a better interpretation of the archaeological sites in caves or rock shelters where piles or dense bone concentrations were registered in the study region. From the identification of different taxonomic, anatomic, mortality, and bone modification patterns in this highly-dense accumulation, we evaluate the possible causes of its formation, and produce actualistic information which may be of use to learn about the different processes that accumulate and scatter zooarchaeological remains in the cave environments of the study area. The results show a monospecific assemblage integrated by no less than 43 *Ovis aries* individuals whose death was natural. The accumulation is characterized by a natural disarticulation pattern, which appears to be more accelerated in appendicular elements, a homogenous weathering profile with minor differences that may be associated with the microenvironments recorded inside the cave, and the very low incidence of natural agents, where trampling was the highest. This work thus provides valuable actualistic information that can be used as a parameter in the determination of possible natural contamination in archaeological contexts.

Keywords: ACTUALISTIC TAPHONOMY, BONE ACCUMULATIONS, NATURAL DEATH, *OVIS ARIES*, ZOOARCHEOLOGY, SOUTHERN PATAGONIA.

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Introduction

Zooarchaeological research in certain areas of Argentinian Patagonia has been carried out for several decades in a systematic manner and with a strong emphasis on taphonomy (Borrero, 1988, 1990, 2000, 2001, 2003, 2007; Borrero *et al.,* 1991, 2005; Borrero & Muñoz, 1999; Martin, 2006; Fernández, 2008, 2010; Muñoz, 2009; Cruz & Muñoz, 2010; Mondini & Muñoz, 2014; among others). However, in the northeast of the Central Plateau of Santa Cruz province, taphonomic studies have made less progress (Giardina *et al.,* 2000; Miotti & Marchionni, 2011; Marchionni *et al*., 2012; Marchionni, 2013, 2016). Given the need to learn about the taphonomic processes that operate in this plateau portions, we have undertaken a regional taphonomic study, the goal of which is to generate a model that will allow us to define the different agents and processes that could have an incidence in the formation of the archeological record in the different microenvironments of the study area. Although this research acknowledges that those multiple processes that modify the faunistic contexts cannot simply be inferred from the observed results, it is necessary to carry out actualistic designs to identify those processes and to understand their peculiarities (Brain, 1981; Abramova, 1993).

In some of the archaeological sites of the plateau under study (Figure 1a), the accumulation of certain bone remains results in high density sectors. We believe that this particular spatial distribution of bones could correspond to specific activity areas on the intra-site scale. It is known that these accumulations are not always of human origin, since different natural processes and agents can also produce them, and they can even be the result of a mixture of natural and cultural materials. Piedra Museo and Cueva Maripe sites, located in the Zanjones Rojo and Blanco basin (Miotti *et al*., 1999; Marchionni *et al.,* 2016), are two examples in the Central Plateau where dense bone concentration was registered. The first site was studied in the 1990s, where two bone piles were recorded and interpreted as the result of the killing and primary processing of guanaco between 10,400 and 9,200 years BP (Miotti *et al*., 1999). The second corresponds to a dense bone concentration in the multiple activity site. This accumulation is dated between 3,500 and 1,900 years BP, and its location in closely associated with rock painting, which confers a particular meaning to this sector of the site (Miotti *et al*., 2014; Marchionni *et al*., 2016). These bone concentration patterns, which are comparable with piles, litters or bone beds that characterize several North American contexts (Speth, 1983; Todd, 1987; Meltzer *et al*., 2002; Brink, 2008), were also recorded in a few sites in Argentina (Borrero *et al.,* 1985; Horwitz *et al.,* 1993-94; Miotti *et al*., 1999; Gutiérrez, 2001; Rindel & Belardi, 2006; Santiago, 2010). However, to interpret their presence and formation in the diverse archaeological hunter-gatherer contexts of the region, taphonomic and actualistic studies must be carried out. Likewise, when these concentrations are of human origin, their study also involves addressing some aspects linked to the functioning and organization of society to discuss, for example, the different strategies connected with human hunting, transport and discard that create this particular pattern in the record (Lubinsky, 2013).

In this work, we analyze a modern bone concentration at Cueva 7 from Los Toldos archaeological locality (Figure 1b) with the goal of identifying any actualistic taphonomic patterns that will contribute to a better interpretation of the archaeological sites in caves or rock shelters where piles or dense bone concentration were registered (Miotti & Marchionni, 2016). In actualistic taphonomy, the processes and resulting patterns are evaluated by the researcher, who can control the parameters of the observed processes. Conversely, the comparative method focuses on the study of the effects, where the process/result relationship is not observed but inferred, and where the results obtained from actualistic research performed by other researchers can be used. Both methods should be considered as complementary aspects of the same research, in which the identification and analysis of the effects, on the one hand, and the actualistic studies, on the other hand, will allow us to obtain a better understanding of the causes and contexts in which these effects are produced (Marean, 1995).

Los Toldos archaeological locality consists of over fifteen caves on both sides of the canyon. At the bottom of this flows a temporary water course known as Zanjón El Pescado. Based on the geological map (Panza, 2001), this basin, along with Zanjones Rojo and Blanco basin, 45 km further south, constitute the most relevant catchment basins in the study area. Throughout them, we can find archaeological sites with chronologies that go from the beginnings of the peopling of the area *ca.* 12,000 years BP until the Late Holocene (Cardich *et al.,* 1973; Miotti, 1998;

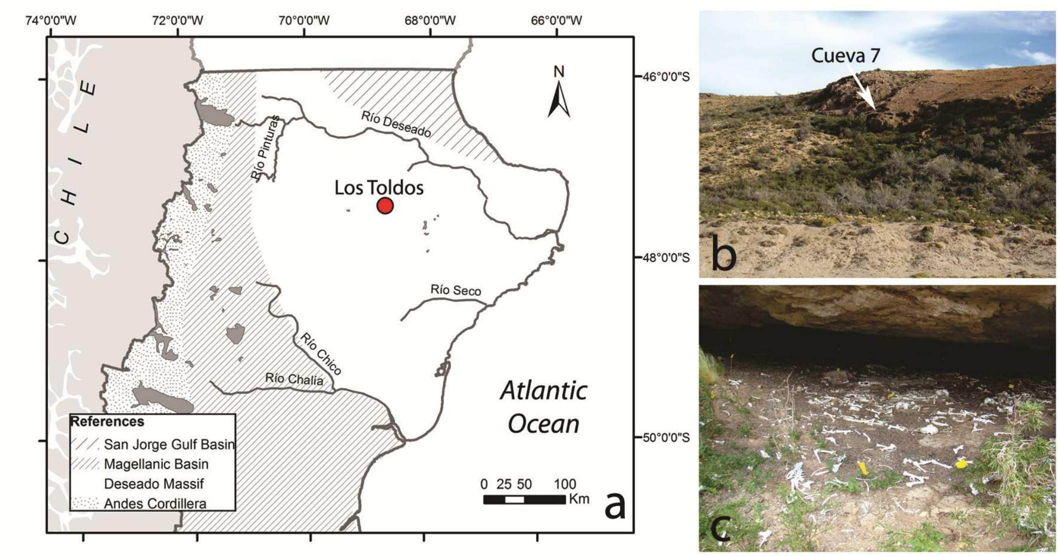

Figure 1. a) Location of Los Toldos archaeological locality in the Deseado Massif (Argentinian Patagonia). b) Cueva 7 in Los Toldos locality, on the south hillside of the canyon. c) Modern bone accumulation in Cueva 7 in 2015.

Miotti *et al.,* 1999; 2014), many of which are in caves or rock shelters. The caves are exceptional cases of sedimentary deposition with unique stratigraphic sequences (Waters, 1992:243) and large sedimentary differences given the environmental variation within the cave (Farrand, 1985; Kornfeld *et al.,* 2008 and bibliography cited therein). Therefore, the study of the formation processes that make up the particular taphonomic histories becomes relevant, not only to understand the dynamics of the microenvironments, but also to provide valuable information for the discussion of the peopling of both the region and the American continent and the exploitation of both Pleistocenic and modern fauna.

A recent bone concentration at Cueva 7 was registered in 2007, which presented a high density of bones and a large number of articulated carcasses. The survey was carried out *in situ* in 2015, and involved the identification of different taxonomic, anatomic, mortality, and bone modification patterns. This paper has two specific aims: on the one hand, to evaluate the hypothesis of whether this context is the result of the catastrophic death of the gregarious animals which sought shelter from heavy and prolonged snowfall in caves and remained trapped with no food, as has been recorded by different researchers in Patagonia (Borrero, 2001; Rindel & Belardi, 2006). On the other hand, is to produce actualistic taphonomic information that will enable us to learn about the different processes that accumulate and scatter zooarchaeological remains in the cave environments of the study area. The previous information serves to identify possible contamination that may have occurred because of the incorporation of bone remains by natural and anthropic agents in the archaeological record.

Cueva 7 site in Los Toldos locality

This site is located in the western end of the *Cañadón de las Cuevas*, in Los Toldos archaeological locality. Cueva 7 is at 462 m.a.s.l. on the south hillside of the canyon, around 14 m above the current stream watercourse (Figure 1b). The cave has an approximate area of 52 m^2 and two openings: the main one opens to the north, and the other to the east. The roof of the cave is low (1 m on average), which means that entering and staying in the cave can be very uncomfortable, since you can only sit or lie down inside the place.

It is interesting to highlight that in 2007 a few red pigmented spots were registered on the roof of the cave (Blanco, 2007), which shows that this space was known by the hunter-gatherer societies that inhabited this locality in the past. However, inside the cave we did not find any archaeological materials on the surface, and despite the fact that the cave has sedimentary potential, recent drillings did not yield any evidence of human occupation (Hermo *et al.*, 2017). Therefore, the only materials found on the surface of the site were modern bone remains and soft tissue, mainly sheep's skin and wool, which comprise the sample that we have analyzed in this work (Figure 1c).

Outside the cave, lithic artifacts and recent bone remains are commonly found, both on the slope and in the surrounding areas. Such remains might have suffered some kind of displacement from the inside of the site, are mainly found in sectors close to the cave's mouth.

Survey methodology and analysis

The study of bone accumulation at Cueva 7 in Los Toldos locality comprised 2 stages: the field survey and the analysis of data in the laboratory.

Figure 2. Sampling units chosen from the actual bone assemblage to be studied *in situ.*

Fieldwork was carried out in the summer of 2015 with the goal of collecting the necessary information to perform the taphonomic study of the assemblage. First, we drew a grid that covered the entire surface of the cave and this was divided into 48 squares of 1 m^2 each. To evaluate the spatial distribution and density per square meter, the bone specimens found in each square were then counted and the result was reflected on a map on graph paper. Because of topographical and logistic constraints, it was impossible to carry out a full survey of the totality of the materials in the site. In this respect, we decided to thoroughly study four sampling units, which were selected in order to obtain representative information from different sectors of the cave. Thus, we selected a square located in the central sector (D3), two near the main mouth of the cave (B1 and F1), and one (B5) in an internal and deep sector, where accessibility is restricted (Figure 2). Additionally, all skulls present in the site were registered, including those that did not comprise the sampling units, so that they could be used as a diagnostic tool to estimate the approximate age of death (from their teeth), and to achieve better control over the represented species and a more accurate MNI estimation. On the one hand, the analysis of the assemblage involved the anatomic and

Figure 3. Floor plan and grid of Cueva 7 showing the density of bone specimens per m^2.

taxonomic determination of the different specimens to determine animal range and to evaluate the skeletal parts that were represented in the site. On the other hand, we surveyed different bone modifications registered on the surface of these bones. This kind of study is used as a methodological approach, from which it is possible to infer different processes and agents involved in archaeological site formation (Binford, 1981; Gifford, 1981, 1991; Lyman, 1994; Marean, 1995). For this work, bone surfaces were examined with the naked eye and with 10x magnification. Among natural modifications, we surveyed those like weathering (Behrensmeyer, 1978; Borrero, 2007; Massigoge *et al.*, 2010), and carnivore (Binford, 1981; Mondini, 2002, 2003; Borrero *et al.,* 2005; Massigoge *et al.,* 2014), rodent (Bocek, 1986; Lyman, 1994), root (Behrensmeyer, 1978; Binford, 1981; Montalvo, 2002), and trampling marks (Behrensmeyer, 1978; Lyman, 1994; Borrero, 2007). In terms of cultural modifications, we took into account different types of butchering marks and the quantity and type of fracture patterns (Binford, 1981;

Table 1. Number of bone specimens on surface of the site by square.

Square	**I**	**H**	**G**	**F**	**E**	**D**	**C**	**B**	**A**
1	35	30	31	41	45	57	21	44	36
2		18	33	31	25	12	20	39	29
3			81	44	68	29	66	84	19
4			4	75	31	18	37	50	14
5					19	25	22	21	6
6					1	35	37	22	2
7						3	88	22	2
8							2	2	3

Johnson, 1985, 1989; Lyman, 1994). All analyzed materials were photographed in the field.

Since this work is part of a general research program, which includes the long-term analysis of how the burial, exposure, movement and destruction processes operate on these remains, we decided not to move the bone materials to the laboratory. Bone specimens from the sample squares and the skulls present in the site were numbered and marked on the exposed surface to effectively monitor the speed and intensity in which the different processes and agents act in this environment.

In the laboratory, we carried out the estimation of the taxonomic and anatomical abundance of the assemblage -NISP, %NISP, MNI, MAU and %MAU- (Grayson, 1984; Lyman, 1994), the determination of the age of death of the animals based on dental eruption criteria (Sisson & Grossman, 1996), and the analysis of the different bone modifications that were registered in order to discuss the formational history of assemblage.

Results

The count of the materials on the grid showed that 1,614 bone specimens were distributed on the current surface of the cave in a heterogeneous way (Figure 3 and Table 1). The general trend showed a higher density in the squares located in the northern half of the cave and near the main mouth. However, although the southern half registered the smallest number of bone remains per m^2, the C7 sampling unit showed the highest density of the site, with 88 bone specimens (Table 1).

The analyzed sample comprised 205 bone specimens (*ca.* 13% of the total), which came from the four selected squares (B1, B5, D3 and F1; Figures 2 and 3), as was decided based on the criteria established in the methodology section.

Taxonomic, anatomical and mortality analysis

The analysis performed indicated that the assemblage contained 94% (%NISP) of *Ovis aries* (sheep) bone specimens. The remaining

6% corresponded to small chips that we were unable to identify as they did not possess any diagnostic features. The study of the frequency of anatomical parts for *Ovis aries* showed a higher representation of axial specimens (76% of the NISP). However, the %MAU value showed that, although skull and cervical vertebra elements were the most numerous (100%), proximal parts of the forelimb (scapula and humerus) registered high frequencies of 75% and 85% respectively (Figure 4) as well. We also found that approximately 78% of the bone specimens inspected here (NISP=150) were completely disjointed. The higher NISP frequency of axial specimens may be linked with a better preservation of such skeletal elements (vertebras and ribs) within the site, which can often remain articulated and in many cases they can present remains of soft tissue (Figure 5a, 5b).

The MNI of *Ovis aries* is 43, as was estimated from the total skull frequency surveyed throughout the cave. Approximate age of death was determined taking into account the characteristics of sheep's teeth. Because jaws, where the incisors are present, were unavailable to us, the results showed a wide age range for each category, as they were only based on the existing molars and premolars in the skulls. The obtained mortality profile (Figure 6) represents the different age groups that characterized the structure of living populations (see Kaufmann, 2009:121-126 and bibliography cited there). Among the studied skulls, one of them showed a pathology in the right maxillary which could correlate with tooth infection.

Modification of bone surfaces

The weathering profile of the assemblage showed a high representation of bone specimens in low stages (Figure 7), which, in many cases, had soft tissue attached, such as skin or tendons. These results suggest very low physical and chemical destruction, and indicate a good state of preservation of the assemblage. Likewise, the effect of weathering registered in all bone specimens is homogenous, except for a few cases in which differences between shafts and ends or between exposed and unexposed faces were observed. In addition, we evaluated weathering differences between axial (vertebrae; n=56) and appendicular (limb long bones; n=28) skeletal parts, and the weathering variation between long bones in different stages of maturation (without fusing; with marked fusion line; and completely fused). However, while no significant differences were found, there was a slight tendency towards a better preservation of the vertebrae (75% in stage 1) than of long bones (61% in stage 1). This trend was also recorded in long bones with different maturation degrees: while over 80% of bone specimens without fusing were in stage 1, approximately 65% of bone specimens with marked fusion line, and less than 50% of those completely fused were in this same stage. In this last group, we also found bone specimens in stage 3 (*ca.* 11%) which showed bone loss.

Regarding the modifications registered on bone surfaces, we found a low frequency of traces of natural agents and processes, and a complete absence of clear cultural marks (Figure 8a). Among natural modifications, we could only register marks produced by trampling, roots and carnivores (Figures 8b, 8c and 8d), all of which were present in a very low frequency (<2% of NISP). The damage produced by trampling affected only axial bones with flattened shape, such as jaws or ribs. Root etching was registered in axial and appendicular elements and was

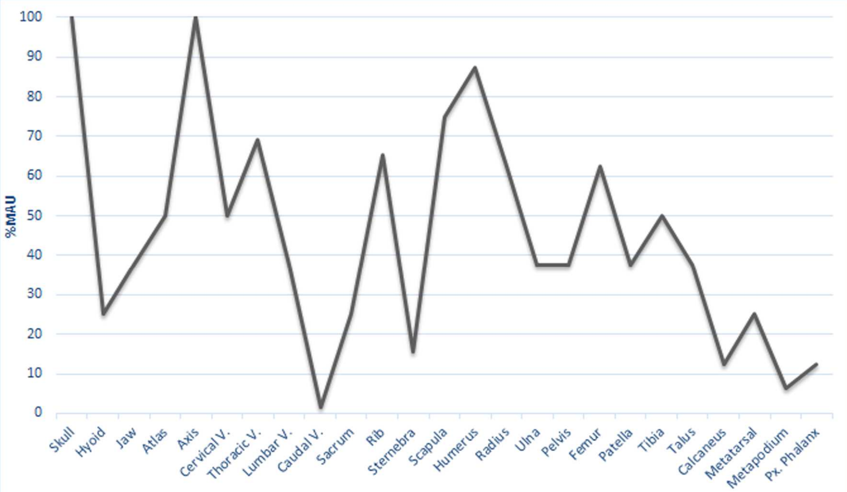

Figure 4. Representation of anatomical parts in %MAU values.

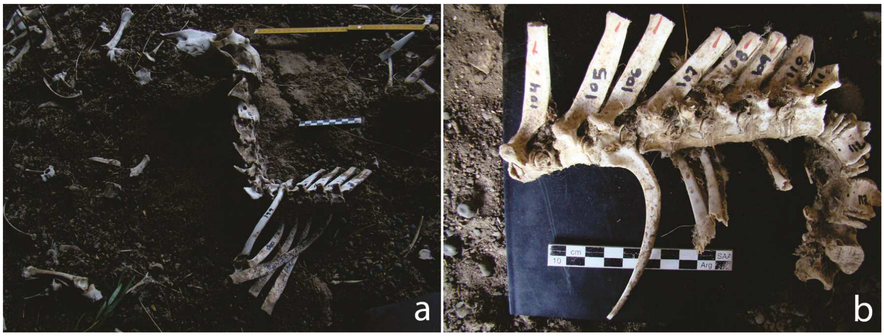

Figure 5. Photographs of articulated axial elements in the assemblage.

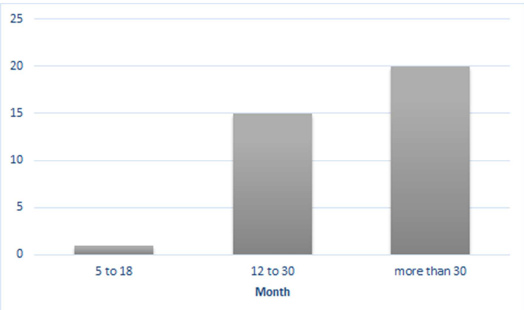

Figure 6. Number of sheep (MNI) at Cueva 7 according to range of death age expressed in months.

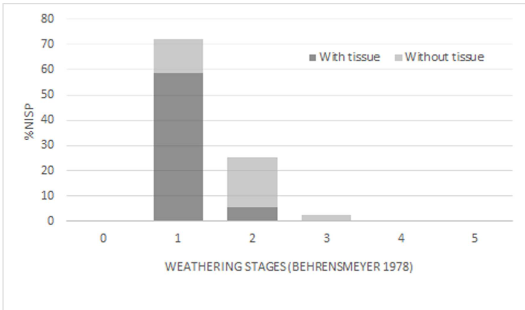

Figure 7. Weathering profile of the assemblage.

Figure 8. a) Bone surface modifications, b) root etching, c and d) carnivore marks: c) punctures and d) scores.

characterized by a dendritic design and brown grooves which were darker than bone surface. Two sheep specimens with carnivore marks were identified: one of them was a fragment of a pelvis with punctures of approximately 2 mm in diameter (Figure 8c), and the other corresponded to a humerus with a score of 7.5 mm in length on its diaphysis (Figure 8b). However, no bone cylinders, signs of digestive corrosion, or the presence of other carnivore indicators were registered at the site.

We found that, within the sampling units, approximately 34% of the bone specimens (NISP=70) were fragmented. We identified 98 fractures in total, and some of these specimens showed more than one fracture. Fracture surfaces were rough and we did not find any cultural attributes that allowed us to infer that these fractures may have been the result of human activity. Among the identified fracture types, we observed a clear dominance of transverse fractures (69%) and a low representation of oblique (16%) and longitudinal fractures (15%).

Discussion and conclusion

The results obtained here allowed us to characterize the recent assemblage studied at Cueva 7 in Los Toldos archaeological locality. The assemblage comprised no less than 43 sheep in advanced disarticulation state, and although they correspond to the different age groups that characterize living populations (Figure 6), we could not achieve a more accurate definition for each category. More specific age categories can be obtained from incisors present in the jaw or by, for example, using two criteria simultaneously: dental eruption and long bone fusion (Sisson & Grossman, 1996; Zeder, 2006). Given the general state of disarticulation and preservation of the assemblage, we could only estimate wide age ranks from the molars present on the skulls.

The highly-dense bone distribution near the main mouth of the cave (Figure 3, Table 1) could be linked with the slight slope of the cave floor to the north, where the presence of modern bones was also registered outside the cave. While this distribution pattern showed a higher disarticulated bone concentration towards the cave slope, the articulated portions were present inside cave. Trampling constituted the main post depositional modification registered on bone surfaces (Figure 8), and although its frequency was low, the main perturbations of the assemblage were probably linked to this type of scatter. Given the characteristics of the site, the trampling of bone specimens may have been produced by small animals rather than by humans who might have produced more damage as a whole.

The analyzed sample showed a monospecific assemblage integrated by 43 sheep with different skeletal elements. Based on the environmental, ecological and geological characteristics of the study area (Cabrera & Willink, 1980; Redford & Eisenberg, 1992; Panza 2001; Harris, 2008), we understand that if the carnivores that live in the area (pumas, foxes and grassland cats) produced this bone accumulation, the same could only be ascribed to the voracious action of pumas, or perhaps of many red foxes. However, we did not register any taxonomic, anatomical, disarticulation and/ or marks or patterns similar to those found by other researchers in connection with burrowing carnivores in Patagonia (Borrero, 1990, 2001, 2007; Borrero & Martin, 1996; Martin & Borrero, 1997; Cruz, 2000; Borrero *et al.*, 2005; Martin, 2006; Fernández *et al.*, 2010; among others). Nor did we find any bone modifications as described by Mondini (2002) to discriminate bone accumulation produced by selective agents as carnivores or humans. Based on the taphonomic information, we understand that the species selection registered at Cueva 7 resulted from faunal ethology. Seeking shelter from snowfall in caves is a typical behavior for flocks of sheep in the study area. The results obtained suggest the hypothesis that the probable cause of death would correspond to the hunger and overcrowding suffered by the sheep that may have got trapped in the cave seeking shelter from snowfall as has been observed in the catastrophic death of *Lama guanicoe* (Borrero, 2001, 2007; Mameli & Estévez, 2001; Belardi & Rindel, 2008). Likewise, this hypothesis is supported by the absence of cultural indicators of human appropriation of fauna and the low incidence of carnivores that the set showed (Figure 8). It is further strengthened by the presence of advanced-terminal disarticulation patterns (Muñoz & Cruz, 2014) that match the natural sequence that characterizes this process (Lyman, 1994). If the intervention of other agents took place, either causing the death of the sheep or later, once the sheep were dead, as a post depositional modification of the disarticulation pattern, we would expect an altered disarticulation sequence. This argument does not rule out the hypothesis that these or other carnivore species, may have scavenged and moved the sheep carcasses, or dragged any materials, even outside the cave (Gutiérrez *et al.,* 2016).

The minor differences observed between the axial and appendicular frequency of elements could be explained from the greater disarticulation registered in appendicular elements more than by carnivore or human selective action. This condition could promote the movement, burial and/or dispersion of the disarticulated bones, even towards the outside of the cave. This cause of anatomical representation could help us understand the complete absence of butchering marks and the low record of carnivore marks.

The weathering profile shown in Figure 7 suggests a similar time of exposure for all bone specimens. Following Behrensmeyer (1978), this profile can be the result of the synchronic death of animals, possibly due to catastrophic more than attritional causes, as we are assuming. Although some expected weathering differences were registered between bone shafts and ends, and between exposed and unexposed faces, other observed differences were unexpected. We found slightly better preservation in axial and immature elements, which differs from what the bibliography says regarding the differences between anatomical parts or the ontogenetic development of bone (Behrensmeyer, 1978; Massigoge *et al.*, 2010). This could be explained as a diachronic deposit of the carcasses in the site. However, it is possible to hypothetically think that the diverse microenvironments of the cave, where shelter, sunlight and humidity conditions are different, could have produced different weathering on these carcasses. This idea should, nevertheless, be evaluated in future works.

We did not register a significant incidence of natural agents or processes on bone surfaces. Apart from weathering and trampling, we recorded few specimens with root etching and carnivore marks. The incidence of roots on the assemblage is low, as only three specimens from the same sample unit (F1) registered root marks. F1 is the only sample unit that presents vegetation. The registered etching features are in accord with marks produced in the skeletal element-sediment interface and indicate the presence of herbaceous cover at the moment in which the element was deposited (Montalvo, 2002). Based on this observation, we suggest that the distribution of vegetation around Cueva 7 when the assemblage was deposited must have been very similar to the current situation. Given the low incidence of roots on bones, we believe that this agent could not have moved or fragmented the bones. While the presence of irregular fractures in the assemblage may be due to trampling or weathering, both are low.

In taphonomic terms, and as several researchers have highlighted, these modern cases once again warn us about the potential mixing that can take place in the same site between bone remains accumulated by natural causes and others resulting from human activity (Borrero, 2001; Rindel & Belardi, 2006). This work serves to understand that, in the study area, dense bone accumulations in caves could result in bone beds or piles as a consequence of the natural death of fauna that seek shelter in them. This pattern can be directly linked to the known alternate use of caves in Patagonia by humans and animals (Borrero, 1990). In connection with the goals proposed in this work, the described taphonomic pattern provides useful information to identify the dense bone concentrations registered in caves which are caused by natural catastrophic death, and these may either be the only bone record in the site or they can be mixed with archaeological materials. We understand that it is fundamental to consider the full set of taphonomic indicators registered here in order to infer the origin of the assemblage since the taxonomic profiles that show the selection of species are not in themselves a good indicator to identify the human agent. Likewise, this information is useful to compare and recognize other causes of bone accumulation that can result in piles or bone beds. Although the information that we present here constitutes a valuable body of data to identify natural bone accumulation, some indicators can register changes, for example, in cases where humans may have taken advantage of this kind o resources. This massive death of animals has implications for the human population since they constitute a potential food source (Borrero *et al.*, 2005), as they reduce the cost of animal acquisition by hunting and capture, and they offer certain predictability in terms of finding.

While the present work is one of the first performed from an actualistic perspective in the study area, we believe that the results provide relevant information to learn about the agents that accumulate and scatter zooarchaeological materials in the region and how their incidence may vary in the different microenvironments of the area.

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