Human palaeontology (Archaeozoology)

Who was the first? An experimental application of carnivore and hominid overlapping marks at the Pleistocene archaeological sites

Ruth Blasco *, Jordi Rosell

*Institut Català de Paleoecologia Humana i Evolució Social (IPHES), Unidad asociada al CSIC, Àrea de Prehistòria,
Universitat Rovira i Virgili, Plaça Imperial Tarraco, 1, 43005 Tarragona, Spain*

Abstract

There are many types of evidence that provide information about methods for obtaining animal nutrients. Several researchers suggest that the main element to be considered is the skeletal representation of the different species identified in the faunal assemblage. This element must be associated to the animals' age at death and the localisation of processing marks of the carcasses (both those of anthropic origin and those produced by carnivores). Occasionally, these marks coincide on the same point of the bone, giving cause for overlapping marks. These marks can be considered an aid more to identify the anthropic manner for obtaining animal recourses. However, these cases are very unusual at archaeological sites, and it is not always easy to identify which of the two predators has obtained the prey first. Through the experimental process presented in this article, we have observed diagnostic elements on overlapping marks that show the action sequence of the predators (hominids and carnivores) on carcasses. These experimental criteria were applied to different archaeological sites of the Lower and Middle Pleistocene in the Iberian Peninsula: Bolomor Cave (Valencia, Spain) and level TD10-1 and TD6-2 of Gran Dolina (Atapuerca, Burgos). In these assemblages, we were able to distinguish hunting and scavenging events through overlapping marks, providing a new element to the general interpretation of these sites. ***To cite this article: R. Blasco, J. Rosell, C. R. Palevol 8 (2009).***

Résumé

Qui a été le premier ? Une application expérimentale de superpositions de traces de carnivores et d'hominidés dans des sites archéologiques du Pléistocène. Il existe de nombreux types d'évidences qui fournissent des informations sur les techniques utilisées pour obtenir la nourriture d'origine animale dans les sites archéologiques. Plusieurs chercheurs suggèrent que le principal élément à considérer est la représentation squelettique des différentes espèces identifiées. Il faut ajouter à cet élément, l'âge de mort des animaux et les traces résultant du traitement des carcasses (celles générées par les activités humaines et celles produites par les carnivores). Occasionnellement, ces marques coïncident sur le même point de l'os, ce qui conduit à des superpositions de traces. Ces superpositions peuvent être un élément de plus pour identifier le principal agent accumulateur dans un site. Toutefois, ces cas sont très rares dans les sites archéologiques et le plus souvent, il n'est pas facile de déterminer quel est le prédateur qui a accédé en premier à la proie. À partir de l'expérimentation que nous présentons dans ce travail, nous avons observé des éléments diagnostiques sur les superpositions qui montrent la séquence d'intervention des prédateurs (carnivores et hominidés) sur les carcasses. Ces critères

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* Corresponding author.
  E-mail addresses: rblasco@prehistoria.urv.cat (R. Blasco), jordi.rosell@urv.cat (J. Rosell).

expérimentaux ont été appliqués à différents sites archéologiques du Pléistocène inférieur et moyen de la Péninsule ibérique : Grotte du Bolomor (Valence, Espagne) et les niveaux TD10-1 et TD6-2 de Gran Dolina (Sierra de Atapuerca, Burgos). Dans ces assemblages, nous avons pu distinguer des événements de chasse et de charognage à partir de la superposition des traces, en fournissant ainsi un nouvel élément à l'interprétation générale de ces sites. ***Pour citer cet article : R. Blasco, J. Rosell, C. R. Palevol 8 (2009).***

1. Introduction

The study of subsistence strategies at archaeological sites is important in order to know the behaviour of human communities in the past. One of the most important aspects to define the strategies used by the hominids is the procurement of faunal resources. During the last decades, one important debate about the animal obtaining ways in different moments of the Pleistocene has been proposed. There are countless works related to this subject [1,2,8,12,19,21,24,26,27,33,37,43,52,54-57,*inter alia*]. As a result of this discussion, a combination of key elements, in order to identify these techniques for obtaining animal biomass, appears at a methodological level. However, each of these elements implies a particular controversy.

1.1. Taxonomical criteria

Several interpretations have been proposed according to taxonomical composition of faunal assemblages. The presence of dominant species in an assemblage of anthropic origin can be interpreted on one hand, as the result of specialised hunting activities [2,3,18,29,32, *inter alia*], and on the other hand, as the result of scavenging of the prey left by some carnivores (for example, large felids) [12,17]. On the contrary, some authors think that the very varied taxonomic representation can be symptomatic of an opportunist strategy [31]. In all cases, it is important to consider data from palaeoecological and taphonomical studies. They can provide information about the existence of other potential hunting species in the area that are not obtained by human groups.

1.2. Animals' age at death

According to Gaudzinski and Roebroecks [32], in European assemblages of anthropic origin, where the hunting is the most common technique to obtain faunal resources, the animals' age at death usually falls within adult range. For these researchers, human groups tend to look for healthy and adult specimens. On the other hand, immature or senile animals, which do not make full use of their physical faculties, are usually the common prey of carnivores and, therefore, a potential secondary access for hominids [21,48].

1.3. Skeletal representation

Differential transport of anatomical parts to places of habitat is one of the most widely studied matters by the Ethnoarchaeology [4,5,16,34,39,44–47]. These works aim to establish patterns in transport and to explain differential skeletal representation at archaeological sites. For O'Connell et al. [45,46], certain conditioning factors exist, which have an influence on transport-related decisions:

- size of the prey;
- time of the day the animal is obtained;
- number of available carriers;
- distance to the camp.

Oliver [47] adds a new conditioning factor to these: the technology available to process the animal. Certain elements exist, which are discarded or cannot be used optimally without the use of a specialised technique, such as boiling. The mobilisation of the skeletal parts is a phenomenon that is closely linked to the way animal carcasses are obtained, as parts greatly moved depend on the state of the carcasses at the time they are obtained. Several authors suggest that, at archaeological sites interpreted as *camp sites,* where it is common for hominids to have primary access to animals, skeletal elements with a higher nutritional content predominate (principally limb bones) [8,27]. On the contrary, in places where secondary accesses are made to carcasses, the "Klasies" or "Head and foot" model prevails [36–38].

1.4. Location and type of processing marks on the carcass

Study of the situation and type of cutmarks on anatomical elements indicates the action carried out. Incisions related to the extraction of viscera or large muscle mass can be interpreted as a primary access to carcasses [15,23,24,40,42,43,49]. These striae are usually located on the diaphysis of limb bones or on the inside of the ribs. Crader [20] observed that a greater proportion of meat on certain sections could lead to a lower representation of cutmarks. On the other hand, the abundance of carnivore toothmarks on the anatomical portions with large nutritional value and the location of cutmarks on bones with a lower nutritional content could be related to secondary accesses to the carcasses by hominids.

The combination of all these elements is basic to making a good zooarchaeological interpretation of the whole assemblage. However, we must take into account that archaeological sites are usually palimpsests composed by multiple events. Therefore, distinguishing between them is often a complex task, and so palaeoeconomic interpretations tend to generalise. However, some archaeological assemblages occasionally have bone remains that allow individualising specific events of primary and/or secondary access. These direct evidences are bone remains with *overlapping marks*. By overlapping, we mean the marks made by two taphonomical agents or more, which are located in the same point of the bone. Therefore, they allow establishing a time sequence of actions. Thus, overlapping marks acquire great significance when the involved agents are carnivores and hominids. In these cases, they represent direct evidence on the order of accessing the carcasses. Unfortunately, these marks tend to be rare or absent at many archaeological sites, and they are often difficult to interpret when recorded. Identifying which mark is under (previous) or over (subsequent) is not always clear. For this purpose, an experiment has been performed to reproduce this overlapping process for establishing the criteria to identify the order of the predator's action.

2. Materials and methods

In order to carry out this experimental process and reproduce overlapping marks on the bones, ten skeletal elements with meat were used: two scapulae, one pelvis, one tibia and one humerus from a modern adult pig (*Sus domesticus*) and two scapulae, one pelvis, one tibia and one humerus from a modern adult cow (*Bos taurus*). With the objective of reproducing toothmarks, five medium-sized gundogs (*Canis familiaris*) were used. Four are of adult age and one is of a younger age (9 months). These dogs were kept separately in cages, each one of 3×2 m. The resulting toothmarks were classified into three types: pits, punctures, and scores [8,11,14,25,41]. *Pits* consist of superficial marks lacking a long axis, and *punctures* are deep pits that penetrate through the cortical bone or along the edges of an intact or broken bone. *Scores* are surface marks formed when a carnivore tooth cusp crushes and drags along the bone surface, evenly lifting and cutting through different cortical layers with U-shaped cross-sections. In all types of toothmarks, the maximum and minimum width has been measured in millimetres.

The bones were defleshed with a flint flake and cutmarks on the bone surface were documented. These marks are mainly incisions. The *incisions* are striations with a linear outline of variable length, width, and depth. The incisions have a V-shaped section and display internal microstriation [50]. In some cases, Hertzian cones [13], shoulder effects and barbs [53] are found. The number of striations, location on the anatomical element and orientation regarding the longitudinal axis of the bone (oblique, longitudinal, transverse) were taken into account for this study. Maximum and minimum lengths were measured in millimetres. These cutmarks were made.

The generated surface alterations (cutmarks and carnivore toothmarks) were treated at both macroscopic and microscopic levels (Olympus SZ stereomicroscope working from 18 to 110 magnifications). All the experimental process was photographed systematically.

3. Experimental process

First, five anatomical elements (one scapula, one pelvis, and one tibia of *Sus domesticus* and one scapula and one tibia of *Bos taurus*) were defleshed and incisions on the bone surface were recorded. All other skeletal parts (one scapula and one humerus of *Sus domesticus* and one scapula, one pelvis and one humerus of *Bos taurus*) were not subjected to any surface modification. Once the cutmarks were analyzed, all the bones were photographed and thrown to the gundogs. Two skeletal elements were given to each one of these animals: one with cutmarks on the surface and another without cutmarks. The dogs chewed the bones for two days. After this time, the bone remains were collected and photographed once again. All the bones were subjected to the action of the carnivores and therefore, fractures, punctures, pits and scores were documented.

Table 1
Number of cutmarks made on the skeletal elements before being subjected to the dogs gnawing. Maximum and minimum lengths were taken in millimetres.
Tableau 1
Nombre de stries réalisées sur les éléments squelettiques, avant qu'ils ne soient soumis à l'action des chiens. Longueurs maximale et minimale ont été prises en millimètres.

	Skeletal elements	Number of cutmarks	Type cutmarks	Location	Bone surface	Orient.	Measurements (mm)
Sus domesticus	1 scapula	9	Incisions	Supraspinous fossa	Posterior	obl	20.1–29.3
		7	Incisions	Subscapular fossa	Anterior	obl	19.8–23.2
	1 pelvis	10	Incisions	Iliac fossa	Anterior	obl	15.9–34.7
		3	Incisions	Pubis	Lateral	obl	22.5–45.8
	1 tibia	8	Incisions	Diaphysis	Anterior	obl	12.4–32.2
		6	Incisions	Distal metaphysis	Posterior	tr	15.6–28.4
Bos taurus	1 scapula	8	Incisions	Supraspinous fossa	Posterior	tr	27.8–41.4
		12	Incisions	Subscapular fossa	Anterior	obl	23.9–39.2
	1 tibia	11	Incisions	Diaphysis	Anterior	obl	19.8–22.4
		13	Incisions	Diaphysis	Posterior	tr	12.7–25.3
		6	Incisions	Proximal metaphysis	Lateral	obl	16.5–21.2
Total	5	93					

After this, incisions were made on the five bones that did not have cutmarks prior to the action of the carnivores. These striae were made at the same point where the carnivore toothmarks had been observed. Once this process was carried out, the bones were cleaned and analysed at macroscopic and microscopic level to observe possible differences between cutmarks made previously and those made after the action of the carnivores.

3.1. Results of the experimental process

3.1.1. Carnivore toothmarks over cutmarks
Cutmarks were documented on the five defleshed anatomical elements before being subjected to the action of the carnivores. In total, 93 incisions were analysed (Table 1). After the action of the dogs, toothmarks were documented on all the bones (Table 2). Punctures are the most common type of modification (57.4%). This kind of toothmark is mainly documented on the scapula and pelvis of the two species. However, scores are more common on the tibia. In general terms, the observed measurements do not exceed a maximum width of 1.8 mm for scores. The minimum dimensions for this type of toothmark lie between 0.2 and 0.5 mm. However, the size and gradients are extended on the punctures. The maximum measurement does not exceed a width of 4.8 mm and the minimums oscillate between 0.4 and 3.5 mm.

Only in 11.8% of the cases, overlapping of toothmarks over cutmarks was observed. These are located on the subscapular fossa (two), scapular neck (one) and supraspinous fossa (one) of the scapula, on the iliac fossa (one) and ischium (one) of the pelvis and on the diaphysis (two) and distal and proximal metaphysis (three) of the tibia. Overlapped marks were observed on six scores and five punctures. In general, all cutmarks interrupted by toothmarks do not portray variations in their delineation or in their width or depth in any case. Furthermore, the section of the cutmark affected by the toothmark tends to disappear in 90.9% of the cases (Fig. 1).

Observations drawn from this experimental series can be summarised as follows:

- overlapping is documented on both limb bones and flat bones;
- punctures dominate on flat bones and on the metaphysis of limb bones;
- scores are most common on the diaphysis of limb bones;
- cutmarks interrupted by toothmarks do not describe variations in their delineation, width or depth;
- the section of the cutmark affected by a toothmark tends to disappear (whether it is due to dragging the teeth or because of the pressure of the cusp). Therefore, toothmarks do not usually contain signs of cutmarks on their internal surface (side walls and base).

3.1.2. Cutmarks over carnivore toothmarks
Five skeletal elements with meat were subjected to the action of the dogs. After the time set for the activity of the carnivores, all the bones showed toothmarks (Table 3). In the same way as in the previous series, punctures are the most common type of modification (68.75%). These

Table 2
Number of toothmarks observed on the skeletal elements with cutmarks. Maximum and minimum widths were taken in millimetres.
Tableau 2
Nombre de morsures observées sur les éléments squelettiques avec des stries. Largeurs maximale et minimale ont été prises en millimètres.

|	Skeletal elements	Number of toothmarks	Type toothmarks	Location	Bone surface	Measurements (mm.)
Sus domesticus	1 scapula	2	Pits	Supraspinous fossa	Posterior	0.2 × 0.4; 0.2 × 0.5
		2	Punctures	Subscapular fossa	Anterior	2.6 × 3.9; 4.3 × 4.8
		2	Punctures	Scapular neck	Anterior	4.8 × 4.3; 3.6 × 2.9
		4	Scores	Subscapular fossa	Anterior	0.7–1.1; 1.3–1.8
	1 pelvis	7	Punctures	Iliac fossa	Anterior	2.6 × 2.9; 3.7 × 4.8
		3	Scores	Ischium	Lateral	0.8–1.2; 1.4–1.6
	1 tibia	5	Punctures	Distal metaphysis	Anterior	2.4 × 3.2; 3.5 × 3.8
		2	Punctures	Proximal epiphysis	Articular	1.9 × 2.1; 2.2 × 2.4
		2	Scores	Diaphysis	Lateral	0.5–0.8; 0.9–1.1
		3	Scores	Proximal metaphysis	Medial	0.2–0.6; 1.1–1.3
Bos taurus	1 scapula	6	Punctures	Supraspinous fossa	Posterior	3.9 × 4.2; 4.1 × 4.3
		4	Punctures	Subscapular fossa	Anterior	2.5 × 2.9; 3.5 × 3.7
	1 tibia	3	Punctures	Proximal metaphysis	Anterior	2.7 × 2.9; 3.8 × 3.9
		5	Scores	Diaphysis	Posterior	0.7–1.1; 1.3–1.6
		4	Scores	Diaphysis	Lateral	0.7–0.9; 1.1–1.4
Total	5	54				
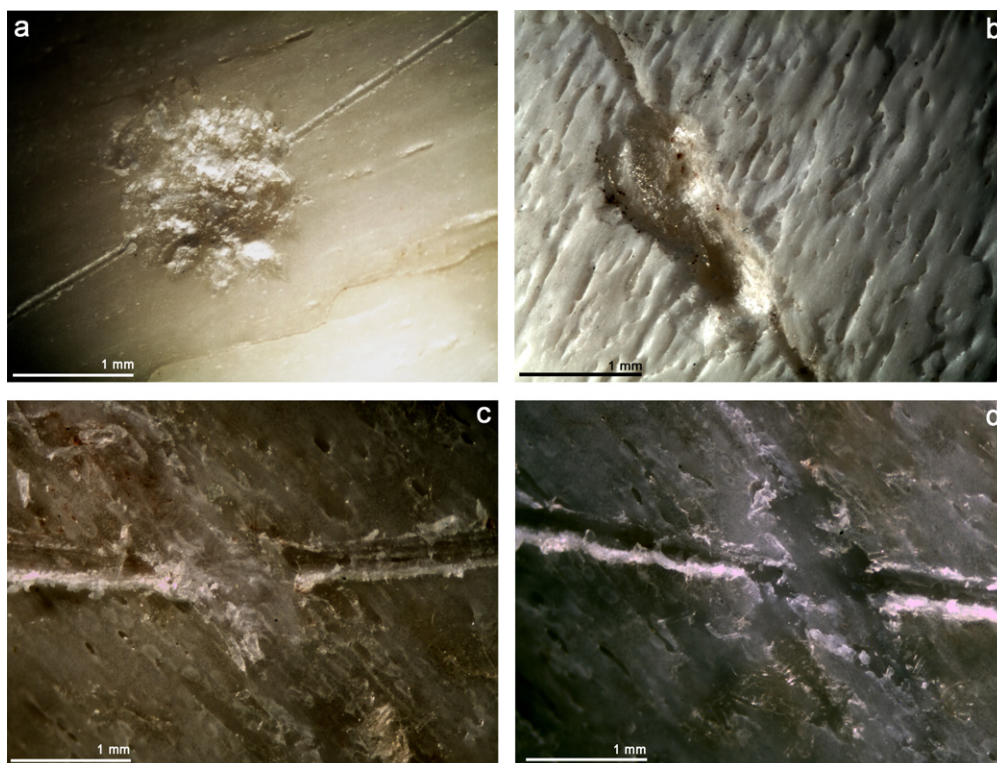
Fig. 1. Experimental examples of carnivore toothmarks over cutmarks (view binocular SZ11): **a, b**: punctures over incisions; **c, d**: scores over cutmarks. The cutmarks do not describe any variation. The incisions disappear when the cusps of teeth are dragged on the bone.
Fig. 1. Exemples expérimentaux de morsures de carnivore sur stries de découpe (vue à la binoculaire SZ11): **a, b**: perforations sur incisions; **c, d**: rainures sur stries. Les stries ne décrivent aucune variation. Les incisions disparaissent, lorsque les cuspides des dents sont traînées sur l'os.

Table 3
Number of toothmarks identified on the anatomical elements without cutmarks. Maximum and minimum widths were taken in millimetres.
Tableau 3
Nombre de morsures identifiées sur les éléments anatomiques sans stries. Largeurs maximale et minimale ont été prises en millimètres.

	Skeletal elements	Number of toothmarks	Type toothmarks	Location	Bone surface	Measurements (mm)
Sus domesticus	1 scapula	11	Punctures	Subscapular fossa	Anterior	0.5 × 0.9; 1.8 × 2.2
		6	Punctures	Supraspinous fossa	Posterior	2.8 × 3.7; 4.9 × 5.1
		3	Scores	Subscapular fossa	Anterior	0.6–0.8; 1.3–1.7
	1 humerus	3	Punctures	Distal metaphysis	Anterior	2.5 × 3.1; 3.3 × 3.5
		2	Punctures	Proximal metaphysis	Lateral articular	2.2 × 2.6; 3.1 × 3.3
		4	Scores	Proximal epiphysis	Medial	0.4–0.7; 1.2–1.4
		3	Scores	Diaphysis		0.8–1.1; 1.9–2.1
Bos taurus	1 scapula	9	Punctures	Subscapular fossa	Anterior	3.5 × 3.6; 4.4 × 4.7
		7	Punctures	Supraspinous fossa	Posterior	3.4 × 3.5; 4.5 × 4.9
	1 pelvis	3	Punctures	Iliac fossa	Posterior	2.5 × 2.7; 4.3 × 4.5
		2	Scores	Ischium	Lateral	0.4–0.7; 2.1–2.4
	1 humerus	2	Scores	Diaphysis	Anterior	0.5–0.9; 1.1–1.5
		6	Scores	Diaphysis	Posterior	0.8–1.2; 1.8–2.1
		3	Punctures	Proximal metaphysis	Lateral	3.8 × 4.2; 4.7 × 4.9
Total	5	64				

were mainly registered on flat bones. The gradients of the toothmarks are also similar to those documented in the previous series (the type of carnivore is the same). In general terms, the measurements observed on scores oscillate between 2.1 and 0.4 mm, and on punctures between 5.1 and 0.5 mm. After this, incisions were made at the same point where the clearest toothmarks were observed. In total, overlapping of cutmarks over toothmarks was produced 32 times: ten incisions were made on scores and 22 on punctures.

In this experimental series, modifications were observed on both cutmarks and toothmarks (Table 4) (Fig. 2). Among other factors, the alterations appear to be conditioned by the type of toothmark. On punctures, the main modification affects the width and depth of incisions in the area adjoining the toothmark (86.36%). On the other hand, the most common alteration registered on scores is a variation in the delineation of cutmarks on the toothmark (90.12%). In general, both types of toothmarks contain sections of cutmarks on their edges in 85.74% of the cases. In the punctures, this modification sometimes describes notches on one of the edges (27.28%). When the toothmark is not very deep, striae are likely to appear on the base (46.87%). Here, we must clarify that depending on the type of stone tool, the tool's wear, and the force used to make the cutmark, the striae can appear on the base of the toothmark at different depths. Finally, it was observed on punctures that several of these modifications are entirely related to the direction of the cutmark (Fig. 3):

- when the cutmark comes into contact with the puncture, an extension of its width and depth is normally produced;
- when the incision comes out of the puncture, it bumps into the toothmark edge and is printed on the internal surface of the toothmark.

At the point of departure, the cutmarks often described an extension depth greater than when it enters in the puncture, and in some cases, a notch on the toothmark edge is produced.

These alterations were registered in the same way on both flat bones and limb bones of the species used for this experiment.

In general, the observations drawn from this experimental series can be summarised as follows:

- punctures dominate on flat bones and on the metaphysis of limb bones;
- scores are most common on the diaphysis of limb bones;
- the type of toothmark conditions the modifications;
- the cutmarks made on punctures are subject to variations in width and depth in the area closest to the toothmark. In the case of scores, incisions usually portray variations in delineation;
- toothmarks contain signs of cutmarks on their edges. When the toothmark is not very deep, striae can also appear on the base. This last alteration is mainly produced on scores;
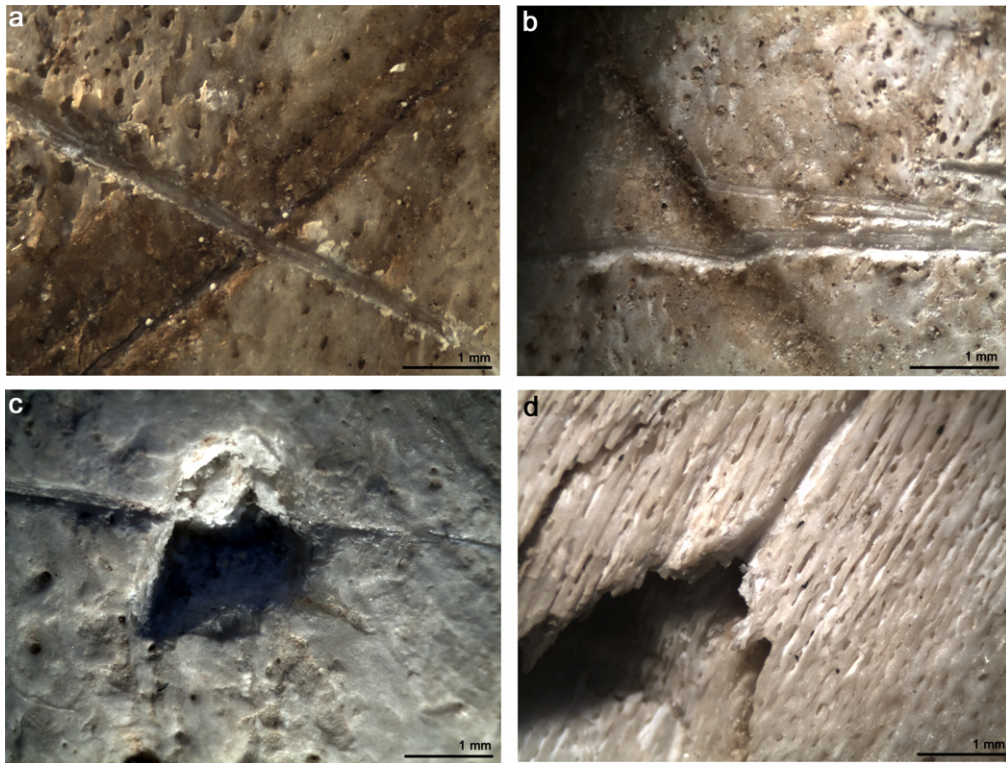
Fig. 2. Experimental examples of cutmarks over carnivore toothmarks (view binocular SZ11). **a, b**: incisions over scores. The cutmark crosses the score and remain printed on toothmark edges; **b**: note the change in the incision delineation on the score; **c**: overlapping of cutmark over puncture. Cutmark width and depth increase in the area near to toothmark. The incision remains printed on the toothmark opposite edge; **d**: detail of the increase of cutmark width and depth at the puncture edge.

Fig. 2. Exemples expérimentaux de stries de découpe sur morsures de carnivore (vue binoculaire SZ11). **a, b** : incisions sur rainures. La strie traverse la rainure et reste imprimée sur les bords de la morsure ; **b** : changement dans la délinéation de l'incision dans la morsure ; **c** : superposition de stries sur perforations. La largeur et la profondeur de la strie augmentent dans la zone proche à la morsure. L'incision reste imprimée sur le bord opposé de la morsure ; **d** : détail de l'augmentation de la largeur et de la profondeur de la strie sur le bord de la morsure.
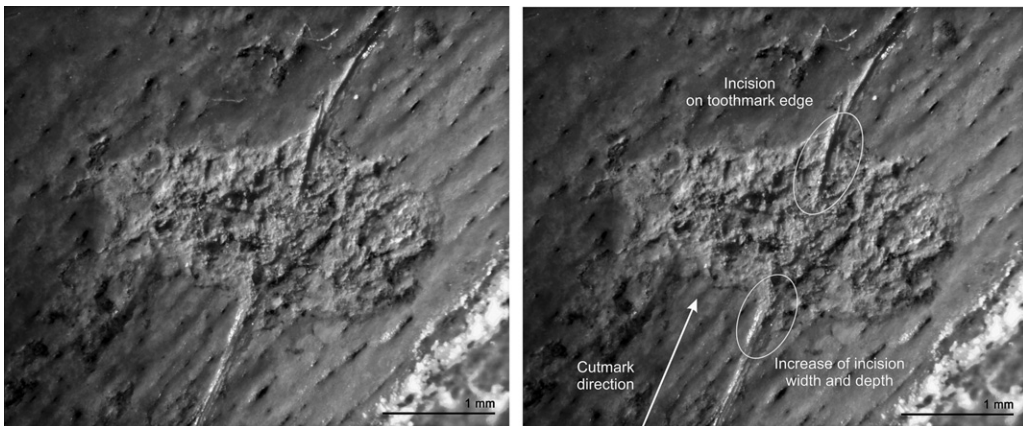

Fig. 3. Modifications observed on cutmarks and carnivore toothmarks according to incision direction.

Fig. 3. Modifications observées sur les stries et les morsures de carnivore selon la direction de l'incision.

Table 4
Cutmarks and toothmarks modifications according to the action sequence of hominids and carnivores on experimental bones.
Tableau 4
Modifications des stries et des morsures de carnivore en fonction de la séquence d'intervention des hominidés et des carnivores sur les os expérimentaux.

	Skeletal element	Type of toothmark	Type of modification					
			Cutmarks modification			Modifications on toothmarks		
			Delineation	Width	Depth	Cutmarks on toothmarks edges	Notches on toothmarks edges	Cutmarks on toothmarks base
Cutmarks/Toothmarks	Flat bones	Punctures (4)	–	–	–	–	–	33.34% (1)
		Scores (3)	–	–	–	33.34% (1)	–	–
	Limb bones	Punctures (1)	–	–	–	–	–	–
		Scores (3)	–	–	–	–	–	–
Toothmarks/Cutmarks	Flat bones	Punctures (19)	10.53% (2)	89.47% (17)	84.21% (16)	68.42% (12)	26.32% (5)	26.32% (5)
		Scores (2)	100% (2)	–	–	100% (2)	–	100% (2)
	Limb bones	Punctures (3)	–	66.67% (2)	66.67% (2)	66.67% (2)	33.34% (1)	33.34% (1)
		Scores (8)	87.50 (7)	25% (2)	12.50% (1)	87.50% (7)	–	87.50% (7)

• several of the observed modifications are related to the direction of the cutmarks;
• all the described modifications do not always occur at the same time and can appear independently.

4. Faunal record application

Gran Dolina (Burgos, Spain) is a cave with a sedimentary sequence divided into 11 stratigraphic levels that cover from the end of the Lower Pleistocene to the Middle Pleistocene. In this study, we present the remains with overlapping marks from two sublevels: TD6-2 (Aurora Stratum) and TD10-1. Level TD6 is formed by gravels and boulders clastic flow deposit (2–2.5 m thick) and this level is well-known by the recovered *Homo antecessor* remains at the sublevel TD6-2 [7]. The mean age, obtained by TL, ESR and U-series, is around 800 Ky [6,28]. The macromammal remains include the presence of *Homo antecessor*, *Ursus dolinensis*, *Canis mosbachensis*, *Vulpes praeglacialis*, *Crocuta crocuta*, *Lynx* sp., *Mustela palerminia*, Proboscidea indet., *Equus* cf. *altidens*, *Stephanorhinus etruscus*, *Cervus elaphus acoronatus*, *Dama nestii? vallonetensis*, *Eucladoceros giulii*, *Bison voigtstedtensis* and *Sus scrofa*. The lithic industry is mainly composed by neogen flint and quartzite. Other used raw materials are the cretaceous flint, sandstone, quartz and limestone. Technologically, this industry is classified into the Mode 1 or Oldowan. At the top of Gran Dolina, sublevel TD10-1 has been dated by TL, ESR and U-series and provides a mean age of 310 Ky (MIS 9) [6,28]. The faunal assemblage is composed by *Ursus arctos*, *Panthera leo fossilis*, *Panthera gombaszoegensis*, *Felis sylvestris*, *Vulpes vulpes*, Proboscidea indet., *Equus ferus*, *Stephanorhinus hemiteochus*, *Cervus elaphus*, *Dama dama clactoniana*, *Megaloceros giganteus*, *Bos/Bison* and Caprini indet. At a technological level, TD10-1 is classified as a transitional moment between Mode 2 or Acheulean and Mode 3 or Mousterian. The used raw materials are the same as recovered at TD6-2. Both levels have been interpreted from the zooarchaeological perspective as two places of habitat for hominids [22,35,51]. Primary and immediate accesses to animals dominate the general set of the two levels. The studied sample of TD6-2 from a stratigraphic sounding made during the season 1994-1995 [7]. This faunal assemblage provided 1056 bone remains [22,51]. On the other hand, 11,191 faunal fragments were recovered in the sample of TD10-1. In total, six bone remains have been documented with overlapping marks (one in TD6-2 and five in TD10-1). In all cases, the cutmarks do not describe variations in width, depth or delineation in the area adjoining
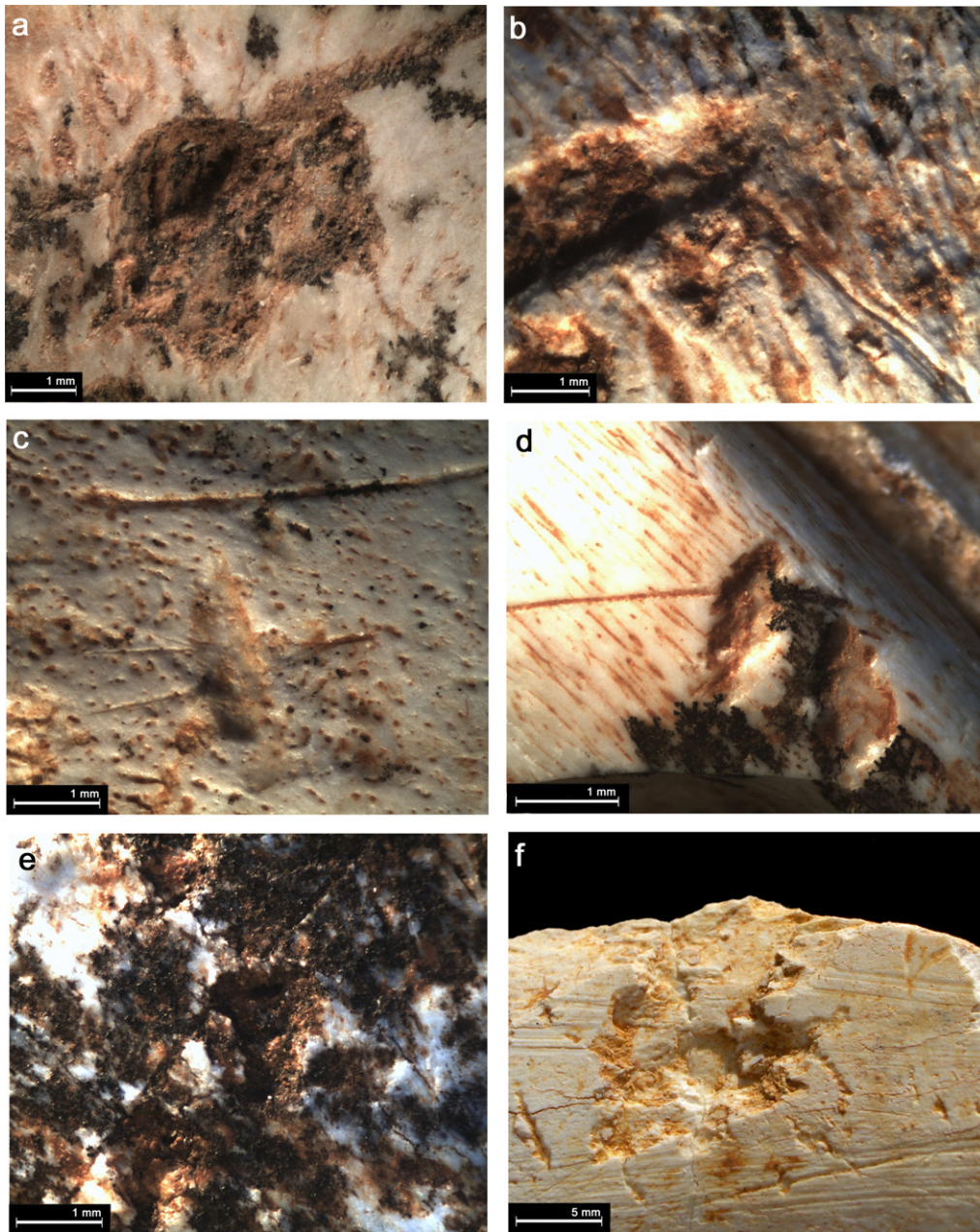
Fig. 4. Overlapping of carnivore toothmarks over incisions from Gran Dolina faunal assemblage (Burgos, Spain). **a**: flat bone from TD6-2 (Aurora Stratum); **b**: limb bone from TD10-1; **c, e**: ribs from TD10-1; **d**: *Cervus elaphus* metatarsal from TD10-1; **f**: Limb bone with carnivore toothmarks over scrape marks from TD10-1. Scrape marks are sub-parallel cutmarks caused when a stone tool is dragged transversally along the length of the bone. In the examples the cutmarks do not describe any variation and the incisions disappear when the teeth enter in contact with the bone. The overlapping marks identified at both levels show that the carnivores access to the bones after the hominids.

Fig. 4. Superposition de morsures de carnivore sur incisions du site de Gran Dolina (Burgos, Espagne). **a** : os plat du niveau TD6-2 (*Aurora Stratum*) ; **b** : os long du niveau TD10-1 ; **c, e** : côtes du niveau TD10-1 ; **d** : métatarsien de *Cervus elaphus* de TD10-1 ; **f** : os long avec morsures de carnivore sur des raclures du niveau TD10-sup. Ce sont des traces subparallèles causées quand un outil lithique est raclé transversalement sur le long de l'os. Sur ces exemples, les stries ne présentent aucune variation et les incisions disparaissent lorsque les dents entrent en contact avec l'os. Les superpositions de marques identifiées dans ces deux niveaux montrent que les carnivores accèdent aux ossements après les hominidés.
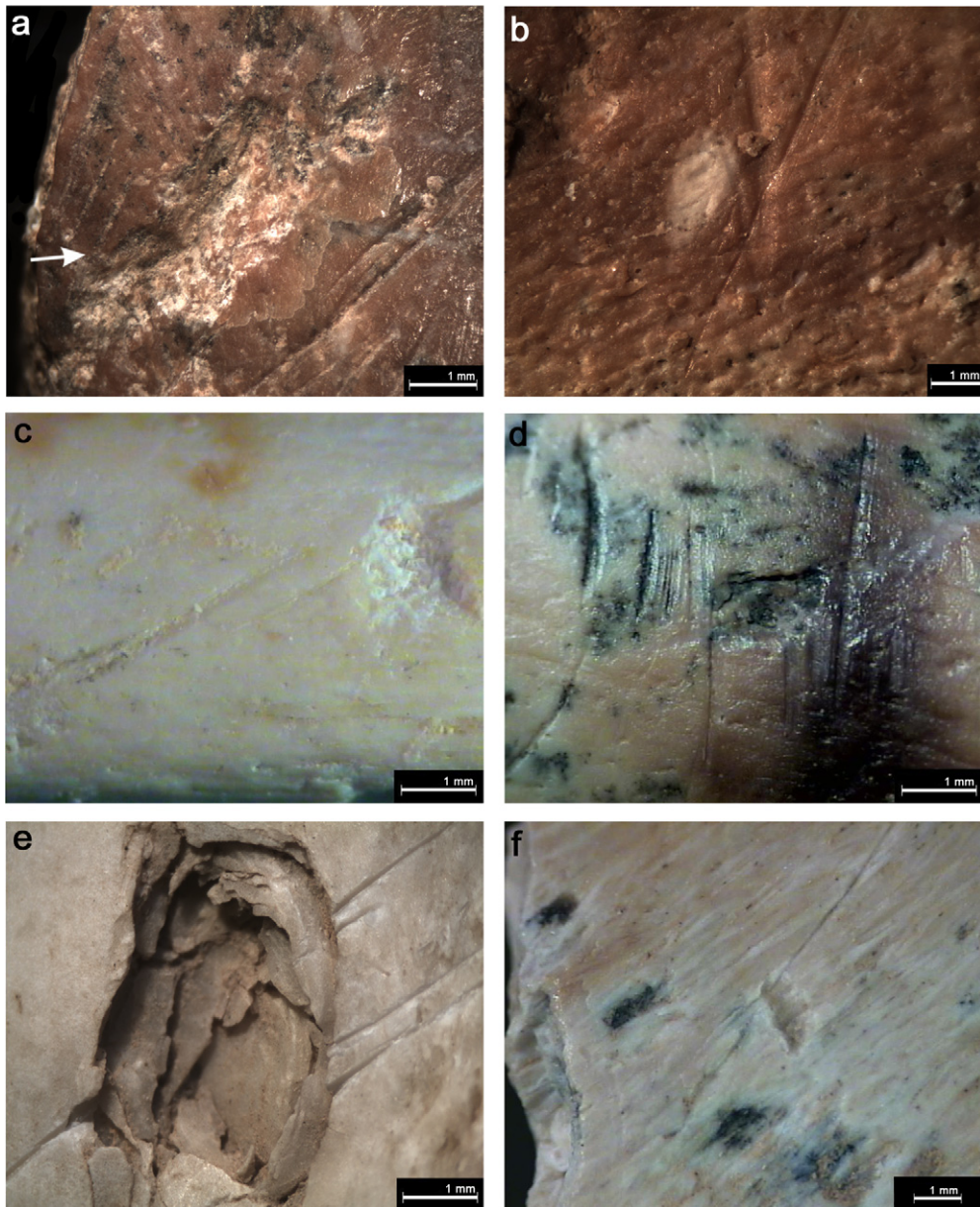
Fig. 5. Examples of overlapping marks on faunal remains from Bolomor Cave (Valencia, Spain). **a**: limb bone with toothmarks over cutmarks from Level IV; **b**: limb bone with one incision over toothmark from Level IV. Note the change in incision delineation on the score and the incision on toothmark edge; **c, d**: limb bones with toothmarks over cutmarks from Level XII; **e**: scapula; **f**: limb bone with cutmarks over toothmarks from Level XII. Note the cutmark width and depth increase in the area near to toothmark, the notch on puncture edge in the case of the scapula and the incision printed on the toothmark edge.

Fig. 5. Exemples de superposition de traces de la Grotte du Bolomor (Valence, Espagne) ; **a** : os long avec morsures sur des stries du niveau IV ; **b** : os long avec une incision sur une morsure de carnivore du niveau IV. Il y a un changement de la délinéation de l'incision dans le *score* et sur le bord ; **c, d** : os long avec morsures de carnivore sur stries du niveau XII ; **e** : scapula ; **f** : os long avec des stries sur des morsures de carnivores du niveau XII. Il y a une augmentation de la largeur et la profondeur des stries dans la zone proche à la morsure, une encoche sur le bord de la *puncture* dans le cas de l'omoplate et l'impression de l'incision sur le bord de la morsure.

the toothmarks. The cutmark disappears on the inside of the toothmark in both cases (Fig. 4). This data, together with the general zooarchaeological analysis, shows primary access to the animal carcasses by the hominids.

Bolomor Cave (Valencia, Spain) is a cave with a sedimentary sequence divided into 17 stratigraphic levels that cover temporal part of the Middle Pleistocene (MIS 9 to MIS 5e). The faunal assemblage from Bolomor
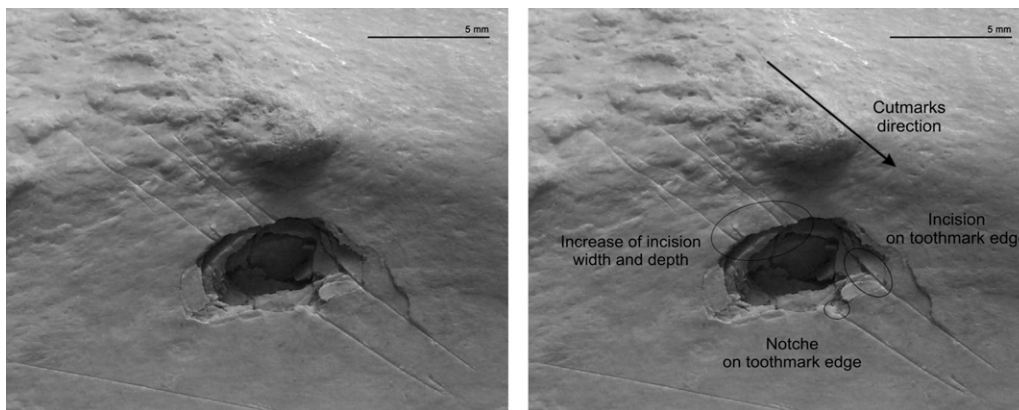
Fig. 6. Scapula with cutmarks over puncture from Level XII of Bolomor Cave. Note the bone modifications according to the direction of incisions.
Fig. 6. Scapula avec des stries sur une *puncture* de carnivore du niveau XII de la Grotte du Bolomor. Il y a des modifications de l'os en fonction de la direction des incisions.

Cave includes 20 macromammals species. The biostratigraphic sequence is mainly characterised by the presence of *Hemitragus* sp.*, Equus ferus*, *Cervus elaphus* and *Dama* sp. and by a more specific record at certain times of other species such as *Megaloceros giganteus*, *Sus scrofa*, *Macaca sylvana*, *Equus hydruntinus*, *Bos primigenius*, *Stephanorhinus hemitoechus*, *Paleoloxodon antiquus*, *Hippopotamus amphibius* and *Castor fiber*. The presence of carnivores in the cave is sporadic. The lithic industry recovered at this site is classified as a Middle Palaeolithic technocomplex. The documented raw materials consist mainly of flint, but also limestone and quartzite have been recovered [30]. This study presents overlapping marks from two levels: Level XII (MIS 6) and Level IV (MIS 5e) [9,10,30]. Both levels have been interpreted as human places of habitat with high elements of primary accesses to animal carcasses [9]. The analysed faunal remains in this study are: 1059 at Level XII and 25327 at Level IV.

Overlapping marks have been identified on 19 bone remains: six at level XII and 13 at level IV. Most of this overlapping concurs with the general interpretation of the sets on the primary access to carcasses by hominids.

Most of the cutmarks do not describe variations in their delineation, width or depth in the area closest to the toothmark. In the same way, cutmarks do not usually appear on toothmark edges and base (Fig. 5a, c, d). However, at both level XII and level IV, three bone remains have been identified, which suggest occasional secondary access of hominids to carcasses abandoned by carnivores. On these bone remains, we have identified:

- variations in the cutmark's delineation (Fig. 5b);
- extension of cutmark's width and depth in the area closest to the toothmark (Fig. 5e);

- incisions on the toothmark edges and base (Fig. 5b, e, f).

According to experimental criteria, the direction of the cutmarks on punctures has been clearly identified in one case (Fig. 6).

Nevertheless, some overlapping marks do not present sufficient criteria to identify the predators' sequence of access to the prey. In these cases, the general characteristics of the archaeological set must be considered: the taxonomy, skeletal representation, the animals' age at death, the anthropic processing marks and those made by carnivores.

5. Conclusions

The overlapping marks on bone remains of an archaeological assemblage are a direct evidence to determine whether hominids were the first to obtain the prey or not. Through this experimental process, we have observed diagnostic elements on overlapping marks that show the sequence of action of the predators (hominids and carnivores) on carcasses. These criteria consist of modifications on both cutmarks and toothmarks. In cases in which the cutmarks are located over the toothmarks, the following characteristics are documented: variations in the delineation, thickness and depth of cutmarks in the area closest to the depression; the toothmarks contain signs of cutmarks on their edges and when the depression is not very deep, striae can also appear on their base; and/or according to the direction of the cutmarks, when the incision comes into contact with the toothmark, an extension of the width and depth is produced and when the incision comes out of the puncture, normally is printed on the toothmark wall describing an increase

of depth on the puncture edge. Sometimes, this extension of depth produces a notch on the toothmark edge. On the other hand, in cases where the toothmarks are above the cutmarks, the section of incision interrupted by the tooth-mark tends to disappear. These experimental criteria have been applied to different archaeological sites of the Lower and Middle Pleistocene in the Iberian Peninsula: levels XII and IV of Bolomor Cave (Valencia, Spain), and levels TD10-1 and TD6-2 of Gran Dolina (Atapuerca, Burgos). In these assemblages, the overlapping marks indicate primary accesses to the carcasses by hominids. According to zooarchaeological data, these kinds of accesses are most common in the presented archaeological sets [9,22,35,51]. However, despite this predominance of type of accesses, only in the case of Bolomor Cave, sporadic human scavenging has been registered at both level IV and level XII from the over-lapping marks.

Acknowledgements

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