



Another window to the subsistence of Middle Pleistocene hominins in Europe: A taphonomic study of Cuesta de la Bajada (Teruel, Spain)



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ABSTRACT

Cuesta de la Bajada is a Middle Pleistocene site (MIS 8–9) in which some of the earliest evidence of Middle Paleolithic stone tool tradition is documented. The small format tool assemblage, dominated by simple flakes and scrapers, is associated to abundant remains of equids and cervids, in which both percussion and cut marks are well represented. The anatomical distribution of these bone surface modifications indicate primary access to fleshed carcasses by hominins. Hunting is further supported by the analysis of age profiles, in which prime adults are predominant both in equids and cervids. The taphonomic analysis of the site adds more information to human predatory behaviors as documented in other Middle Pleistocene sites and is one of the best examples of hunting documented in the Middle Pleistocene European archaeological record.

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1. Introduction

In the past fifteen years, an increasing number of taphonomic studies have supported behavioral reconstructions of European Middle Pleistocene hominids as hunters, especially after Marine Isotopic Stage (MIS) 7 (<242 Ka), reversing 1980s academic trends that portrayed Middle and Early Pleistocene hominids as scavengers. Several analyses of Middle Paleolithic sites have supported reconstructions of Neandertals as probable hunters who were heavily dependent on meat (Gaudzinski, 1996, 1998, 1999; Gaudzinski and Turner, 1999; Jaubert et al., 1990; Marean, 1998; Marean and Kim, 1998; Marean and Assefa, 1999; Mussi, 1999, 2001; Chase, 1999; Conard and Prindville, 2000; Roebroeks, 2001; Bar-Oz et al., 2004; Villa, 2004, 2008). For the earlier part of this period, sites such as Taubach (Bratlund, 1999) and Wallertheim 11 (Gaudzinski, 1996) in Germany, Coudoulous I (level 4) (Jaubert, 1999) and Biache-Saint-Vaast (Auguste, 1991, 1995) in France and

Bolomor Cave (Blasco, 2011; Blasco et al., 2010; Blasco and Fernández Peris, 2012), Atapuerca TD10 (Blasco, 2011; Blasco et al., 2013; Rodríguez-Hidalgo et al., 2015) and Áridos (Yravedra et al., 2010) for Spain contain convincing evidence of carcass exploitation by hominids, likely involving primary access to animals. However, the archaeological evidence of carcass consumption and hunting becomes more ambiguous prior to MIS 8–9 (Gaudzinski, 1999; Gaudzinski and Turner, 1999; Voormolen, 2008; Villa, 2008). This ambiguity can be attributed to complex taphonomic histories and poor bone preservation in sites older than 300 ka.

There are some exceptions, as reviewed by Villa (2008). Gran Dolina TD6 (part of the Atapuerca site complex in Spain), dated between 860 ka and 780 ka, contains about 150 bones with hominid-imparted marks, with limited evidence of carnivore intervention (most likely made by small canids, after deposition); this suggests primary access to carcasses (Díez et al., 1999; Fernández-Jalvo et al., 1999). Recent studies support these interpretations, but suggesting a higher impact by carnivores (Saladié et al., 2011, 2014). The abundance and anatomical distribution of cut-marked bones at the pene-contemporary site of Gesher Benot Ya'aqov in Israel is also suggestive of primary access to fallow deer

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carcasses (Rabinovich et al., 2008). At Isernia in Italy, dating to slightly over 600 ka, there are hammerstone-broken bones; however, intensive abrasion prevents accurate identification of cut marks and therefore limits interpretations regarding hominid access to carcasses (Coltorti et al., 2005; Thun Hohenstein, 2009). The presence of a single horse carcass site at Boxgrove (U.K.) with abundant cut marks, mainly distributed on larger bones, indicates defleshing (Roberts and Parfitt, 1999) and also suggests primary access to carcasses by hominids.¹ An abundance of hominid-marked bones at Bilzingsleben (Germany) have also been interpreted as the result of hominids hunting game (Mania, 1990). The Bolomor Cave (Spain) is an important Middle Pleistocene site with a high taxonomic diversity, which also includes mesofauna bearing traces of human exploitation (Blasco and Fernández Peris, 2012; Blasco et al., 2010). The Atapuerca TD 10.1 assemblage, dominated by deer and with a prime-adult mortality profile, contains bone surface modifications also suggestive of specialized (focusing on single taxon) early access (probably hunting) to carcasses (Blasco, 2011; Rodríguez-Hidalgo et al., 2015). Similar inferences of early access to carcasses have been made for megafaunal exploitation at La Cotte de Saint Brelade (Smith, 2015). Despite this mounting evidence of early access to carcass remains in the Eurasian Middle Pleistocene, the most impressive example of hunting comes from the German site of Schöningen 13II-4 (Voormolen, 2008). There, over 650 cut-marked bones have been documented, mostly on a minimum of 21 equid carcasses. Marks are found on all anatomical sections and show thorough butchery of equid and cervid carcasses. The site, better known for its impressive wooden spears² (eight discovered to date), shows a faunal assemblage dominated by equids, with far fewer cervids and bovids. This indicates a specialized faunal exploitation strategy, which is fully supported by Voormolen's (2008) taphonomic analysis.

Given that current evidence for hominid carcass exploitation prior to 250 ka remains scarce, Schöningen appears quite exceptional. This leads us to ask, are sites like Schöningen, Boxgrove, Bolomor Cave and Gran Dolina TD10 and TD6 atypical, or do they reflect behaviors that occurred frequently in the early Middle Pleistocene, but are obscured at other sites by poor preservation and other taphonomic factors? Here we present a taphonomic study of Cuesta de la Bajada (Teruel, Spain), a site dating to 243–337 ka that has, in a substantial part of the assemblage, very good preservation of faunal remains. The taphonomic study was carried out on remains produced by a small excavation (<90 m²) compared to that of Boxgrove or Schöningen. Details of the excavation, stratigraphy, geology and lithic assemblage have been published by Santonja et al. (2014). Here we report on the taphonomic results of the three main levels (CB1, CB2 and CB3) from the collection until the 2007 excavation. Our results show that, as at Schöningen, the site's occupants specialized in the consumption of equids, which were obtained prior to access by carnivores. Although composed mainly of equids, the Cuesta de la Bajada assemblage also contains a significant number of remains of cervids, and of some other taxa represented by a few elements each (Table 1). This taxonomic diversity provided the opportunity to study differential carcass exploitation strategies. This open-air site represents one of the best taphonomically-supported examples of hunting in the European Middle Pleistocene. We use taphonomic

Table 1

Minimum number of individuals (MNI) discovered in each of the three Cuesta de la Bajada levels.

	CB1	CB2	CB3
<i>Equus chosaricus</i>	4	7	11
<i>Cervus elaphus</i>	3	3	9
<i>Stephanorhinus</i> cf. <i>hemitoechus</i>		1	
<i>Elephas</i> (<i>Palaeoxodon</i>) <i>antiquus</i>			2
<i>Bos primigenius</i>	1		1
<i>Capra</i> sp.		1	
<i>Rupicapra rupicapra</i>	1		
<i>Canis lupus</i>		1	

evidence and age profiles to support this conclusion.

2. Methods

There is a hierarchical scale of analytical techniques that is commonly applied to taphonomic studies of archaeological sites. This scale begins with anatomical profile analyses (involving taxonomic and skeletal part identification, specimen and element quantification), continues with the study of bone surface modifications and ends with the study of bone breakage patterns. The first part of the scale has usually played a bigger role than the other two parts in the taphonomic interpretation of faunal assemblages. However, Domínguez-Rodrigo et al. (2007) argued that the analysis of physical modification of bones should play a major role in taphonomic studies. Their “physical attribute approach” inverted this hierarchical scale to begin with bone breakage and bone surface modifications and end with anatomical profiles in the interpretation of faunal assemblages. Biotic agents that interact with carcasses can modify cortical surfaces and break bones in specific ways that are experimentally replicable and taphonomically detectable. Physical agents also leave traces on carcass remains that can be observed in the form of weathering, polishing and abrasion, both at macro- and microscopic levels. Consideration of these factors should be primary and not secondary to any taphonomic study. Here we apply the physical attribute approach to the Cuesta de la Bajada assemblage, focusing only on bone specimens coming from secure contexts. Specimens that came from the surface or that were not plotted were excluded so that we could completely control the position of each analyzed specimen.

2.1. Ageing

Age profiles of bone assemblages have recently re-emerged as important zooarchaeological tools. Assemblages with distinctive age profiles have been used to distinguish carnivores from humans as the main accumulating agents: most carnivores have been viewed as specialists in accumulations of juvenile and old individuals (Vrba, 1980) whereas humans have been identified as the only agent concentrating on prime adults (Klein et al., 1981, 1983; Stiner, 1994, 2005; Steele, 2000; but see Arriaza et al., 2015). Traditional ageing methods have been sometimes quite coarse, differentiating between broad age groups: infantile/juvenile, adult and old individuals, based on epiphyseal fusion and tooth eruption and wear data. However, greater precision is possible. Spinage (1971, 1973) pioneered a model for using crown heights to age ungulates that was further developed by Klein et al. (1981, 1983), Klein and Cruz-Urbe (1984) and Steele (2002). This is now known as the quadratic crown height method. It uses a series of quadratic formulas that can be used to predict age at death of animals from tooth crown heights. This method needs to be tested on modern age-controlled populations and it has been applied to very few taxa thus far. Fortunately, one of the best-studied species for this method is *Cervus elaphus*, which is represented at Cuesta de la

¹ Roberts and Parfitt (1999) suggest that a hole in the scapular blade may have been made by a spear.

² The discovery of these hunting weapons marks a historic sea change in the hunting-scavenging debate. Most researchers previously believed that hominids were scavengers during the entire Middle Pleistocene in Eurasia; many have since been convinced of a more dynamic role for hominids in carcass obtainment.

Bajada. Ageing of *C. elaphus* has been very precisely developed using a large known-age control sample ($n = 226$ individuals) to determine the relationship between tooth crown height and age and to refine the quadratic crown height method (Steele, 2002).

For the cervid teeth at Cuesta de la Bajada, mandibular dp_4 , M_1 , M_2 and M_3 were measured following Steele (2002) and Klein and Cruz-Urbe (1984). Crown height and breadth were taken on the anterior lobes of each tooth. Basal and occlusal breadths were also measured. Crown height was measured as the minimum distance between the occlusal surface and the enamel-dentine junction line on the buccal surface. Measurements were taken with high-resolution Mitutoyo digital calipers to the hundredth millimeter. In infantile and juvenile individuals, eruption patterns were also identified. The formula used here is the same used by Steele (2002) for *C. elaphus*:

$$dp_4 : AGE = AGEs[(CH - CH_0)/CH_0]^2$$

$$M_1 : AGE = (AGETpl - AGEe)[(CH - CH_0/CH_0)]^2 + AGEe$$

where AGEs is the age at which dp_4 is shed (26 months); AGEe is the age of eruption for M_1 (6 months); AGETpl is Age of Tooth Potential Longevity (163.6 months); CH_0 is the mean initial unworn crown height (26 mm); and CH is the crown height (in mm). AGETpl and CH_0 data were taken from Steele's (2002) quadratic regression tables. The same formula (with different AGETpl and CH_0 values) applied to M_1 was also applied to M_2 and M_3 , as a control framework to confirm ages estimated from M_1 and also to maximize the number of teeth (and individuals) that could be aged. However, Steele (2002) stressed the slightly lower resolution of the quadratic formula when applied to M_2 – M_3 . The quadratic formula enabled age estimates within 10% of lifespan age classes. The resulting mortality profiles were plotted in triangular graphs showing three broad age groups, based on the following definitions: subadults comprise individuals below 20% of lifespan, prime adults are individuals aged between 20% and 50% of lifespan, and old adults were individuals older than 50% of lifespan. These triangular graphs showed bootstrapped confidence intervals as described by Steele and Weaver (2002). See also Steele and Weaver (2012) and Weaver et al. (2011).

Equids were aged using a combination of tooth eruption patterns and observations of the incisor crown (Silver, 1969; Levine, 1982). The combined features used were: incisor crown shape, presence/absence of cups, stars (pulp cavity) and spots (deepest part of infundibulum after disappearance of the cup). For horses less than 10–11 years, incisors have successively flat, oval, rounded, triangular and rectangular shapes. Parallel to these changes, the cup (center of infundibulum) becomes smaller as the dental star (pulp cavity) emerges. The shapes of the cup and the star also change with age. The ages of equids had a 2-year confidence interval, in contrast with the more precise ageing (in months) of cervid teeth. Crown heights of cheek teeth were also measured following Levine (1982) to compare with results derived from the analysis of incisor shape. The resulting ages were estimated in 10% life span age intervals, defining each age group and plotted in a triangular graph as was done for the cervids.

2.2. Skeletal part profiles

A taphonomic study should aim to maximize the number of bone specimens that can be used to understand processes involved in the accumulation and modification of the assemblage. Therefore, knowing the carcass size is more taphonomically informative than the exact species. The bulk of most bone assemblages are fragments

(e.g., flat bones, limb shafts) that cannot be identified to species, but excluding them from anatomical profiling analyses because they cannot be taxonomically identified can seriously bias a taphonomic study in terms of skeletal part representation and bone surface modifications. Moreover, taphonomic processes affect carcasses differently according to their size and not their taxonomic identity: for example, remains of a young cow and a deer may have similar skeletal part representation and surface modifications when consumed by a pack of wolves, but these signatures can be very different for an adult cow. Lumping juvenile and adult cattle remains may mask these differences. Thirdly, a significant number of bones in the Cuesta de la Bajada assemblage are highly altered by the burial environment, thereby showing chemical weathering affecting diagnostic criteria on their surfaces and rendering species determination very difficult. For all these reasons, we decided to divide the bone sample by size only. "Small" refers to Bunn's (1982) sizes 1³ to 3A⁴ and applies mostly to deer bones and the few infantile or juvenile (<2 years) equid remains found at the site. "Intermediate" or "medium-sized" refers to Bunn's size 3B and applies mostly to older juvenile and adult equid bones, the bulk of remains at the site. "Large" refers to Bunn's sizes 5 and 6 (>one ton in weight), corresponding to rhino and elephant, respectively. These are very minimally represented at the site.

Specimens were divided into cranial (skull, mandible and loose teeth), axial (ribs, vertebrae) and appendicular anatomical sections. For many taphonomic analyses, pelvis and scapulae were lumped with axial bones given that their cancellous texture and response to taphonomic processes are similar to those of axial elements (Yravedra and Domínguez-Rodrigo, 2009). Long limb bones were classified as upper (humerus and femur), intermediate (radius and tibia) or lower (metapodials) limbs as suggested by Domínguez-Rodrigo (1997a).

Carnivores are known to delete certain bones and bone portions from faunal assemblages: for example, Brain's (1967, 1981) reports of dog-modified bone assemblages showed that proximal epiphyses of humeri and tibiae, distal radii and both femoral epiphyses were underrepresented. Studies with hyenas have shown similar patterns (Marean et al., 1992; Capaldo, 1995, 1997; Pickering et al., 2003). Estimates of the Minimum Number of Elements (MNE) for long limb bones were therefore made using both epiphyseal and shaft specimens, and major differences can be seen between these estimates and those made using epiphyses alone in the Cuesta de la Bajada assemblage; these estimates sometimes differ by more than an order of magnitude, as is expected in a situation of intensive carnivore ravaging. This is supported by actualistic studies that show that limb bone shafts always survive at rates higher than epiphyses when subjected to carnivore ravaging (Pickering et al., 2003; Pickering and Egeland, 2006; Marean et al., 2004; contra Stiner, 2002, 2004, 2005). This can be explained by the shafts' higher density and lack of grease. The ratio of shafts per epiphyseal specimen ranges from 3:1 (Blumenschine, 1988; Marean et al., 2004) or 5–7:1 (Capaldo, 1995) to 10:1 (Blumenschine, 1988) in modern experiments on bone breakage, with or without carnivore intervention. This varies by bone type, with hammerstone-broken intermediate limbs producing more shafts than upper limbs (Pickering and Egeland, 2006).

The identification and quantification of MNE (Lyman, 1994a:

³ Including remains of Caprinae and Canidae, which were very few in the assemblage.

⁴ Animals averaging <150 kg. While some *C. elaphus* males can reach 200 kg, even then they are noticeably smaller than adult horses. For this reason, and to keep cervids and equids in different taphonomic categories, we consider the former as "small" and the latter as "intermediate" carcass size.

290) can be made following different methods. Higher-order (i.e. more abstract) estimates such as MAU (Minimum Number of Animal Units) and MNI (Minimum Number of Individuals) hinge entirely on accurate MNE estimates. For long limb bones, the exclusion of shafts in the counting of elements can have serious consequences, as shown by Morlan (1994), Lam et al. (1998), Marean and Kim (1998), Marean (1998), Marean and Frey (1997), Bartram and Marean (1999), Milo (1998), Costamagno (2002), Barba and Domínguez-Rodrigo (2005), Pickering et al. (2003) and Marean et al. (2004). To calculate limb MNE, Marean et al. (2001) have created a method using GIS-based software, inspired by previous approaches that assigned long limb specimens to different portions of the element by considering section, side and orientation (Watson, 1979; Klein and Cruz Uribe, 1984; Patou Mathis, 1984, 1985; Münzel, 1988; Becker and Reed, 1993; Todd and Rapson, 1988; Delpech and Villa, 1993; Morlan, 1994).

We did not use this software for our analysis⁵; rather, we used an integrative approach to MNE estimation that is described in detail by Yravedra and Domínguez-Rodrigo (2009). This method uses the bone section division proposed by Patou Mathis (1984, 1985), Münzel (1988) and Delpech and Villa (1993), and divides shafts into arbitrary sectors that can be easily differentiated and oriented, irrespective of areas of muscular insertion. The criteria used in the division of each sector consider the orientation (cranio-caudal, latero-mesial) of each specimen. The method also considers criteria for element identification described by Barba and Domínguez-Rodrigo (2005) that describe the thickness, cross-section and medullary surface of shaft specimens. After identifying specimens to element, we estimated the MNE by laying all specimens from the same element and carcass size group across a very large surface, enabling us to compare specimens side-by-side. This is the best way to conduct a comprehensive analysis (*sensu* Lyman, 1994b) that considers factors such as element size, side, age and biometrics.

Faith and Gordon (2007) recently showed that skeletal element abundances can be quantified using Shannon's evenness index. Citing optimal foraging theory, they argue that the degree of selectivity with which foragers transport carcasses will be reflected in the distribution of specimens across classes of "high-survival elements" (*sensu* Marean and Cleghorn, 2003; Cleghorn and Marean, 2004). Crania and appendicular elements are higher-density anatomical regions that tend to survive taphonomic processes better than most axial elements. In situations where entire carcasses are transported, or where no transport has occurred, there should be a perfectly even distribution of these high-survival elements (standardized by their frequency in a complete carcass, using MAU); as transport becomes increasingly selective, evenness should decline. The interpretation is that the even representation of cranial and long limb bones indicates short-distance carcass transport, whereas lower evenness suggests long-distance transport. To use this method, it is critical to use assemblages where limb MNE estimates are derived from both shafts and epiphyses.

Faith et al. (2009) suggested a possible diachronic trend where Lower Paleolithic (ESA) sites showed evidence of short-distance transport and Middle Paleolithic (MSA) sites showed evidence of long-distance transport, suggesting that the latter is a behavior that appeared relatively late in human evolution. The present work enables us to further test this hypothesis, and enlarges the very

small sample of early sites in which limb MNEs have been properly estimated. Limb MNE estimates from Cuesta de la Bajada were standardized by transforming them into MAU before calculating Shannon's evenness index.

2.3. Size sorting and bone surface modifications

We analyzed specimen size distribution to detect preservation bias: assemblages affected by physical processes such as hydraulic jumbles, or by selective recovery of remains, will show fewer smaller specimens (especially from limb shafts). We also looked for traces of abrasion and polishing attributable to water transportation, and we evaluated the preservation of cortical surfaces. Finally, we sought and identified bone surface modifications whenever possible. These include cut marks, tooth marks, percussion marks and natural marks (biochemical and abrasion marks). Marks were identified using hand lenses under strong direct light (60 W) following the methodological and mark diagnostic criteria specified in Blumenschine (1988, 1995) and Blumenschine and Selvaggio (1988) for tooth and percussion marks, and Bunn (1981), Fisher (1995) and Domínguez-Rodrigo (1997a, 1997b, 2002) for cut marks.

Blumenschine (1995:29) described carnivore tooth marks as "contain[ing] bowl-shaped interiors (pits) or U-shaped cross-sections (scores; see also Bunn, 1981) that commonly show crushing that is conspicuous under the hand lens, and which, macroscopically, gives the mark a different patina than the adjacent bone surface." He describes percussion marks as "pits, grooves or isolated patches of microstriations. Pits and grooves are usually associated with densely packed and shallow patches of microstriations oriented approximately transverse to the long axis of the bone ... these patches of microstriations occur within and/or emanate from the depression. Microstriations also occur as isolated patches" (Blumenschine, 1995: 29). In our analysis, attributes for tooth and percussion marks were recorded for each bone specimen and tallied using the bone portion system described by Blumenschine (1988, 1995) – epiphyseal, near-epiphyseal and mid-shaft portions – to enable comparisons with his data. Marks on near-epiphyseal specimens are not reported since our definitions differ. Blumenschine classifies shaft specimens showing any cancellous bone on the medullary surface as near-epiphyseal, whereas we would only consider a specimen to be near-epiphyseal when cancellous tissue is present on at least one-third of the medullary surface; this was shown to produce major quantitative differences in a recent re-analysis of the Olduvai Bed I assemblages (Domínguez-Rodrigo et al., 2007). Since we use Blumenschine's (1988) experimental data here, we discarded near-epiphyseal specimens for comparability.

Marks were also recorded according to element type and the precise location where they appear, as described by Domínguez-Rodrigo (1997a, 1997b, 1999). This approach is very informative since carnivores modify bone sections differently according to the order of access to carcasses. Marks are differentially distributed on bone sections when flesh, marrow and grease are removed from bones by carnivores. By considering element type in the analysis of tooth marks, one can better detect the moment of carcass obtainment by hominids in the carcass consumption sequence. Elements modified by carnivores can thus be identified and compared with those modified by hominids, and then carnivore-hominid interaction and order of access to carcasses can be understood.

Bones from Cuesta de la Bajada show intensive modification created by roots and their associated fungi and bacteria. Criteria used to differentiate these biochemical marks from other structurally similar marks are described by Domínguez-Rodrigo and Barba (2006, 2007) and are applied here. Useful criteria for

⁵ This method can prevent an analyst from identifying elements in a comprehensive way: i.e., considering multiple variables (section shape, thickness, etc.) to differentiate between specimens that clearly belong to different animals (and thus are different elements), even if they belong to the same carcass size and do not physically overlap.

distinguishing tooth marks from biochemical marks include: depth of crushed cortical layers, overall symmetry of the mark's trajectory, lack of exfoliation, staining of the inside of the mark (and not just the outline of the groove, as in biochemical marks), and especially the clearly U-shaped cross-section of a tooth mark *versus* shallow exfoliation in a biochemical mark.

2.4. Bone breakage patterns

Breakage patterns were analyzed from three distinct but complementary perspectives: the analysis of notches, the distribution of shaft circumference types and measurements of breakage plane angles. Additionally, we documented the breakage type (green *versus* dry/diagenetic) following Villa and Mahieu (1991). According to their criteria, dry breaks result in numerous breakage planes that are longitudinal and transverse to the axis of the bone. The angle between the cortical and medullary surfaces is close to 90° and the breakage plane surface is uneven, with micro-step fractures and an uneven texture. This contrasts with the smoother surface of green-broken specimens, their oblique breakage planes and acute or obtuse breakage plane angles.

For notch analysis, whenever possible we differentiated between those created by dynamic loading (hammerstone percussion) and those created through static loading (carnivore pressure). Capaldo and Blumenschine (1994) quantified the frequency and morphology of notches produced by these two methods, showing that percussion notches are more abundant than carnivore notches, and are also broader and shallower in cortical view. The flakes removed from percussion notches also show a more obtuse angle, as a reflection of the acute angle left on the medullary side of the notch. Here we measured and quantified five variables used to define notches: notch breadth and notch depth from the cortical view, scar breadth and notch depth on the medullary surface, and the platform angle of the scar. Each notch was then classified as follows (modified from Capaldo and Blumenschine (1994)):

1. *Complete notches* have two inflection points on the cortical surface and a non-overlapping negative flake scar.
2. *Opposing complete notches* are two complete notches that appear on opposite sides of a fragment and result from two loading points.
3. *Incomplete Type A notches* are missing one of the inflection points.
4. *Incomplete Type B notches* have a collapsed loading point, resulting in an incomplete negative flake scar on the medullary surface.
5. *Incomplete Type C notches* have negative flake scars that overlap with an adjacent (also Incomplete Type C) notch.
6. *Bifacial notches* have double scars, one visible on the cortical surface and the other on the medullary surface.

Supplementing the work of Capaldo and Blumenschine (1994), Domínguez-Rodrigo et al. (2007) also found that the distribution of notch types differs in assemblages broken by humans *versus* by carnivores: incomplete Type C and opposing notches are twice as abundant in a carnivore-broken samples than in a hammerstone-broken experimental samples. These data provide important supplementary information on the agent of breakage in archeofaunal samples, although they are still preliminary and need further confirmation.

When limb bones are broken they typically produce numerous shafts fragments, some epiphyseal fragments, and the latter are often consumed by carnivores (e.g., Bunn, 1983, 1986, 1991, 1993; Bunn and Kroll, 1986; Binford et al., 1988; Blumenschine, 1988; Marean and Spencer, 1991; Marean et al., 2000). Bunn (1982,

1983) documented differences in the way humans and carnivores modify long bone shafts as evidenced in the amount of shaft circumference preserved. He classified shafts as Type 1 (less than half the circumference), Type 2 (more than half but less than complete), and Type 3 (complete circumference). Experiments showed that when bones are broken by either humans or carnivores, the frequencies of each types may vary, but the ratio of Types 2 and 3 together to Type 1 ranges from 0.44 to 0.10; i.e., Type 1 specimens always outnumber the other types (Bunn, 1982).

Finally, we documented breakage plane angles on specimens with breakage planes >4 cm. The physical principle is the same that applies to notches, as well as to stone flakes: dynamic loading (hammerstone percussion) creates an impact on bone that expands according to the density of the bone and the force of the impact, detaching a fragment with an angle that tends to be acute or obtuse, just as stone flakes made by percussion tend to have acute or obtuse platform angles. By contrast, static loading (carnivore gnawing) results in angles closer to 90°, just as pressure flaking results in stone flakes with platform angles closer to 90°. This approach was experimentally modeled on bones from small and large carcasses with varied density (Alcántara et al., 2006) and was successfully applied to archaeological and paleontological contexts (Pickering et al., 2005). We apply this approach to the Cuesta de la Bajada assemblage.

3. Results

One of the most striking features of the Cuesta de la Bajada assemblage is that it is mainly composed of equid bones (Table 2). Equids have been identified as *Equus chosaricus* (Santonja et al., 2014). Cervids (*C. elaphus*) are the second-largest group, but with a much smaller number of bones per individual (see level-by-level analysis below). Other taxa are minimally represented both in terms of individuals (Table 1) and elements (Table 3). Here we present our results by analysis type and by archaeological level.

3.1. Skeletal part representation

3.1.1. Level CB1

A total of 341 plotted specimens were identified in this level (Table 2), belonging to a minimum of four equids (two of which are subadult), three cervids (all adult), one size 1 bovid, one size 3–4 bovid and a proboscidean (Table 1); the latter three individuals are represented by a very small number of specimens each (see below). Forty-one specimens could confidently attributed to deer, including most post-cranial remains from small carcasses (Table 2). Excluding the 73 specimens that could not be assigned to a carcass size, cervid remains make up 15% of the identifiable sample (13 NISP per MNI). Subadult equids are represented by very few bones (9 NISP per MNI). Older equids are much better represented, with 73 NISP per MNI. Equid MNI was derived from dental and pelvic elements.

Both equids and cervids are represented by elements from the whole skeleton, but cancellous parts are less well represented (Fig. 1). There is a contrast in element representation between small and medium-sized carcasses, with the latter having a more even representation. Small carcasses are represented mainly by cranial (dental) remains and to a much lesser degree by pelves and metapodials. Medium-sized carcasses are better represented by dense parts: cranial elements and metapodials are better represented than most other elements except pelves and scapulae, which together with compact bones show a survival frequency that is unexpectedly high when compared to limb epiphyses. When carnivore ravaging is documented, scapulae and pelves usually survive less often than dense limb epiphyses. Their higher survival here suggests very limited carnivore disturbance. By contrast, the

Table 2

Number of identifiable specimens (NISP) for small and medium-sized carcasses according to archaeological level.

	CB1			CB2			CB3		
	small	medium-sized	indet size 2–3	small	medium-sized	indet size 2–3	small	medium-sized	indet size 2–3
Horn	1			8			8		
Skull	2	16	4	23	28	8	24	38	15
Mandible	5	7	2	14	12	1	32	25	5
Teeth	12	31		40	119	11	46	145	15
Vertebrae indet.	4	5	1	16	43	4	11	11	
cervical		3			8			9	
		1			5		2	2	
					3		1	4	
Ribs	2	9		21	51	7	15	31	10
Scapulae	3	7	1	6	31		4	33	1
Innominate	8	20		10	36	2	8	21	3
Humerus									
prox.				1	2			4	
	1	12		3	33		11	49	1
				1	3			1	
Radius									
prox.				1	4		1	3	
	1	4	1	3	14		2	23	
		1			1			1	
Ulna	1	1			9			3	
prox.					3			3	
Metacarpal ^a									
prox.		1			4			3	
		4		1	5		7	13	
	1	3			4			4	
Femur									
prox.		1			2			2	
	0	8		3	26	1	11	36	
				1	1			1	
Tibia									
prox.					1				
	3	22		8	38		32	66	5
					1		1	2	
Metatarsal ^a									
prox.		1			8		1	12	
	1	1		5	7		25	7	
	1							1	
Carpal/tarsal	2	20		4	51		5	69	
Phalanges		12		4	34		11	27	
ULB ^b		3		7	15	1	11	15	3
ILB ^b				5	9		2	13	1
LLB ^b	1	18		12	35		9	46	3
Others				1	5		2	5	1
Indeterminate	1	7	64	9	42	271	18	72	205
Total	50	218	73	207	693	306	300	800	268

^a In equids, only central metacarpus and metatarsus are considered here; lateral metapodials were counted in the LLB category.^b ULB, Upper Limb Bone; ILB, Intermediate Limb Bone; LLB, Lower Limb Bone.

virtual absence of ribs and vertebrae points to an important preservation bias, which could result from carnivore intervention or from hominid transport selection decisions. These different interpretations can be examined through the analysis of bone surface modifications, particularly tooth marks. The skeletal profiles in level CB1 could also reflect the much smaller sample size here compared with underlying levels.

Estimation of long limb MNE differs when we use epiphyses or a combination of epiphyses and shafts (Tables 2 and 3; Fig. 2). Despite the small sample size, several elements would go unnoticed if the epiphyseal approach were used. In almost every single element, estimates are higher when using shafts.

When plotting element representation against each element's nutritional value,⁶ a weak relationship is seen (Fig. 3). For small carcasses, Spearman's rho is -0.346 ($p = 0.206$) and for medium-sized carcasses it is -0.107 ($p = 0.717$). These results could reflect small sample size, or biases introduced by carnivores or other taphonomic agents. Support for this latter inference comes from the moderate relationship between bone density and MAU representation for small carcasses (Spearman's rho = 0.410 ; $p = 0.156$) and medium-sized carcasses (Spearman's rho = 0.403 ; $p = 0.171$). Shannon's evenness index for limb bone representation, using MAU, is 0.84 for small-sized carcasses and 0.91 for medium-sized carcasses. This low degree of evenness could indicate that carcasses were originally deposited incomplete, despite post-depositional preservation biases, or it could reflect long distance transport or be an artefact of small sample size.

3.1.2. Level CB2

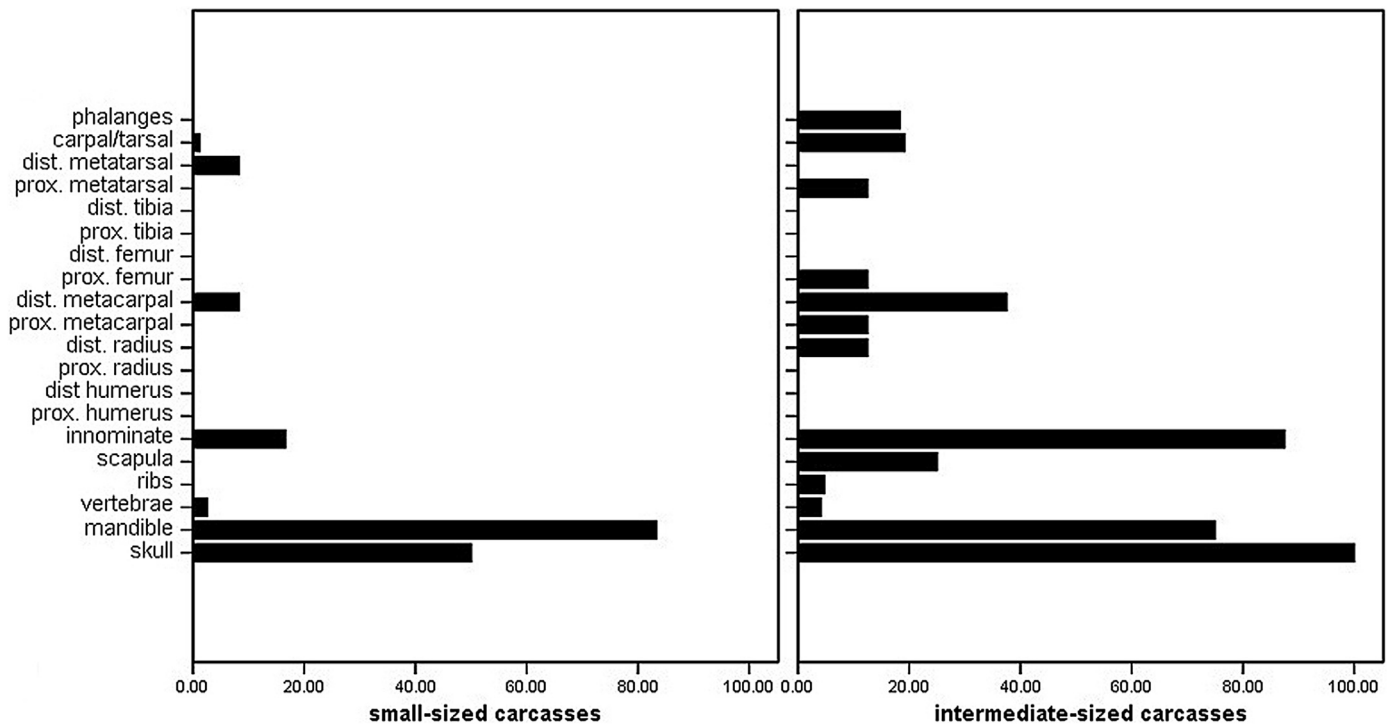
A total of 1206 plotted specimens were identified in this level,

⁶ MNE from small carcasses were transformed into %MAU and compared to Metcalfe and Jones (1988) FUJ (Food Utility Index) for caribou. Equid %MAU was compared to the equid food utility index obtained by Outram and Rowley-Conway (1997).

Table 3

Minimum number of elements (MNE) for small and medium-sized carcasses according to archaeological level.

	CB3		CB2		CB1	
	Small	Medium-sized	Small	Medium-sized	Small	Medium-sized
Skull	11	7	2	6	3	4
Mandible	10	6	3	5	5	3
Vertebrae indet	8	8	4		4	3
		cervical ^a		8		1
		toracica		5		1
		lumbar		3		
Ribs	5	10	3	17	0	5
Scapulae	5	14	1	14	0	2
Innominate	4	6	4	16	2	7
Humerus	2	7	2	10	1	3
Radius	2	9	2	8	1	2
Metacarpal ^b	3	5	1	8	1	3
Femur	3	8	2	4	0	2
Tibia	4	8	2	7	1	3
Metatarsal ^b	9	9	3	8	1	1
Carpal/tarsal	5	69	4	51	2	20
Phalanges	11	27	4	34	0	11

^a Including atlas and axis.^b In equids, only central metacarpus and metatarsus are considered here; lateral metapodials were not included.**Fig. 1.** Frequencies of skeletal elements and long limb bone portions (according to MNI) for small- and medium-sized carcasses from CB1.

belonging to a minimum of seven equids (of which two are sub-adult) and three cervids, as well as one rhino, one proboscidean and one canid, the latter three represented by very few specimens each, as was seen in level CB1 (Tables 1 and 2). Estimates of MNI for equids were obtained from scapular, pelvic and tarsal elements. Of the total NISP, 165 specimens can confidently be attributed to cervids.⁷ Excluding the 306 specimens that could not be assigned to carcass size due to intense fragmentation, cervid remains make up 18% of the identified specimens. Despite having an MNI that is a

little over one-third the MNI of equids, cervids show a NISP:MNI ratio that is almost half that of equids, which are more completely represented. Estimates of equid MNI were obtained from scapular, pelvic and tarsal elements.

Both equids and cervids are represented by elements from the entire skeleton. Certain cancellous bones and bone sections are very underrepresented (Fig. 4). Small carcasses are mainly represented by crania and pelvis.⁸ Long limbs are underrepresented (according to MNI) and are mostly represented by the densest

⁷ Most long limb specimens from small carcasses belong to cervids, not subadult equids.

⁸ Long limb bones are better represented when using shafts, than when excluding them as seen in Fig. 5.

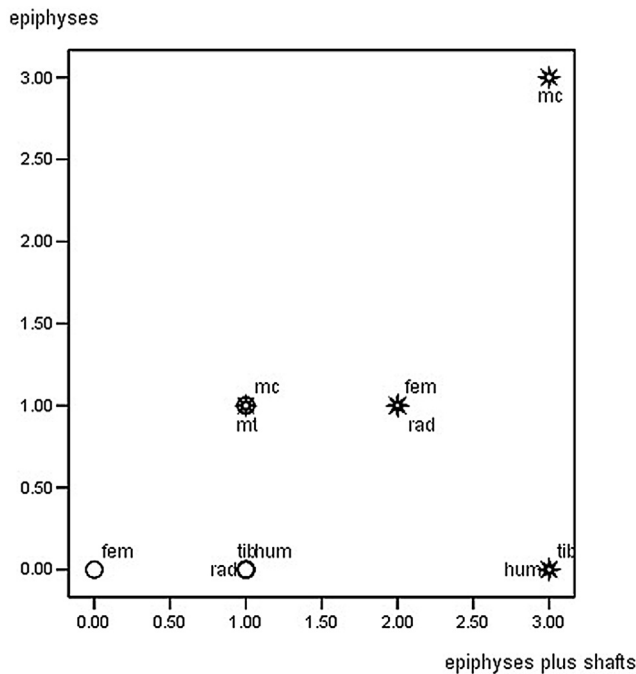


Fig. 2. Estimates of minimum number of elements from long limb bones from CB1 when using epiphyses only and epiphyses plus shafts for small-sized carcasses (open circle) and medium-sized carcasses (star).

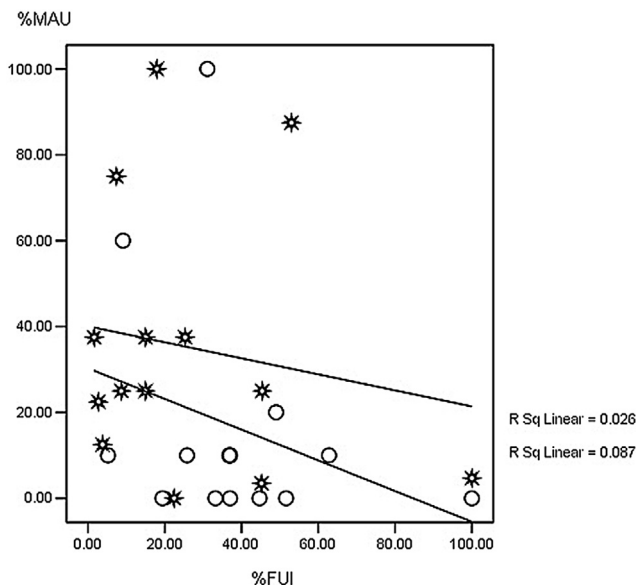


Fig. 3. Correlation between anatomical parts represented at CB1 (%MAU) and their nutritional value (%FUI) for small-sized carcasses (open circle) and medium-sized carcasses (star).

portions of each element. The least dense elements in the skeleton are virtually absent, especially compact bones (carpals, tarsals and phalanges), vertebrae and ribs. It could be argued that in small carcasses there is a preservation bias related to skeletal density. Medium-sized carcasses (equids) show a similar pattern in which crania, pelves and scapulae are the best represented; however, in contrast with smaller carcasses, the remainder of the skeleton is more evenly represented. The best-represented long limb epiphyseal portions are the densest ones and metapodial epiphyses are the most abundant. Ribs and vertebrae are the most under-

represented skeletal elements, as was the case with small carcasses. Though there is some density-mediated attrition, the presence of fairly complete pelvic and scapular remains together with a high proportion of compact bones indicates rather limited carnivore intervention in the modification of medium-sized carcasses.

As in level CB1, we see a major quantitative difference in MNE estimates made using shafts and epiphyses together *versus* epiphyses alone (Table 3; Fig. 5). This supports claims that when bone assemblages have undergone any taphonomic bias, long limb MNE estimates are better derived when including shafts (Marean and Kim, 1998; Marean and Assefa, 1999; Pickering and Domínguez-Rodrigo, 2004; Assefa, 2006; Yravedra and Domínguez-Rodrigo 2009). It is difficult to estimate how taphonomic biases have affected the representation of elements *versus* their original pre-depositional representation. When plotting element representation against nutritional value as described above for level CB1, a weak negative relationship is seen (Fig. 6): for small carcasses, Spearman's rho is -0.089 ($p = 0.753$), and for medium-sized carcasses, Spearman's rho is -0.24 ($p = 0.404$). When compared to bone density a positive relationship is documented for small carcasses (Spearman's rho = 0.371 ; $p = 0.213$), but not for medium-sized carcasses (Spearman's rho = 0.080 ; $p = 0.793$). This suggests the following possibilities: carcasses may have been selectively transported by hominids, who discarded axial sections at kill site; complete carcasses transported to the site may have undergone strong post-depositional ravaging by carnivores; or taphonomic agents other than hominid and carnivores may have intervened and modified the original skeletal pattern. These three possibilities will be examined further below.

Shannon's evenness index for small-sized carcasses is 0.96 and for medium-sized carcasses is 0.97. This suggests that high-survival elements were equally selected by accumulating agent(s). This supports the hypothesis that there is a very small taphonomic bias against low-survival elements in medium-sized carcasses (a bigger bias for smaller carcasses), that carcasses were non-selectively transported and that transport distance may potentially have been short.

3.1.3. Level CB3

A total of 1368 plotted specimens were identified in this level, representing a minimum of 11 equids (four of which are juvenile), nine cervids (two of which are juvenile), one size 3–4 bovid and one proboscidean (Tables 1 and 2). A total of 242 bones were attributed to cervids, giving a ratio of 26 NISP per MNI, substantially higher than cervid NISP/MNI ratios in the overlying levels. Juvenile equids are represented by 17 NISP per individual, and adult equids by almost 133 NISP per MNI. Estimates of equid individuals were derived from scapular, dental and tarsal elements.

As in the overlying levels, small and medium-sized carcasses differ in skeletal part representation, with the latter having more complete representation (Fig. 7). Crania, followed by scapulae and some denser elements such as long bones, constitute the bulk of elements represented in cervids and very young equids. All elements are represented (Table 3) in older equids, with crania, scapulae, metatarsals and pelves being better represented. The densest portions of long limb bones are better represented than the most cancellous ones, and ribs and vertebrae are poorly represented. Although this might suggest carnivore ravaging, the high survivorship of pelves, scapulae and compact bones indicates that carnivore impact must have been fairly small. This is supported by the following: large portions of innomates have been preserved; scapulae show large parts of their blades intact or only broken by diagenesis; and the surviving compact bones show almost no tooth marks. The pre-depositional representation of adult equids can be

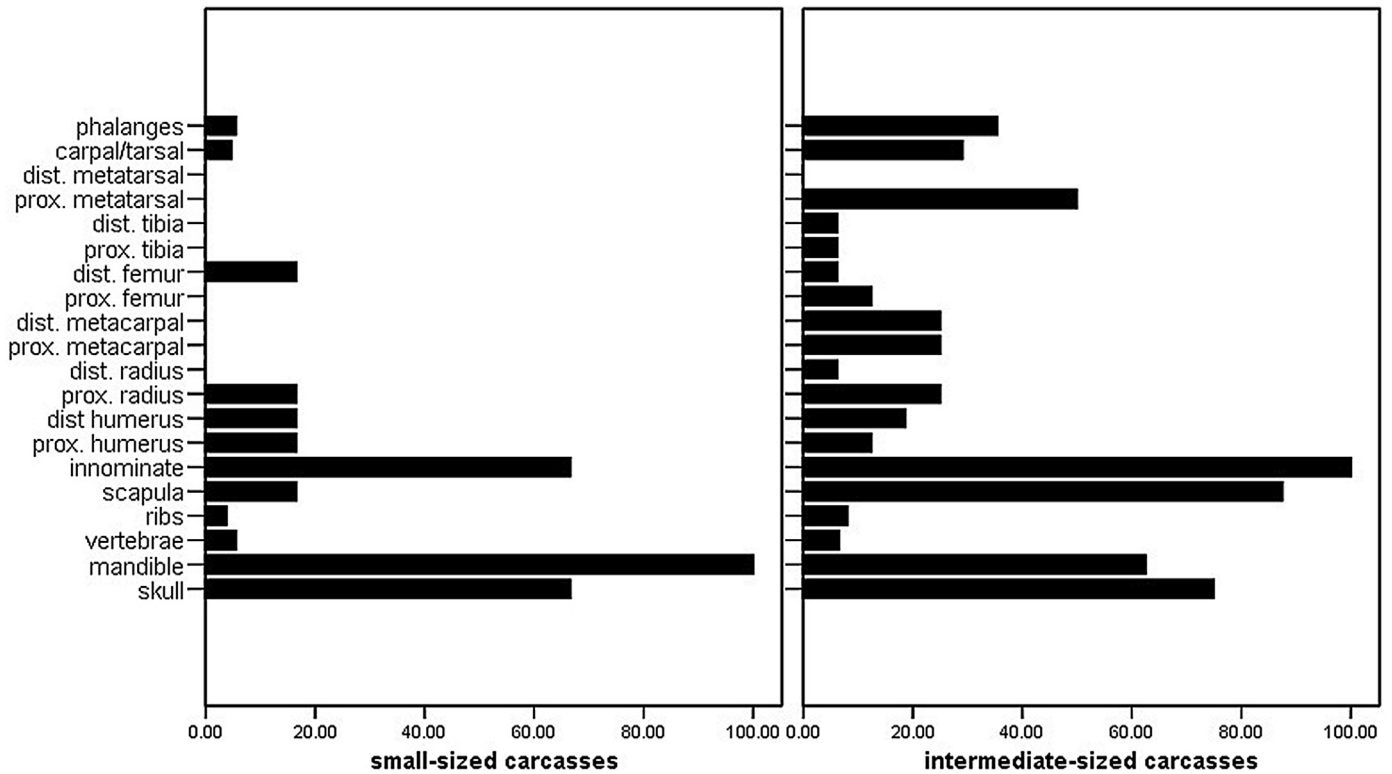


Fig. 4. Frequencies of skeletal elements and long limb bone portions (according to MNI) for small- and medium-sized carcasses from CB2.

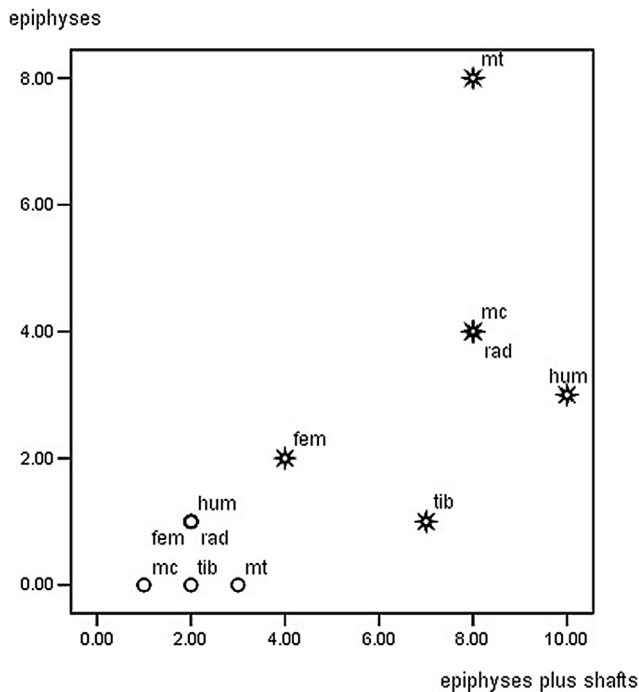


Fig. 5. Estimates of minimum number of elements from long limb bones from CB2 when using epiphyses only and epiphyses plus shafts for small-sized carcasses (open circle) and medium-sized carcasses (star).

interpreted as having been fairly complete, and post-depositional disturbance (which accounts for deletion of elements like ribs and vertebrae) seems to have been limited. Whether this deletion was caused by carnivores or other taphonomic agents will be discussed below. This preservation process seems to have been the

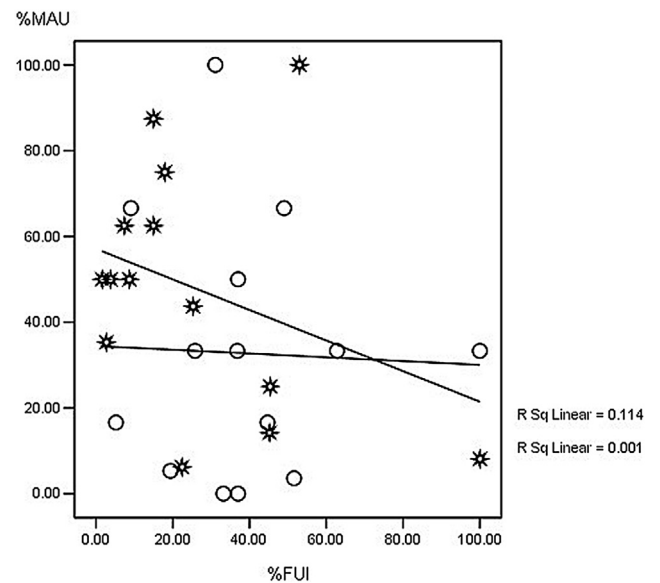


Fig. 6. Correlation between anatomical parts represented at CB2 (%MAU) and their nutritional value (%FUI) for small-sized carcasses (open circle) and medium-sized carcasses (star).

same that explains the very biased skeletal pattern documented among cervids and subadult equids.

As in the overlying levels, long limb MNE estimates are higher when using shafts and epiphyses than when using epiphyses alone (Fig. 8). Using these estimates to compare element representation with nutritional value yields weak negative correlations for small carcasses (Spearman's rho is -0.112 ; $p = 0.692$) and for medium-sized carcasses (Spearman's rho is -0.292 ; $p = 0.310$) (Fig. 9).

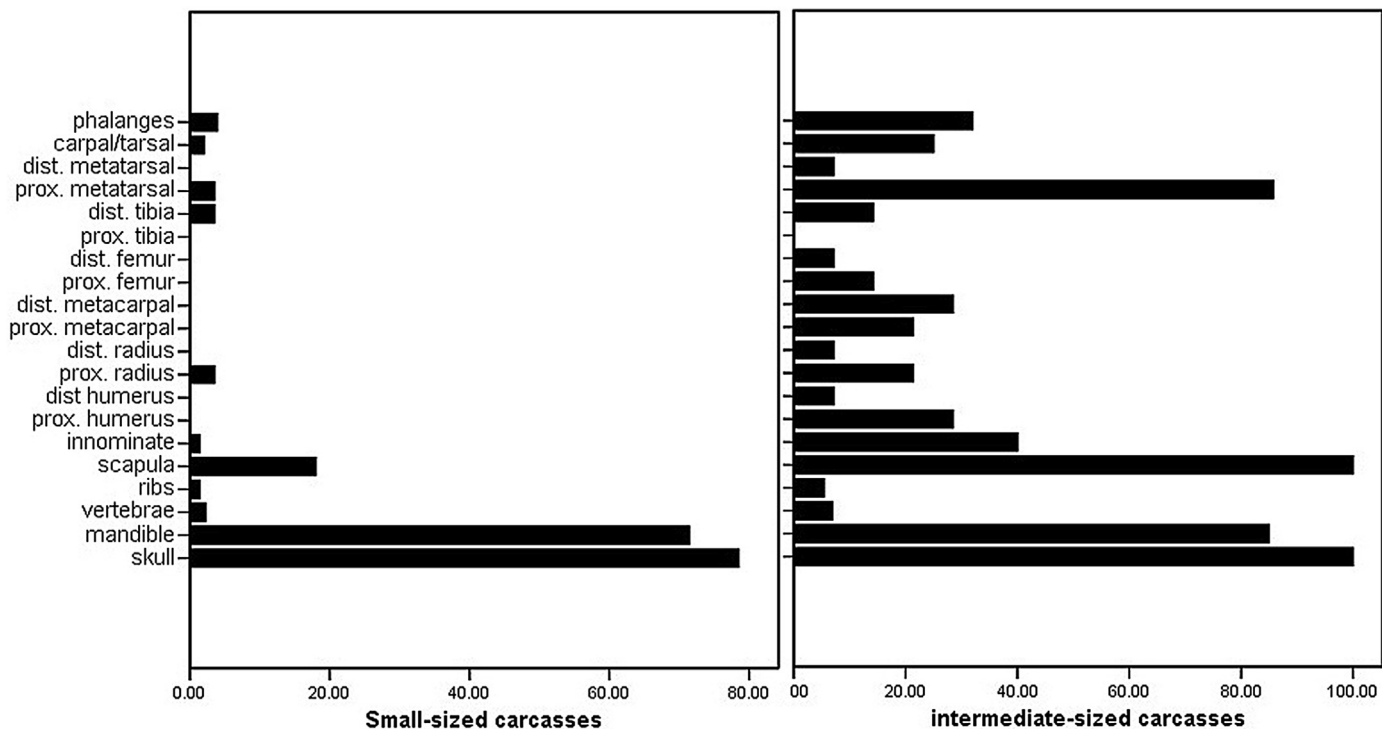


Fig. 7. Frequencies of skeletal elements and long limb bone portions (according to MNI) for small- and medium-sized carcasses from CB3.

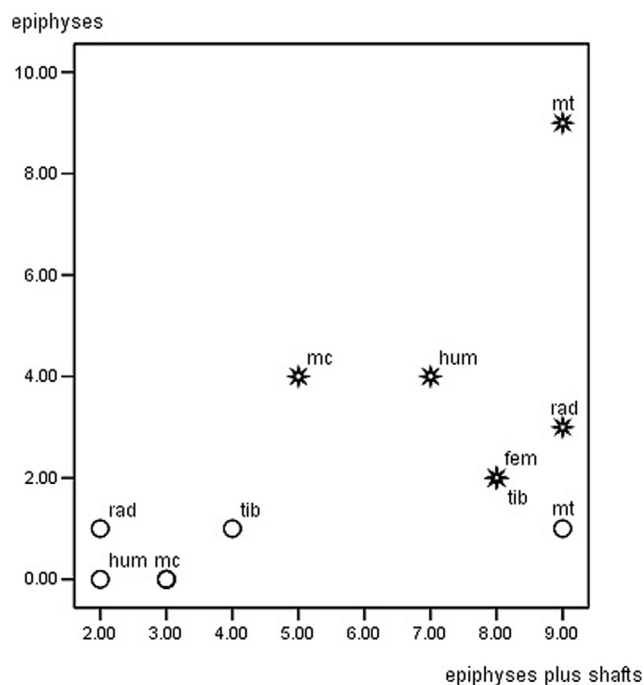


Fig. 8. Estimates of minimum number of elements from long limb bones from CB3 when using epiphyses only and epiphyses plus shafts for small-sized carcasses (open circle) and medium-sized carcasses (star).

Once again differential preservation accounts for the negative correlations in small carcasses, but not so much for medium-sized animals. When comparing MAU to bone density a positive relationship is documented for small carcasses (Spearman's $\rho = 0.421$; $p = 0.151$). In contrast, medium-sized carcasses show a very small positive relationship between bone density and MAU

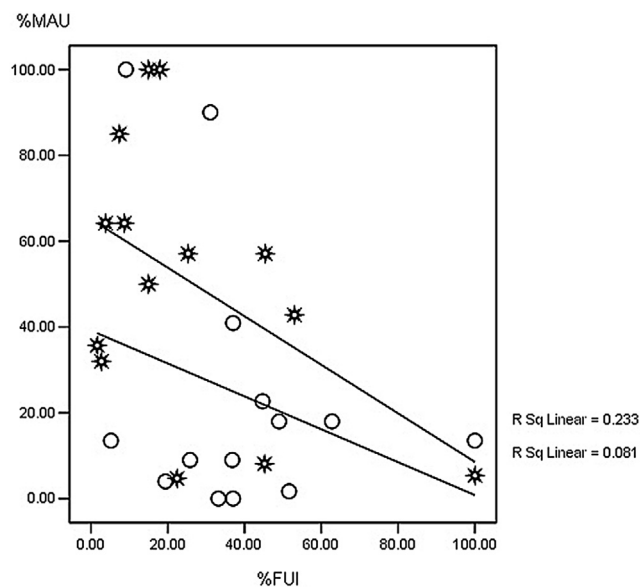


Fig. 9. Correlation between anatomical parts represented at CB3 (%MAU) and their nutritional value (%FUI) for small-sized carcasses (open circle) and medium-sized carcasses (star).

representation (Spearman's $\rho = 0.171$; $p = 0.575$). However, Shannon's evenness indices (0.8 for small carcasses and 0.97 for medium-sized carcasses) suggest that adult equid carcasses were fairly complete at the site. This indicates that the missing elements may have undergone post-depositional deletion, probably by carnivores, given that all the high-survival bones from the entire skeleton are well represented. Cervids and subadult equids, in contrast, may not have been completely represented. Whether the missing elements were absent due to differential preservation or

transport selection remains an open question, which we explore further below using other taphonomic indicators.

3.1.4. Summary

The above results support our decision to group remains by carcass size and not taxonomically. The differences in element representation between adult and subadult equids would have otherwise passed unnoticed: young subadult equids are very marginally represented, even more than cervids, whereas several of the subadult equids are close to adulthood (see ageing below), and therefore are of similar body size and are better represented. One could argue that immature bones would be very easily deleted from the record by ravaging carnivores or other processes mediated by bone density. But the similarly uneven representation of cervids, despite their high numbers (especially in level CB3), is more difficult to explain and cannot be attributed to identifiability, since cervid bones can be easily distinguished from equid bones.

One could argue that carnivore intervention remains a strong possibility for cervids, and possibly for parts of the equid sample. This is supported by differential preservation of denser long limb epiphyses, and underrepresentation of proximal humeri, distal radii, and both femur ends, as well as poor preservation of ribs and vertebrae. However, this interpretation is contradicted by an abundance of complete compact bones (tarsals, carpals, phalanges and some sesamoids) and fairly complete scapulae and pelves. These hypotheses will be further tested below by the study of bone surface modifications.

However, we can also examine skeletal part profiles through an optimal scaling analysis, focusing on anatomical regions that are highly sensitive to carnivore ravaging, including a measure of representation of the high survival bone set (*sensu* Marean and Cleghorn, 2003) and comparing the Cuesta de la Bajada assemblage to actualistic data with significant carnivore contributions. We selected some of the best-known African hyena dens from Africa (Table 4), defined as settings where bone ravaging by hyenas is moderate, compared to intensive ravaging in a more open, competitive savanna habitat (Capaldo, 1995; Domínguez-Rodrigo et al., 2007; Egeland, 2007). We compared CB1, CB2 and CB3 to hyena dens representing a wide range of bone-breaking behaviors, from the most intensively ravaged (Maasai Mara) to the least ravaged (Eyasi).

We used four variables relevant to bone ravaging and bone preservation in order to compare the datasets (Table 4). These are: the frequency of scapulae and pelves, the frequency of axial bones (vertebrae and ribs), the frequency of compact bones (carpals, tarsals, phalanges), and Shannon's evenness index. A multiple correspondence analysis was obtained with loading factors distributing these variables and the sample used in two dimensions (Fig. 10). The first and second dimensions load high on two of these variables (frequencies of axial and compact bones), in both cases with loadings higher than 0.7. These two variables are therefore the best discriminators in the sample. In Fig. 10, four spaces can be observed according to the positive or negative values of the loadings in two dimensions. The space comprised within the positive values of the first dimensions and the positive-negative values of the second dimension is characterized by a very low to low axial component, low to moderate compact bone component, low scapular-pelvic component and high evenness. This is where most hyena dens cluster. The only outlier is the Eyasi hyena den, which is a very atypical den (Prendergast and Domínguez-Rodrigo, 2008). The remaining space is characterized by moderate axial and moderate to high scapular-pelvic components, high compact components and moderate to high evenness. This is where the bulk of the Cuesta de la Bajada remains (the adult equids) cluster. Subadult equid and cervid remains lie at the periphery of this space, and in

some cases (level CB1) they appear more like a very low-competition den. These sub-assemblages occupy their own space and are difficult to interpret, either because sample sizes are too small or because they underwent different taphonomic processes from the adult equid sub-assemblages. The adult equid remains indicate minimal (if any) post-depositional ravaging by hyenas (see below), suggesting that underrepresentation of some skeletal elements may be also attributable to other agents.

3.2. Bone size representation and bone breakage patterns

When using only the plotted specimens, those <5 cm are underrepresented (especially in CB2), which could suggest that hydraulic jumbles or other post-depositional processes led to bias (Fig. 11). However, when including non-plotted and sieved remains (the bulk of all remains)⁹ specimens between 1 and 3 cm are predominant. This suggests that the three archaeological levels underwent minimal post-depositional disturbance by physical agents and that the missing bones can be attributed to biotic processes. It also suggests that both plotted and sieved materials should be used to determine post-depositional preservation biases.

Specimens in the three levels have similar proportions of green and dry fractures (Table 5). Burial conditions have seriously impacted many of the remains, affecting bone structure (many specimens are brittle) and by creating multiple diagenetic fractures. Given the bones' poor condition (some of them were disintegrating during excavation) and the ambiguity of some breakage planes, fracture types could only be determined on about half of each level sub-assemblage (Fig. 12). Cancellous bone was more altered by diagenesis than dense bone: axial remains have more dry breaks than any other element type, with frequencies of 47% in level CB1, 53% in level CB2, and 51% in level CB3. Therefore, using only dense specimens (limb bone shafts) gives us a more reliable indicator of the frequencies of dry and green breaks. In each of the three levels, shafts are overwhelmingly green-broken (80%–90%); some of these same specimens also have diagenetic breaks, at much lower frequencies. This indicates that most limb bones were broken while fresh, clearly supporting the idea that biotic agents (hominids and/or carnivores) were responsible for the modification (and probably the accumulation) of the Cuesta de la Bajada assemblage.

The distribution of Bunn's (1982) shaft circumference types also shows that bones were extensively broken (Fig. 13). When we compare these data to experimental data, both the carnivore-only and hammerstone-to-carnivore models show similar proportions, due to the intensive post-depositional deletion of epiphyses by carnivores in both cases. Only level CB1 resembles any of the experimental assemblages, while levels CB2 and CB3 have significantly lower frequencies of Types 2 and 3, probably reflecting the few epiphyseal portions that have survived in these assemblages. This indicates that none of the three Cuesta de la Bajada sub-assemblages is similar to felid-accumulated assemblages (as described by Domínguez-Rodrigo et al., (2007)), and that either hominids or hyaenids are most likely responsible for their accumulation and modification. Canids are not known to repeatedly prey on equids. The abundance of Type 1 specimens in levels CB1, CB2 and CB3 probably reflects the presence of some dry-broken bones, which are not found in any of the experimental assemblages.

Measurements of breakage plane angles also give ambiguous results (Fig. 14). In level CB1, planes with angles <90° suggest static loading, whereas planes >90° have a wide range of variation that overlaps with experimental data for both static and dynamic

⁹ There are about 12,000 small fragments from the non-plotted and sieved samples from the three levels combined.

Table 4
Minimum number of elements (MNE) in each of the hyena dens used: Amboseli (wildebeest), Maasai Mara carcass sizes 3 and 4 (MM3&4), Maasai Mara carcass size 2, Syokimau carcass sizes 1 & 2 (Syok.1&2) and 3 & 4 (Syok.3&4), and Eyasi hyena den on carcass size 1 (ovicaprids) (Eyasi 1). Data for the hyena dens were taken from [Kerbis \(1990\)](#) for Amboseli and Maasai Mara, [Bunn \(1982\)](#) for Syokimau and [Prendergast and Domínguez-Rodrigo \(2008\)](#) for the Eyasi hyena den.

	Amboseli-gnu	MM-3&4	MM-2	Syok.-1&2	Syok.-3&4	Eyasi-1	CB1-2	CB1-3	CB2-2	CB2-3	CB3-2	CB3-3
Mandible	6	24	20	7	10	20	5	3	3	5	10	6
Cranium	9	20	10	3	8	15	3	4	2	6	11	7
Vertebrae	11	10	3	3	4	33	4	5	4	16	8	15
Scapulae	4	11	4	2	3	8	0	2	1	14	5	14
Humerus	11	17	4	2	11	11	1	3	2	10	2	7
Radius	9	23	5	1	6	10	1	2	2	8	2	9
Metacarpal	7	14	3	2	4	2	1	3	1	8	3	5
Innomimates	3	6	2	3	2	7	2	7	4	16	4	6
Femur	3	9	2	0	2	9	0	2	2	4	3	8
Tibia	7	22	5	2	5	27	1	3	2	7	4	8
Metatarsal	11	11	3	2	3	7	1	1	3	8	9	9
Compact bones	26	54	9	4	9	10	2	33	8	85	16	96
Ribs	1	1	0	1	1	24	1	5	3	17	5	10
Total	108	222	70	32	68	183	22	73	37	204	82	200
Scapula + pelvis%	6.4	7.6	8.5	15.6	7.3	8.1	9	12.3	13.5	14.7	10.9	10
Rib + vertebrae%	11.1	4.9	4.2	12.5	7.3	31.1	22.7	13.6	18.9	16.1	15.8	12.5
Compact bone %	24	24.3	12.8	12.5	13.2	5.4	9	45.2	21.6	41.6	19.5	48
Evenness index	0.97	0.97	0.85	0.85	0.93	0.91	0.84	0.91	0.96	0.97	0.81	0.97

Categorical (Dummy) variables*
 Scapula + pelvis%1=<9%, low scapular-pelvic 2 = 9%–12%, moderate scapular-pelvic 3 = 12%–16%, high scapular-pelvic
 rib + vertebrae%1=<5%, very low axial 2 = 5%–13%, low axial 3 = 13%–20%, moderate axial 4=>20%, high axial
 compact bone %1=<10%, very low compact 2 = 10%–20%, low compact 3 = 20%–30%, moderate compact 4=>30%, high compact
 evenness index =<90, uneven carcasses 2 = 90–95, moderately uneven carcasses 3=>95, even carcasses evenness index 1=<90, uneven carcasses 2 = 90–95, moderately uneven carcasses3=>95, even carcasses

* Used for optimal scaling analysis and [Fig. 10](#).

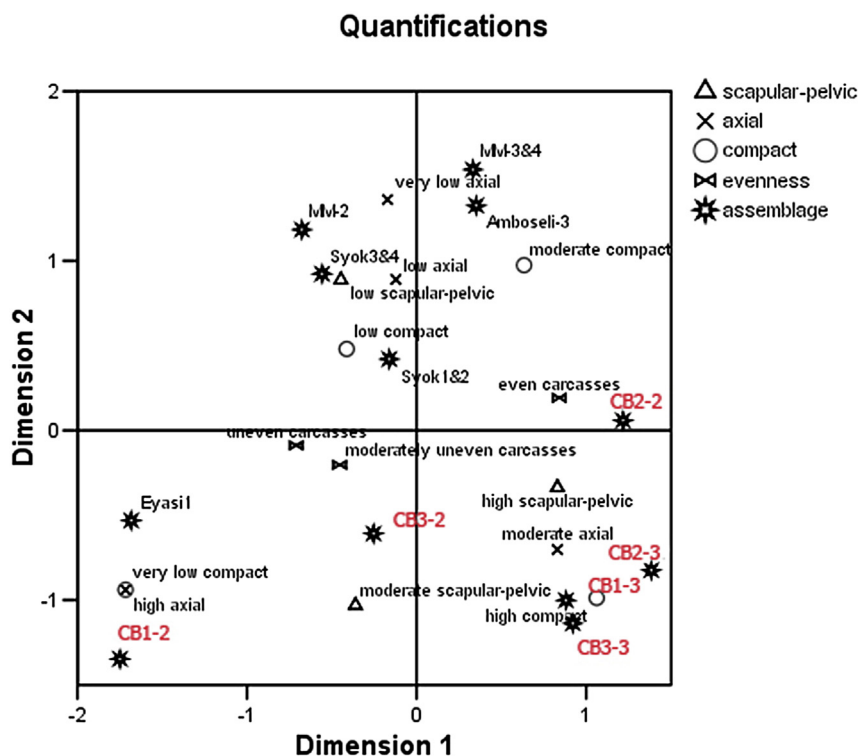


Fig. 10. Optimal scaling (multiple correspondence) analysis (using HOMALS) of the nominal variables shown in [Table 4](#), comparing several hyena dens and the Cuesta de la Bajada deer and horse assemblages. The sample was previously tested for normality, linearity and heterocedascity. Dimension 1 accounts for 71% of variance and Dimension 2 for 64%. The compact bone variable loads high in Dimensions 1 (0.9) and 2 (0.7) and seems to be the most determinant variable, followed by axial (0.78 & 0.85, respectively) and then scapular-pelvic (0.34 & 0.63).

loading. In level CB2, planes with breakage angles >90° are also closer to the experimental data for static loading. We see the opposite in level CB3, where angles <90° are more similar to those experimentally obtained through dynamic loading. The problems

with using angle measurements of longitudinal breakage planes were outlined by [Domínguez-Rodrigo et al. \(2007\)](#), who suggested that information derived from angle measurements on oblique planes is more reliable. If we focus only on oblique planes, the data

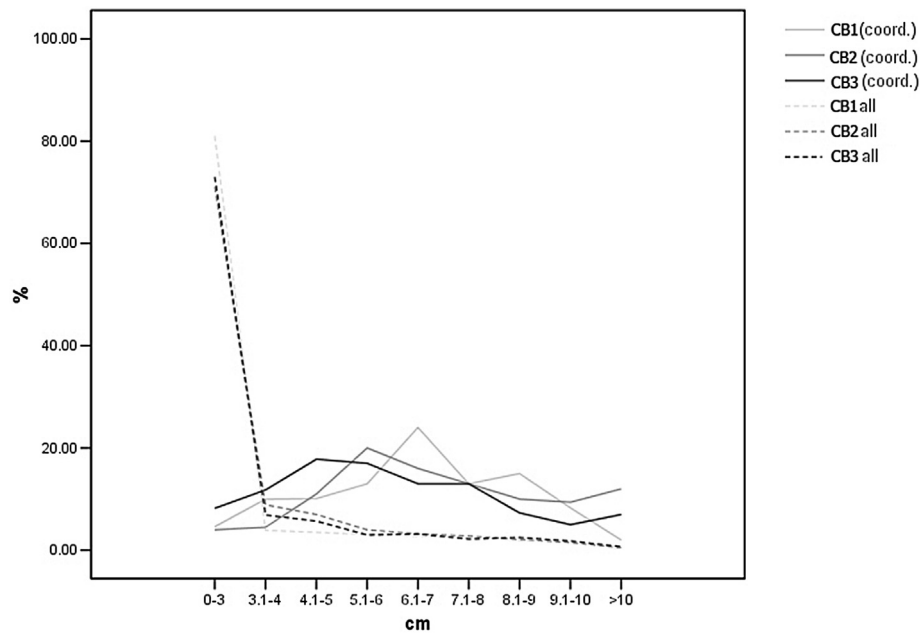


Fig. 11. Distribution of percentages of specimen sizes in the three archaeological levels analyzed, showing data for the coordinated materials only (coord.) and for the coordinated, non-coordinated and sieved materials (all).

Table 5

Green and dry (diagenetic) bone breakage at each of the archaeological levels. Percentages are for number of shaft specimens (see Table 2).

	Green only	Green and diagenetic	Diagenetic	% Assemblage here breakage could be identified
CB1	86.6	4.6	8.8	47
CB2	87.6	10.4	2	52
CB3	81.5	15.8	2.7	57

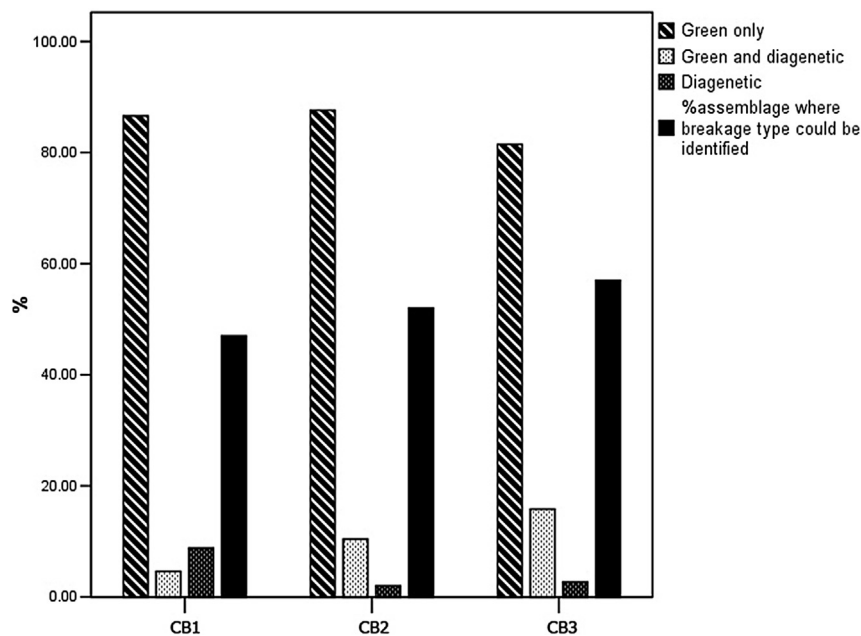


Fig. 12. Frequencies of green and dry (diagenetic) bone fractures identified in the CB2, CB3 and CB1 bone assemblages. The percentage of each assemblage (including all bones) where fractures could confidently be identified as green or dry and the combination of these two types of fractures on long limb bones only are shown. Last bar shows the percentage of specimens in each assemblage whose breakage type could be identified.

for level CB1 remain ambiguous; in level CB2, specimens showing angles $>90^\circ$ are more similar to those obtained through static loading, but those $<90^\circ$ are ambiguous. In level CB3, angles are more similar to those experimentally obtained through dynamic

loading.

This ambiguity may be related to the fact that all the experimental work was carried out on bones less dense than equid bones. In experiments that recorded both breakage plane angles and notch

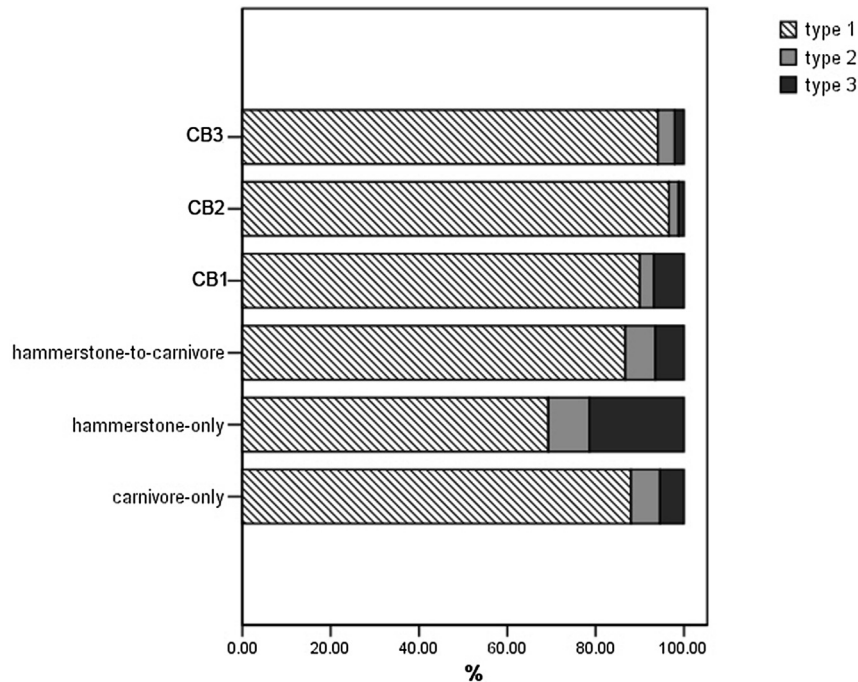


Fig. 13. Distribution (in percentages) of the different types of bovid long bone circumference types (Bunn, 1982) in experimental assemblages and at CB1, CB2, and CB3 from Cuesta de la Bajada. Data for experimental assemblages are from Marean and Spencer (1991) and Marean et al. (2004).

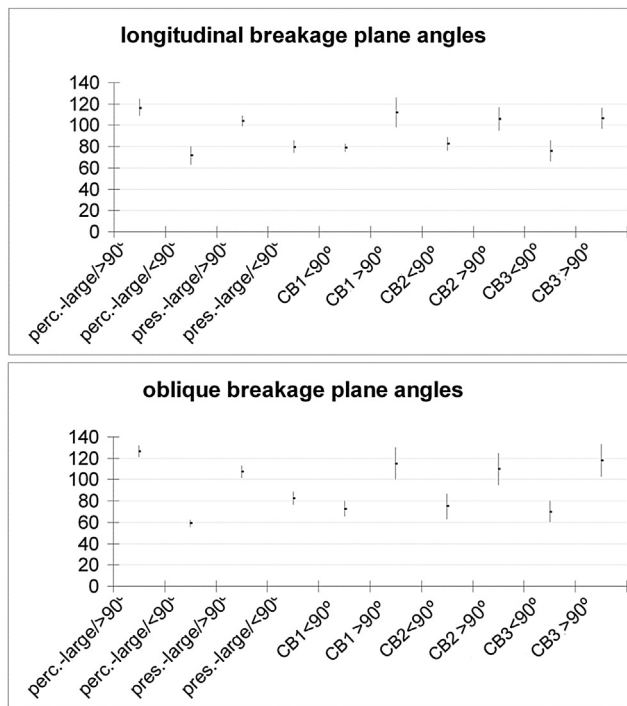


Fig. 14. Distribution of angle values in specimens larger than 4 cm showing longitudinal and oblique breakage planes. Measurements for dynamic (perc. = percussion) and static (pres. = pressure) are from Alcántara et al. (2006). Figure shows mean and 95% confidence intervals. A total of 283 specimens were used for CB3, 201 for CB2 and 98 for CB1.

measurements, Capaldo and Blumenshine (1994) observed that the experimental sample showed different values for upper and intermediate limb bones *versus* the denser metapodials. The high density of equid bones suggests that we need further experiments

and a broader set of referential data. Until then, breakage plane measurements on equid bones must be interpreted cautiously.

In the three sub-assemblages, there were abundant impact points and impact scars on the medullary surfaces of bones but very few clear notches. Table 6 shows the distribution of notch types and the frequency of complete single notches that could be measured both on the cortical and medullary surfaces. These measurements yielded a wide range of ratios that fall within the ranges for experimental data from both static and dynamic loading (Fig. 15); no breaking agent can be clearly inferred. However, the number of notches falling outside both of the experimental ranges is quite remarkable. This shows that the experimental dataset used to derive these referential frameworks is too small, and shows too much overlap to offer any resolution when applied to large carcasses. There is no reliable experimental sample for equids at the moment; we therefore suggest, as above, being cautious in the interpretation of notch measurements. Despite the lack of a proper referential framework, the distribution of notch types suggests some human agency (not excluding other agents) in bone breakage. All notch types occur. Double-overlapping and -opposing notches are documented in higher frequencies than in hammerstone-broken experimental scenarios, which suggests the sample reflects an intermediate point between complete dynamic or static loading. The double-opposing: single notch ratio is 1.0 in level CB1, 0.3 in level CB2 and 0.4 in level CB3. The double-overlapping: single notch ratio is 1.5 in level CB1 (with a sample size too small to allow meaningful interpretation) and 0.4 in levels CB2 and CB3. These are closer to experimental data for static loading than dynamic loading. This could be interpreted either as a mixed signal of carnivores and hominids, or as a result of using referential data that does not account for the thickness and density of equid bones (De Juana and Domínguez-Rodrigo, 2011).

If carnivores were the bone-breaking agents, one would expect a number of tooth marks; but this is not supported by the analysis presented below. Instead, many of the double-overlapping and -opposing notches may have resulted from some intrinsic breakage

Table 6

Frequencies of main notch types in carnivore-made assemblages (Maasai Mara and Eyasi hyena dens) and human-butchered carcasses (experimental and Hadza assemblage) compared to those from CB1, CB2 and CB3 (Cuesta de la Bajada) and the archaeological site of Schöningen.

	Maasai Mara hyena den	Eyasi hyena den	Human-butchered large carcasses ^b	Hadza assemblage
% Complete notches/all notches ^a	45/132 (34)	5/18 (27.7)	59/77 (76.6)	13/20 (65)
% Overlapping notches/all notches	46/132 (34.8)	8/18 (44.4)	10/77 (12.9)	2/20 (10)
% Double-opposing notches/all notches	21/132 (15.9)	5/18 (27.7)	7/77 (9)	1/20 (5)
	CB1	CB2	CB3	Schöningen
% Complete notches/all notches	2/9 (22.2)	11/23 (34.7)	20/46 (34.7)	95/176 (45.9)
% Overlapping notches/all notches	3/9 (33.3)	5/23 (21.7)	9/46 (19.5)	41/176 (19.8)
% Double-opposing notches/all notches	2/9 (22.2)	4/23 (17.3)	9/46 (19.5)	40/176 (19.3)

^a All notches included all notch types plus clearly identifiable single incomplete notches.

^b This sample included only bovids and not equids (for details of the sample see Domínguez-Rodrigo et al., 2007).

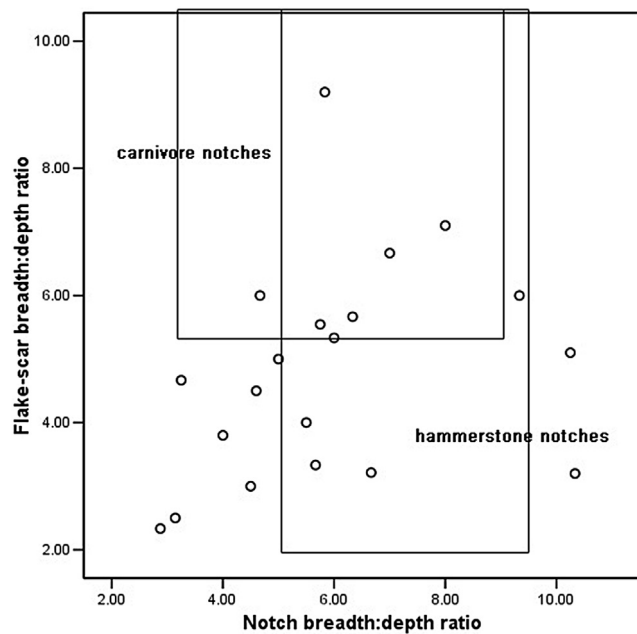


Fig. 15. Notch measurements for Cuesta de la Bajada (CB3) specimens, showing notch length:breadth ratio from the cortical surface and flake scar length:breadth ratio from the medullary surface. Boxes represent the ranges of variation (95% confidence intervals) for these ratios as documented in experimental assemblages produced by static (carnivore) and dynamic (hammerstone percussion) loading (Capaldo and Blumenshine, 1994).

properties of equid bones. This is supported by the taphonomic data from Schöningen, where equids also dominate the faunal assemblage. In this site, the frequencies of double-opposing and -overlapping notches are very similar to those we documented at Cuesta de la Bajada (Voormolen, 2008). The proportion of notch types at Schöningen is also very similar to that seen in level CB3. A paucity of tooth marks and an abundance of cut and percussion marks at Schöningen, together with other taphonomic variables, clearly showed that hominids were the main agents responsible for acquiring and exploiting equid carcasses. The high number of double-overlapping and -opposing notches was therefore unrelated to carnivore activities, and this may also be the case in our site.

A correspondence analysis¹⁰ of the distribution of three notch types (single, double-overlapping and double-opposing) among

¹⁰ This correspondence analysis is not statistically meaningful given the paucity of available data, but it is useful at least to group specific variables and bone assemblages.

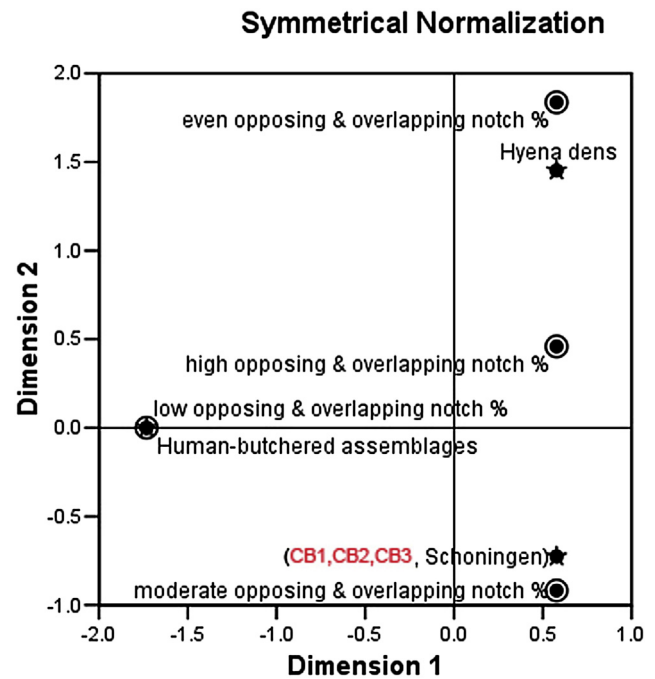


Fig. 16. Correspondence analysis of notch types and bone assemblages. Data from Table 6 were transformed into categorical/dummy variables (dividing notches into 4 equal values according to the range). Human assemblages (Human experimental and Hadza) were grouped separately from carnivore assemblages (hyena dens) and archaeological assemblages (CB1, CB2, CB3 and Schöningen). Circles show values of notches in each dimension and stars show values of assemblages in each dimension. Data for hyena dens and human assemblages were obtained from Domínguez-Rodrigo et al. (2007) and Prendergast and Domínguez-Rodrigo (2008). Data for Schöningen were extracted from Voormolen (2008).

experimental and archaeological datasets shows a separation between dimensional values (Fig. 16). Dimension 1, explaining 61% of the variance, clearly separates the human-made assemblages from both the Cuesta de la Bajada and Schöningen assemblages, and from the hyena dens. A higher proportion of double-overlapping and -opposing notches in the archaeological and den assemblages separates them from the human-made ones. However, the dens and archaeological assemblages are also widely separated by Dimension 2, which explains 38% of the variance. The chi-squared value is 13 ($p = 0.043$), indicating that the equid-dominated archaeological assemblages are as distinct from (non-equid) human-made assemblages as they are from carnivore-made assemblages. The statistical significance of this analysis is limited by the low number of assemblages compared. However, it would seem to suggest that the frequencies of notch types found at Cuesta de la Bajada and Schöningen likely reflect poorly-understood physical

Table 7

Preservation and agents affecting the bone assemblages at Cuesta de la Bajada. Percentages shown are on the total NISP shown in Table 2 except teeth.

	Good preservation	Good/moderate preservation
CB1	33.7	41
CB2	9.1	11.7
CB3	21	27.3

	Biochemical marks	Water affected/carbonate	Trampling
CB1	51	31	13.5
CB2	78	44	33.8
CB3	71	35	20.9

properties of equid bones, rather than the carnivores' activities. This calls for more experimentation on equid bones.

Variation in notch type frequencies may also be related to differences among analysts' protocols for identifying notches. For example, a specimen may show overlapping negative scars from multiple breakage planes on the medullary surface. These "impact points" are often not associated with notches that are clearly visible on the cortical surface. Some analysts (including us) would not call the overlapping impact points "double-overlapping notches." In the absence of common analytical protocols, there may be wide variation in notch type frequencies reported by different researchers.

In summary, the diagnostic features of bone breakage—breakage plane angles, notch measurements and notch type frequencies—that have been successfully applied to bovid bones to differentiate between hominid and carnivore agents in the past (e.g., Domínguez-Rodrigo et al., 2007) do not seem to provide enough resolution in the Cuesta de la Bajada assemblage. This may be explained by the structural properties of equid bones, which are more robust and require multiple impacts to open (De Juana and Domínguez-Rodrigo, 2011). Fortunately, studies of bone surface modifications can currently offer some resolution, as we explain below.

3.3. Bone surface modifications

Bones from Cuesta de la Bajada have been affected by a series of biostratigraphic and diagenetic processes that vary by archaeological level, but preservation of cortical surfaces is generally not very good (Table 7; Fig. 17). The proportion of well-preserved bones in level CB1 is higher than elsewhere, but this may reflect the small sample size. Level CB2 shows the poorest preservation, with 90% of specimens poorly preserved and of limited value for the identification of carnivore- or hominid-imparted surface modifications. Poor preservation can be attributed to at least two factors in the depositional environment: first, the effects of soil humidity (and associated pH) and water, leading to carbonate precipitation, bone surface exfoliation and occasional porosity and rounding of edges; and second, the effects of roots (and their associated bacteria and fungi), which have modified bone surfaces resulting in discoloration, coating, exfoliation, and pitting or scoring (Fig. 18). The latter is by far the most common modification found in the site (Fig. 19), with frequencies ranging from 51% of specimens in level CB1 to 78% in level CB2. Chemical modifications caused by soil humidity and associated pH affect bones to a lesser degree (31–44% depending on the level) and a substantial number of specimens show both types of modifications (Fig. 20). This indicates that the depositional environment was at least periodically humid and covered by vegetation.

The three levels are also marked by high frequencies of micro-abrasion marks caused by trampling, which are found on 13.5% of specimens in Level CB1, 20.9% in level CB3, and 33.8% in level CB2 (Table 7). Bone surfaces in level CB2 show the highest incidence of

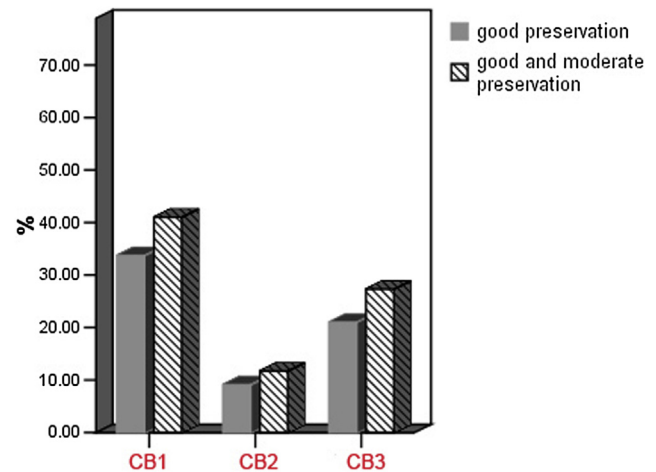


Fig. 17. Percentages of well-preserved and moderately-well preserved bone specimens in each archaeological assemblage. Good preservation refers to all the cortical surface present and preserved. Moderately-well preserved bone indicates that two thirds of the cortical surface is intact.

natural marks, leaving very few specimens available for reliable detection of carnivore- and hominid-imparted traces. Abrasion marks made the secure identification of cut marks particularly difficult in a few cases. Large individual sediment particles frequently left striations that have many of the typical signatures of cut marks; fortunately in several cases, the calcified sediment remained adhered to the bone surface and we could dismiss these as natural marks. Since we were cautious in excluding any potentially ambiguous cut marks, our reported frequency may be lower than the reality.

For the sake of comparison and given the small samples of well-preserved bone in two of the three levels, we decided to lump small and intermediate carcass size groups. We used only those specimens whose surfaces were rated as "good" (the complete surface well-preserved and visible) and "moderate" (at least two-thirds of the surface well-preserved and visible). Level CB1 contained 115 good specimens and 34 moderate specimens; level CB2 had 110 good specimens and 32 moderate specimens; and level CB3 had 289 good specimens and 88 moderate specimens. The samples used and tooth, cut and percussion mark frequencies are shown in Table 8; all frequencies consider only the samples of specimens with good and moderate preservation discussed here.

3.4. Tooth marks

Carnivores seem to have been moderately active in the three archaeological levels (Table 8). They may have played a major role in the formation of level CB1 (unless the estimates just reflect small sample sizes), and they seem to have carried out substantial ravaging in level CB2. Both levels show very similar frequencies of tooth marks in the total sub-assemblage (14%) and on long limb shafts alone (18%), and marks are found in most anatomical areas, especially in level CB2. However, these apparently "high" percentages only suggest secondary carnivore intervention, after hominid activities (Fig. 21). In carnivore-first experimental and den datasets, especially those coming from assemblages of comparably-sized carcasses modified by hyenas, tooth mark frequencies range from 50% to 100% of the assemblage (Blumenschine, 1988, 1995; Villa et al., 2004; Marra et al., 2004; Faith, 2007; Pokines and Kerbis Peterhans, 2007; Domínguez-Rodrigo et al., 2007). Frequencies of tooth marks (especially on long limb shafts) only drop to below 20% in experiments where carnivores had secondary access to carcasses



Fig. 18. Four examples of root etching and biochemical modification of bone surface due to the concurrence of plant roots and associated fungi and bacteria. Notice the discoloration of bone surface, the contrast in the coloring in the outline of some marks, and the grooving, scoring and exfoliation.

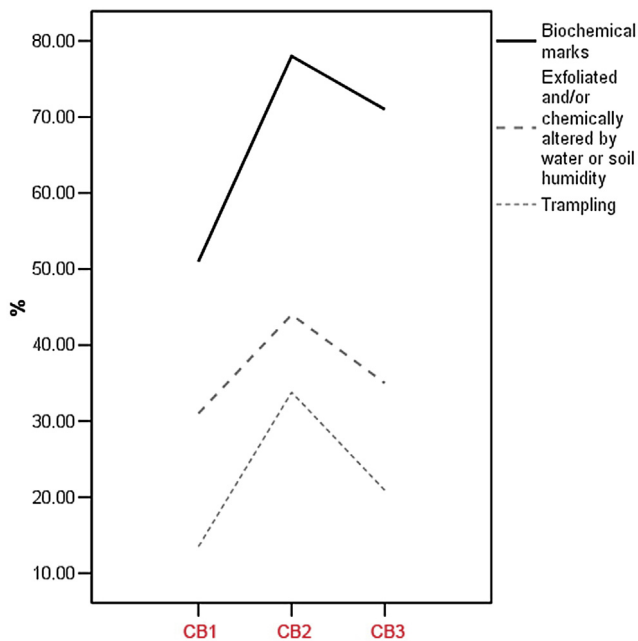


Fig. 19. Percentages of alterations underwent by the Cuesta de la Bajada bone assemblages caused by biochemical modifications created mostly by plant roots, soil chemistry and trampling/microabrasion.

after humans (Blumenschine, 1988, 1995; Capaldo, 1995, 1997, 1998).

The tooth mark frequencies in levels CB1 and CB2 indicate stronger carnivore ravaging than in level CB3. This could partially



Fig. 20. Bone specimen showing intense surface modification due to a combination of chemical processes involving soil pH, water and bioturbations.

explain the skeletal part profiles and distribution shown in Fig. 10, where the smallest carcass sizes in level CB1 clustered with the “atypical” Eyasi hyena den. However, it does not explain the clustering of the adult equid carcasses far from the carnivore samples. It might be that the tooth mark frequencies reflect the very small samples of well-preserved bones in both assemblages: <150 specimens total, and only 54 shaft specimens in level CB1 and 64 in level CB2. In level CB3, which had a larger sample of well-preserved specimens (377 total, 151 shafts), the picture changes substantially: tooth marks constitute just 6.8% of the total sub-assemblage and 7.9% of the shafts. These frequencies fall into the lowest part of the range of variation documented in hammerstone-to-carnivore

Table 8
Percentages of bone surface modifications (tooth-, percussion- and cut marks) on the combined sample of specimens with good and moderate preservation shown for each site. Numbers in parentheses are percentages. Numbers outside parentheses are number of specimens bearing marks.

	NISP	CB1				CB2				CB3		
	well preserved ^b	TM	PM	CM	well preserved ^b	TM	PM	CM	well preserved ^b	TM	PM	CM
Skull	10	1 (10)	—	—	9	—	—	—	26	—	—	2 (7.6)
Mandible	4	—	—	—	5	—	—	—	11	2 (18.1)	1 (11.1)	5 (45.4)
Vertebrae	7	1 (14.2)	—	—	9	—	—	—	9	—	—	2 (22.2)
Ribs	15	—	—	—	14	—	—	1 (7.1)	19	1 (5.2)	—	7 (36.8)
Scapula	2	—	—	—	2	1 (50)	—	—	10	2 (20)	—	3 (30)
Innominate	2	2 (100)	—	1 (50)	2	2 (100)	—	—	9	1 (11.1)	—	2 (22.2)
Humerus	6	2 (33.3)	1 (16.6)	1 (16.6)	6	1 (16.6)	2 (33.3)	2 (33.3)	31	1 (3.2)	2 (6.4)	12 (38.7)
Radius-ulna	6	—	—	—	3	2 (66.6)	—	1 (50)	12	—	3 (25)	3 (25)
Metacarpal	2	1 (50)	—	—	2	1 (50)	—	—	12	4 (33.3)	2 (16.6)	1 (8.3)
Femur	5	2 (40)	1 (20)	—	7	3 (42.8)	1 (14.2)	3 (42.8)	28	2 (7.1)	4 (14.2)	7 (25)
Tibia	10	3 (30)	1 (10)	2 (20)	4	2 (50)	1 (25)	2 (50)	46	5 (10.8)	6 (13)	13 (28.2)
Metatarsal	4	—	—	—	5	3 (60)	—	1 (20)	17	2 (11.7)	5 (29)	—
Carpal/tarsal	10	—	—	—	8	1 (12.5)	—	—	33	4 (12.1)	—	2 (6)
Phalanges	6	—	—	—	8	1 (12.5)	—	—	12	—	1 (8.3)	1 (8.3)
Total	89	12 (13.4)	3 (3.3)	4 (4.4)	84	4 (4.7)	10 (11.9)	275	24 (8.7)	24 (8.7)	37 (13.4)	
Shafts	54				64				151			
Total good and moderate preservation ^a	149				142				377			
Total marked ^a		22/149 (14.7)	3/149 (2)	4/149 (2.6)		20/142 (14)	4/142 (2.8)	12/142 (8.4)		26/377 (6.8)	32/377 (8.4)	70/377 (18.5)
Marked Shafts ^a		10/54 (18.5)	3/54 (5.5)	3/54 (5.5)		12/64 (18.7)	4/64 (6.2)	11/64 (17.1)		12/151 (7.9)	30/151 (19.8)	35/151 (23.1)

^a Including non identifiable to skeletal element.
^b Lumping together good preservation and moderate preservation.

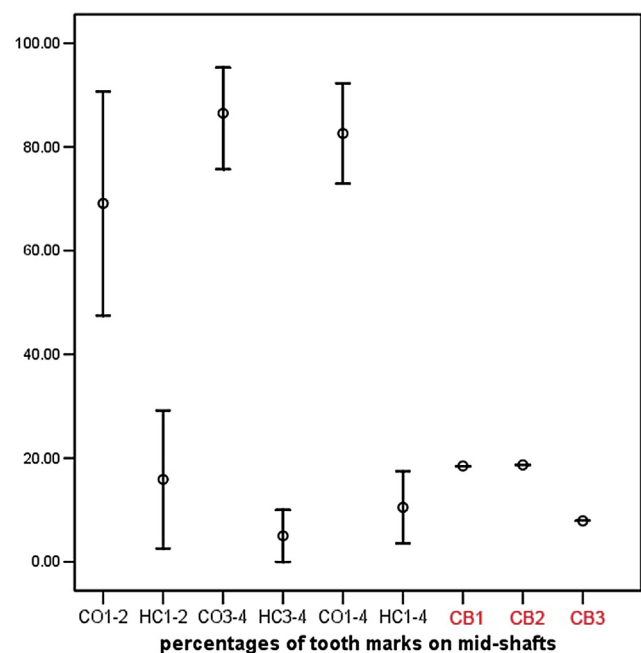


Fig. 21. Distribution of the mean and 95% CI (confidence intervals) for the frequency of tooth-marked specimens for shafts in experimental assemblages and in the three Cuesta de la Bajada assemblages. Experimental data are from [Blumenshine \(1995\)](#): Carnivore-only on carcass sizes 1 & 2 (CO1&2), 3&4 (CO3&4), and total (CO1&4), and Hammerstone to carnivore on carcass sizes 1&2 (HC1&2), 3&4 (HC3&4) and total (HC1&4). Epiphyseal portions were excluded given their very low numbers. Notice how the Cuesta de la Bajada samples are within the second experimental group and in some assemblages (CB3) showing a very low percentage of tooth marks.

experimental scenarios ([Fig. 21](#)). This indicates mild ravaging of hominid-abandoned bones by carnivores, which fully supports the anatomical frequencies observed in [Fig. 10](#), where this assemblage (CB3) clustered together with the adult equid samples from levels



Fig. 22. Example of scapula with multiple dry breaks and absence of carnivore damage. Most of the scapulae in Cuesta de la Bajada appear this complete.

CB1 and CB2, far away from any of the hyena dens. This would also explain the good preservation of pelves and scapulae, the latter showing only diagenetic breakage rather than the blade gnawing and loss typical of carnivore intervention ([Fig. 22](#)).

In summary, tooth marks clearly show that carnivores intervened *after* hominids abandoned the bones at Cuesta de la Bajada. This indicates that most of the green fractures and notches that were documented earlier were not made by carnivores.

3.5. Percussion marks

Percussion marks are not abundant in the long limb mid-shaft samples from levels CB1 (5.5%) or CB2 (6.2%) ([Table 8](#)). These frequencies barely fall into the lowest part of the range of variation for experimental data for percussion marks made on long limb mid-shafts ([Fig. 23](#)). If diagenetic breakage is considered (see Methods

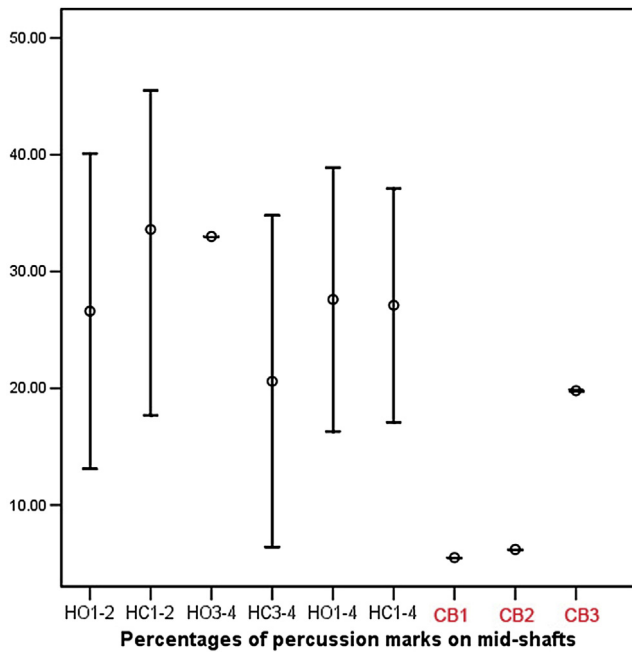


Fig. 23. Distribution of the mean and 95% CI (confidence intervals) for the frequency of percussion-marked specimens for shafts in experimental assemblages and in the three Cuesta de la Bajada assemblages. Experimental data are from [Blumenschine \(1995\)](#): Hammerstone-only on carcass sizes 1 & 2 (HO1&2), 3&4 (HO3&4), and total (HO1&4), and Hammerstone to carnivore on carcass sizes 1&2 (HC1&2), 3&4 (HC3&4) and total (HC1&4). Epiphyseal portions were excluded given their very low numbers.

above and [Pickering et al., \(2008\)](#)), then both tooth mark and percussion mark frequencies increase slightly. For the percussion marks, this would be enough to place the frequencies within the range of variation for hammerstone-broken experimental scenarios. However, as with tooth marks, it is difficult to know if these frequencies are reliable or are influenced by small sample sizes in levels CB1 and CB2. By contrast, in the larger sample from level CB3, percussion marks occur on almost 20% of the long limb mid-shaft sample. This falls well within the range of variation for hammerstone-broken experimental scenarios. This further supports our argument that the green fractures and notches at Cuesta de la Bajada, especially in level CB3, were hominid-made. The ambiguities in interpreting bone breakage data, cited above, can thus be overcome.

3.6. Cut marks

Cut marks are some of the most direct traces of hominid behavior that can be found on bone. They are also the most informative since, in contrast with percussion marks, they not only inform taphonomists about whether nutritional resources (in this case, meat) were extracted, but they also show which behaviors were involved in butchery (skinning, dismembering, eviscerating, filleting). Cut marks are surprisingly abundant in Cuesta de la Bajada, despite the fact that, as noted above, we were very conservative in our identification of ambiguous marks that might have been related to trampling. Cut marks have been found on all the skeletal elements ([Table 8](#)), but they are most abundant on long limb shafts. Cut marks in level CB1 are very few (cut-marked NISP = 4), as was the case with percussion marks; but the cut mark frequency even in this level falls within the range documented in recent archaeological assemblages. Given the sample size problem in this level, it will be excluded from further discussion. However, it is worth noting that three of the specimens are tibia or humerus

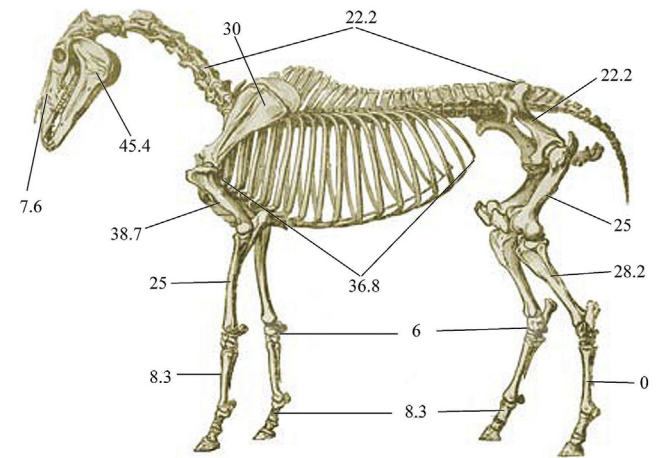


Fig. 24. Skeleton of an equid showing the anatomical distribution of cut marks at CB3. Numbers show percentages. Data can be seen in [Table 8](#).

mid-shafts, suggesting meat filleting.

Cut marks in level CB2 are slightly more abundant (cut-marked NISP = 12), being found on 8.4% of the total sample and 17.1% of the long limb shafts. Like level CB1, the small sample sizes in level CB2 prevent us from making any strong behavioral arguments. However, it is important to note that these high frequencies are consistent with scenarios where hominids had primary access to carcasses and defleshed them ([Domínguez-Rodrigo, 1997a, 1997b, 2002](#)); this is supported by the fact that virtually all cut-marked specimens are mid-shafts of the humerus, femur, radius or tibia.

Only level CB3 contains enough cut-marked specimens (cut-marked NISP = 70) to enable well-supported interpretations. Cut marks occur on almost all the entire skeleton ([Figs. 24 and 25](#)), from skulls to feet, and half of the cut-marked specimens are long limb shafts ([Table 8](#)). This indicates thorough carcass exploitation by hominids. Cut marks on the mandible indicate defleshing and tongue removal. Those occurring on vertebrae and ribs are evidence of defleshing, but 42% (3 out of 7) of the cut-marked ribs show cut marks on their ventral side, indicating evisceration. Limb disarticulation is not well-documented mainly due to the paucity of epiphyseal remains. However, one proximal radial epiphysis has cut marks near the articular surface, and there are two calcanea and one phalanx with cut marks that suggest some degree of disarticulation and perhaps skinning took place. The marks appearing on long limb mid-shafts are abundant on the meatiest bones of both the fore and hind limbs: the humerus (22%), radius (38%), femur (25%) and tibia (28%). Most cut marks occur on equid bones, owing to their abundance in level CB3; cut marks on deer bones occur on one mandible, two tibiae, two humeri, and one femur.

This distribution of cut marks, when compared with actualistic datasets, supports our interpretation of primary access to and extensive exploitation of carcasses by hominids at Cuesta de la Bajada as shown in a principal component analysis ([Figs. 26 and 27; Table 9](#)). The comparative datasets used are from [Domínguez-Rodrigo's \(1997a, 1997b\)](#) experiments replicating primary butchery of complete carcasses and secondary butchery of scavenged carcasses from felid kills, and from [Lupo and O'Connell's \(2002\)](#) documentation of butchery by Hadza hunter-gatherers at base camps, at hunting blinds, at butchery stands and using all assemblages combined. The Hadza data are not directly comparable to the experimental assemblages because they show a much higher bias towards specimens from upper limb bones, compared to other long limbs. This may seriously affect some comparisons, such as the proportions of cut-marked humeri and femora among the cut-

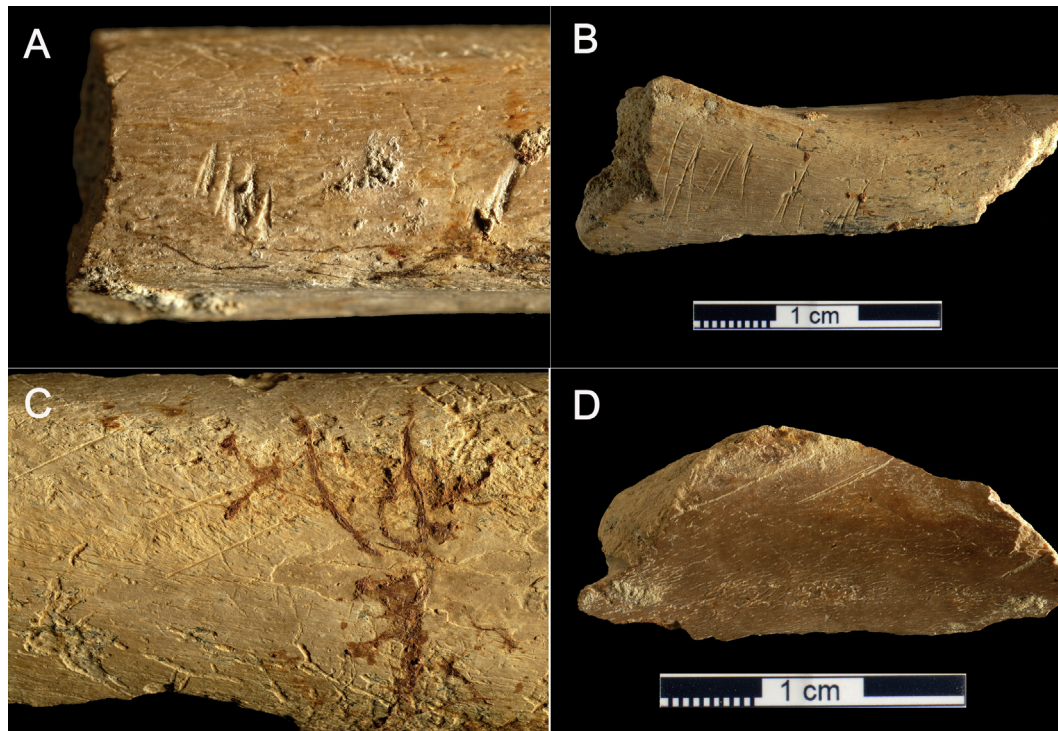


Fig. 25. Some example of cut-marked bones from Pllam. A, ventral side of equid rib (CB3 298); B, cut marks on the medial side of an equid tibial crest (CB3 2215); C, cut marks on an equid tibial mid-shaft specimen, also chemically modified by root etching (CB3 1716); D, cut-marked equid humeral mid-shaft (CB3 1596).

marked specimens. However, using it enlarges the referential framework, since the Hadza data differ from the butchery experiments in that the latter involved complete removal of flesh including small scraps (resulting in higher cut mark frequencies), whereas the Hadza conducted regular defleshing, leaving some scraps behind. Together the datasets provide a good range of variation for cut mark frequencies expected when hominids have primary access to carcasses (Table 9).

The principal components analysis revealed that most of the variance in the model is explained by the association of three key variables (Fig. 26): the frequency of cut-marked upper limb bones, the frequency of all cut-marked mid-shafts, and the %CM ULB:CM long bone ratio. The first two variables load higher than 0.9 in the first factor. ILB, Total % cut-marked specimens and the %CM ULB:CM long bone ratio load 0.8 on the same factor. The second factor is defined by cut-marked LLB.

The distribution of the archaeological and experimental samples along both axes given their factor scores (Fig. 27) demonstrates first, that primary and secondary access to carcasses by hominids can be experimentally modelled and statistically differentiated, and second, that most of the archaeological datasets cluster close to datasets from experiments replicating primary access to carcasses by hominids. Level CB2 is very close to the experimental data for complete butchery. Level CB3 lies between these data and the Hadza butchery data. Level CB1 lies between the Hadza data (to which it is closer) and data from experiments where hominids had secondary access to bones after carnivores; however, given its small size, this level cannot provide very reliable information about specific behaviors. The location of the Schöningen dataset above the Hadza and primary-access experimental data is surprising, with frequencies of cut-marked specimens in each category slightly higher than the average documented in these experiments. This may be because all the referential datasets are derived from butchery of bovid carcasses, and these would likely be less cut-

marked than equid carcasses, which have stronger muscular attachments and therefore require more strokes to deflesh (Lupo & O'Connell, 2002; Domínguez Rodrigo, 2008). In the absence of a referential framework replicating equid butchery, current analogs show that defleshing of carcasses – by hominids who had primary access to them – was taking place in levels CB2 and CB3 at Cuesta de la Bajada, and at Schöningen.

A multiple correspondence analysis further supports this interpretation (Fig. 28; Table 9). This analysis uses the same values for each variable used in the principal components analysis above, but transforms them into five 20% intervals, depending on the range and maximum value of each variable. Each 20% interval is assigned to a category of 1–5 and is computed in two dimensions. The highest intervals are 3–5, corresponding to moderate to very high frequencies of all cut-marked bones, of cut-marked upper limb bones, cut-marked mid-shafts and the ratio of cut-marked upper limb bones to all cut-marked bones. These high frequencies show high score loadings and determine the distribution. As in the analysis above, the archaeological sites (with the exception of level CB1) cluster with the experimental and ethnographic datasets replicating primary access to carcasses; once again, Schöningen is distinct and is associated with the experimental set replicating thorough defleshing of carcasses, probably because this activity left more abundant cut marks on the bovid bones used in the experiment, and this is what we might expect with butchery of equids at Schöningen. This may not be as obvious in the Cuesta de la Bajada samples because there, epiphyses and other portions likely to bear cut marks are underrepresented, compared to Schöningen. Additionally, our conservative approach to identifying ambiguous cut or abrasion marks may have led to lower cut mark frequencies.

3.7. Subaerial weathering

Subaerial weathering has affected the cervid and equid remains

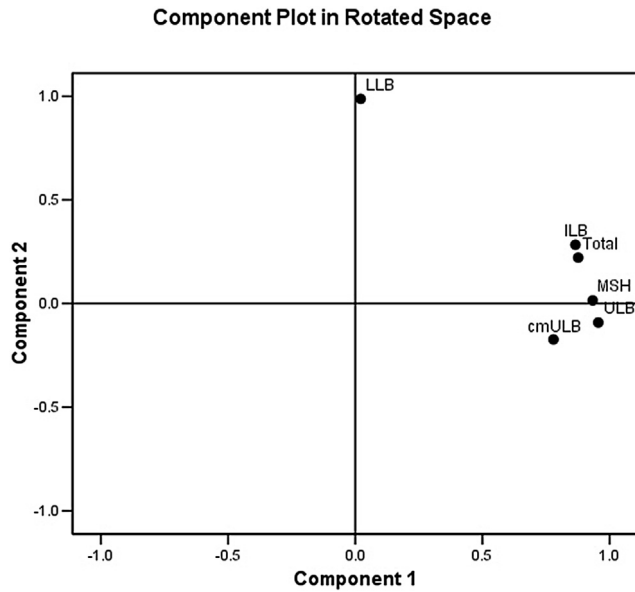


Fig. 26. A, Principal component analysis (using HOMALS) for the analysis of cut marks using the data (Table 9) from Domínguez-Rodrigo (1997b) for experiments replicating early and late access to carcasses, Lupo & O'Connell (2002) for the Hadza assemblages and Voormolen (2008) for Schöningen. Variables used are: ULB, Upper Limb Bones; ILB, Intermediate Limb Bones; LLB, Lower Limb Bones; MSH, mid-shafts; Total; CMULB is the proportion of cutmarked upper limb bones compared total cutmarked long bones [CMULB values have to be used as defined on homogeneous samples, not samples that show biases in element preservation/retrieval. CMULB values used for the Hadza assemblages were replaced by Pairwise/mean values since there is great heterogeneity in the proportion of long limb bones retrieved by Lupo & O'Connell (2002), with very few specimens from humeri and femora compared to radii, tibiae and metapodials]. The sample was tested for normality (Shapiro–Wilks range = 0.91–0.97; P range = 0.10–0.85), linearity and homocedascity. A total of 30 correlations were found, 20 of which were >0.30 with significant α values (0.05) and determinant value of 0.003. KMO test = 0.66; m Barlett's test of adequacy = 0.000. Two factors were obtained which explain 84.3 of variance. Data were rotated with Varimax and Kaiser normalization.

at Cuesta de la Bajada differently by level (Fig. 29). Weathering, could only be confidently identified on bones with “good” and “moderate” cortical preservation. Level CB3 has the highest frequency of Behrensmeier's, (1978) Stage 0 specimens (*i.e.* those with

Table 9

Percentages of cut-marked specimens according to category in experiments replicating primary access to carcasses and complete butchery (H1), secondary access to carnivores' kills (H2) and ethnoarchaeological data from various Hadza sites. ULB, Upper Limb Bone; ILB, Intermediate Limb Bone; LLB, Lower Limb Bone; MSH, Mid-Shaft; cmULB:cmNISP, cut-marked Upper Limb Bones:cut-marked total number of specimens. Data for Hadza cmULB:cmNISP were derived through pairwise/mean (see text for explanation).

	ULB	ILB	LLB	MSH	Total	cmULB:cmNISP
H1 ^a	45	35	19	43	57	24
H1	50	36	13	54	55	31.8
H1	76	23	0	53	54	46
H1	61	38	0	53	42	31
H1	50	42	7	71	29	35.7
H2 ^a	0	8	23	3.7	7	0
H2	8.6	8.3	12.5	3.8	11.4	0
H2	4.5	10	20	9.5	10.5	0
Hadza (base camp) ^b	37	41	33	38	41	28
Hadza (blind) ^b	27	25	28	26	35.6	28
Hadza (butchering stands) ^b	24	29	2	20	17.5	28
Hadza (total) ^b	26	32	15	26	33	28
CB1	9	12.5	0	12	12	33.3
CB2	38.4	42.8	14.2	32.1	32.1	55.5
CB3	32	25.8	10.3	25	25	53
Schöningen	55	48	50	54	51	46

^a Data from Domínguez-Rodrigo (1997b).

^b Data from Lupo and O'Connell (2002).

no weathering); very few specimens show Stage 1 and none are more severe than Stage 1, in keeping with our arguments that this is the best-preserved level. This suggests a short time exposure for bones and a rapid accumulation of carcasses. Level CB2 also has few specimens showing weathering more severe than Stage 0. In Level CB1, weathering is slightly more severe with some bones being attributable to Stage 3. In the latter two levels, cervid bones tend to be more weathered than equid bones, suggesting that they might have been exposed longer, unless this is a sample size effect.

3.8. Age profiles

Tables 10 and 11 shows the ages for equids and metric dimensions for cervid teeth identified in each level. Age profiles for equids are shown separately by method (incisor wear patterns and

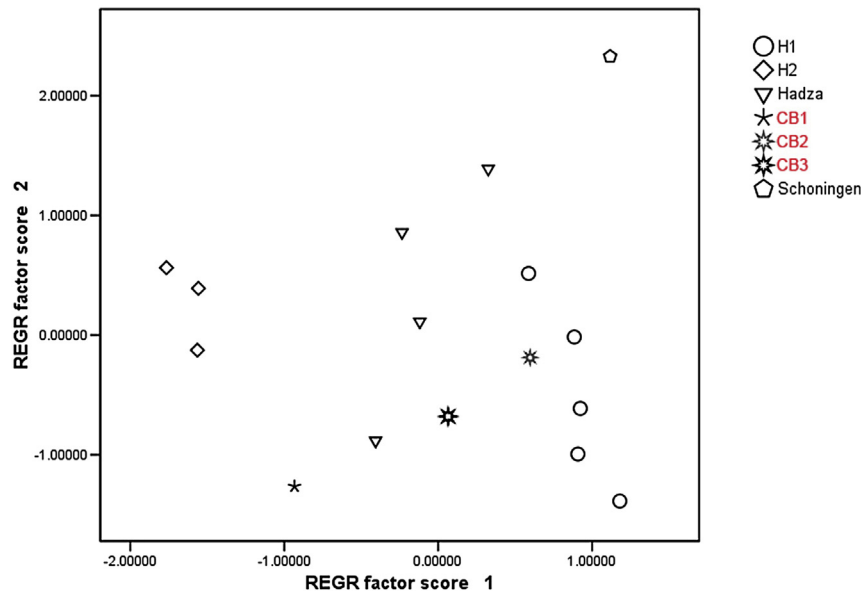


Fig. 27. Scatter plot of the score factors from the principal component analysis shown in Fig. 26 for each experimental and archaeological assemblage.

Table 10
Ages (based on MNI) for the horse individuals identified at each level derived from the analysis of wear pattern in incisor and posterior dentition.

	CB2 incisor	CB1 incisor	CB3 incisor	All levels	CB2 p2-m3	CB1 p2-m3	CB3 p2-m3	All levels p2-m3
0 to 2 years	.	.	2	2	.	.	2	2
2 to 4 years	2	2	2	6	2	1	2	5
4 to 6 years	1	1	5	7	1	1	3	5
6 to 8 years	2	1	1	4	2	2	3	7
8 to 10 years	1	.	.	1	1	.	1	2
10 to 12 years	1	.	1	2	0	.	.	0
12 to 14 years	.	.	.	.	1	.	.	1
14 to 16 years	.	.	.	.	.	.	.	.
>16 years	.	.	.	.	.	.	.	.

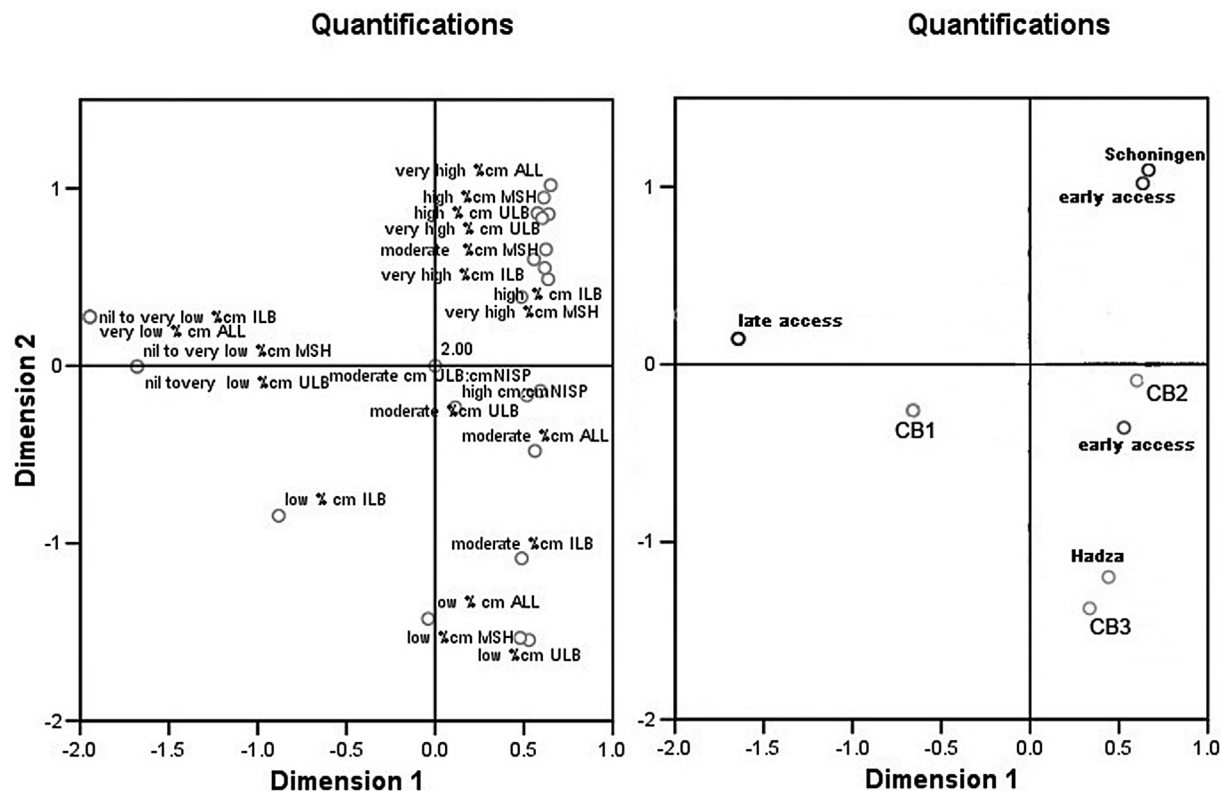


Fig. 28. Multiple Correspondence Analysis of the same variables used for Fig. 26 and 27. Each metric variable was turned into multiple categorical/dummy variables (Table 9) by dividing the maximum value of the range in each of them by five and assigning categorical values from 1 to 5 accordingly for each 1/5 fraction of percentage: 1, nil to low %cm; 2, low %cm; 3, moderate % cm; 4, high % cm; 5, very high % cm. Two plots are shown for the sake of clarity. The quantifications on the left show the dimensional distribution of the variables used according to their values in the 5 fraction division. The plot on the right shows the distribution of the archaeological sites/levels and the experimental and ethnographic analogs used on the same space. The comparison between plots allows the understanding of the gradient of each variable that influences the location of each site/experimental assemblage.

cheek tooth crown heights). The crown-height methods produces older ages than incisor wear patterns, with a small difference ranging between one and two years in most cases (Fig. 30). Using either method, the profile is clearly dominated by prime adult individuals, followed by subadults, with old adults being marginally represented. A prime adult profile is the result of attrition by humans (Stiner, 1994; Bunn and Pickering, 2010). This contrasts with the age profiles typically found in carnivore prey assemblages, which are typically dominated by juvenile and old individuals (Stiner, 1994). Given the site's location and environment, hominids may have hunted equids repeatedly in the same place or, alternatively, they may have scavenged them from carnivores that were using the site. Given the equids' size, lions would be the most likely candidates for this scenario, and indeed lions are the only carnivore that has been suggested to prey on prime adults (Schaller, 1972). Given the taphonomic data discussed above, hominids were

certainly butchering the carcasses prior to any carnivore intervention. Therefore, the only plausible scavenging hypothesis would be confrontational scavenging (power scavenging *sensu* Bunn, 2001). However, Schaller's (1972: Table 47) age data for 174 zebras hunted by lions in the Serengeti shows a very specific age profile: 31% are subadults, 26% are prime adults and 43% are old adults; juveniles and older adults likely dominate because they are easier to hunt. By contrast, the profile for Cuesta de la Bajada shows that 36% are subadults, 56% are prime adults and 8% are old adults; this is twice as many prime adults and many fewer old adults than are found in the modern lion sample. It is worth noting that subadults may be underrepresented (despite their high numbers here) due to differential destruction of juvenile teeth in the archaeological sample. Fig. 31 shows the bootstrapped Cuesta de la Bajada age profile compared to the large lion sample cited above and a human-shot

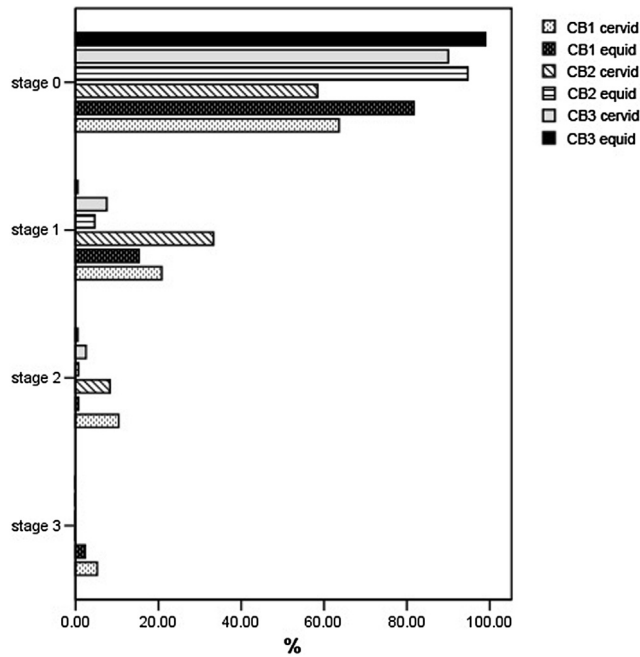


Fig. 29. Weathering stages according to taxon and archaeological level.

sample documented by Schaller (1972). The latter is of limited value and is used here as a secondary analog because it comes from a culling situation, rather than a human population hunting equids for subsistence. The collector of this sample mentioned to Schaller (1972: 226) that his “sample of shot animals of classes I to VIII (subadult) was biased by being too low, and as a result the kill sample of young, yearlings and subadults cannot be compared with the sample of lion-killed zebras” (emphasis added). However, the large Serengeti lion-hunted sample is a good analog, especially since very similar age profiles were also seen in a study of lions hunting in Kruger National Park (Pienaar, 1969). Fig. 31 shows a clear separation between age profiles in the lion-hunted sample and Cuesta de la Bajada. The site's age profile falsifies any scavenging (passive or confrontational) hypothesis and supports the hunting hypothesis.

A similar pattern is seen with cervids, whose age profile at Cuesta de la Bajada is also dominated by prime adults. When using teeth for ageing, there are only two subadults and one old adult, while the remainder (>70%) are prime adults (Fig. 32); again, it is worth remembering that juveniles are sometimes underrepresented in archaeological samples. The bootstrapped cervid sample for Cuesta de la Bajada is compared to two other datasets in Fig. 33: a sample of cervids hunted by wolves, and a sample of cervids hunted by humans (data from Steele, 2002). The archaeological sample is clearly closer to the human-hunted profile and contrasts with the wolf-created profile, again supporting the hunting hypothesis, albeit with a smaller dataset.

3.9. The large macrofauna

The assemblages from levels CB1, CB2 and CB3 contained a very small number of bones from animals >1 ton in weight: rhinocerotidae in level CB2 and proboscideae in all three levels (Table 12). These taxa are represented very few elements each, but their presence shows that the site's environment was also attractive to larger fauna and that natural fossil scatters may have existed either prior to or in between occupations of the site by hominids. None of these bones bear surface modifications made by either humans or

Table 11

Dimensions (in mm) for the deer tooth (crown) specimens from CB3–CB2, which could be aged using the quadratic regression formula.

Specimen		p4	M1	M2	M3
CB3-2898	length	19.25	19.57	22.7	30.49
	width	10.47	12.97	14.13	
	height	12.04	11.14	15.24	16.14
CB3-152	length	18.75	26.78		
	width	13.25	13.93		
	height	19.39	15.04		
CB3-585	length				
	width	12.7			
	height	13.3	14.4		
CB3-1686	length	20.7			
	width	11.52	13.72		
	height	19.06	21.2		
CB3-1626	length				
	width	14.44			
	height	16.84	17.3		
CB3-3007	length			25.96	29.63
	width			17.22	14.38
	height			17.81	19.43
CB3-2981	length	21.8	22.4	25.5	32.98
	width	11.82	12.75	11.87	11.55
	height	13.48	12.54	16.81	17.45
CB3-262	length	17.97	22.44	24.02	27.07
	width	11.92	12.97	13.57	13.54
	height	15.05	12.39	17.07	20.07
CB2-1305	length	15.96	23.9	24.25	33.24
	width	11.29	13.84	15.94	15.65
	height	7.18	5.56	8.49	8.81
CB2-1550	length		22.07	26.17	
	width		10.07	14.44	
	height		16.1	18.1	
CB2-1634	length		19.54		
	width		14.97		
	height		22.07		

carnivores, and most are heavily weathered and cannot be studied further. However, two elephant long bones from level CB3 show clear impact scars on the medullary surface, suggesting green breakage caused by either hominids or, less likely, by hyenas.

4. Discussion

The present study of Cuesta de la Bajada shows that equids dominate all three levels of the site, both in terms of minimal numbers of individuals and minimal number of elements per individual; cervids (*C. elaphus*) are the second-most abundant animals. The carcasses show different qualities of preservation according to size. Medium-sized carcasses, which include older juvenile and adult equids, show much better preservation overall and more complete skeletal representation; small carcasses, including cervids and very few younger equids, are more incompletely represented and poorly preserved. In both groups, the axial skeleton is underrepresented. However, there is high survival of scapulae, pelves and compact bones (carpal/tarsals and phalanges), suggesting that carnivores played only a moderate to marginal role in assemblage modification, depending on the level. Compact bone survival is higher for equids than for cervids, suggesting that

Table 12
Number of identifiable specimens (NISP) or large mammal fauna: rhino and elephant in each archaeological level.

		CB1	CB2	CB2	CB3	CB3
	size	5	5	6	5	6
Skull						
Mandible						1
Teeth			2			
Vertebrae						
	cervical					
	thoracic					
	lumbar					
	caudal					
	sacral					
Ribs			1			
Scapula						
Innominate						
Humerus						
	prox. msh					
	dist	1	1			
Radius						1
	prox. msh					
	dist					
ulna						
	prox. msh					
	dist					
Metacarpal						
	prox. msh					
	dist					
Femur						
	prox. msh					
	dist					
Tibia						
	prox. msh					
	dist					
Metatarsal						
	prox. msh					
	dist					
Carpal/tarsal						1
Phalanges				1		1
ULB						1
ILB		1				1
LLB						
Others			1			
Indet		4	3	2		2

carnivores may have played a larger role in deleting cervid bones than equid bones. This raises the possibility that the accumulation of equid and cervid carcasses took place during different occupational episodes. This scenario might tentatively be supported by more advanced weathering stages on some cervid bones when compared with most equid bones, which are marginally weathered; this might suggest prolonged exposure of cervid bones. However, this is not the case in level CB3, the only context with a sample size large enough to enable confident interpretation. In this level, most bones are subaerially unweathered. It could be argued that some carcasses were deposited sequentially, over repeated occupations during the formation of levels CB1 and probably CB2, but that if this also occurred during formation of level CB3, it cannot be detected.

The differences in skeletal part representation and MNE:MNI ratios in intermediate and small carcass groups is striking. How might this be explained? The only site that makes for good comparison is Schöningen, where the faunal remains are also dominated by equids (Voormolen, 2008). There, axial remains of equids

(ribs = 311; vertebrae = 291), which make up 63% of the assemblage, are much better represented than in Cuesta de la Bajada, where axial remains comprise <15% of the assemblage. Compact bones (n > 150) are also well-represented at Schöningen, comprising 16% of the whole assemblage or 44% of the appendicular assemblage (for the sake of comparability with Cuesta de la Bajada). Equids were fully exploited at Schöningen and only non-biasing taphonomic processes intervened afterwards, despite evidence for carnivore activities in the form of tooth-marked specimens. It is striking that in an assemblage where carnivores also intervened, equid axial remains have survived at frequencies more than four times that reported at Cuesta de la Bajada. Therefore, the equid skeletal part profiles at our site demand other explanations besides carnivore intervention. Remarkably, the cervids at Schöningen, which form a small part of the assemblage, are also represented by very uneven skeletal profiles, with low frequencies of axial and compact bones that are very similar to those reported for the Cuesta de la Bajada cervids. At Schöningen, the sample of 21 equids seems to have been hunted at the site, as the high proportions of axials and the catastrophic age profile indicate (Voormolen, 2008). One possible interpretation for the Cuesta de la Bajada equid assemblage would be that contrary to Schöningen, the underrepresentation of axials and the prime-adult dominated assemblage would suggest that some carcasses may have been selectively transported to or from the site. This would suggest that the site use was less opportunistic than at Schöningen. An argument supporting this interpretation lies in the very different MNI estimates obtained when using scapular and carpo/tarsal elements *versus* long bones. MNI estimates using the latter are substantially lower, which is unexpected for hammerstone-broken assemblages, since the high-survival (high-density) shaft specimens should commonly survive biasing processes affecting preferentially axial bones. The high survival of scapulae and lower representation of long bones needs to be explained and can be accounted for depositional dynamics acting at the spatial level. For this reason, it is crucial that future excavations expose a larger area, showing if the pattern is space dependant.

The evidence presented here shows that hominids butchered most of the carcasses at Cuesta de la Bajada, certainly in level CB3, the best preserved assemblage, if not in all levels. Low tooth mark frequencies indicate that carnivores intervened marginally and would have had secondary access to carcasses, after hominids. The presence of some percussion marks, together with the notches and a predominance of green fractures, show that most bones at the site were broken while fresh, and likely by hominids who were seeking access to marrow. This is most clearly seen in the frequency of percussion marks in level CB3. This level also has the most abundant sample of cut marks, while levels CB1 and CB2 are problematic due to small sample sizes and bad cortical preservation. The abundance of cut marks in level CB3 shows that hominids defleshed carcasses thoroughly. Filleting and evisceration are clearly documented by the locations of cut marks on long limb shafts and the ventral sides of ribs, respectively, but dismembering cannot be well-supported due to the virtual absence of limb epiphyses (especially well-preserved ones). However, cut marks documented on the scapular neck shows disarticulation from humeri. All these behaviors are much better documented by Voormolen (2008) at Schöningen because of better bone preservation and more complete skeletal representation at that site. But importantly, Cuesta de la Bajada shows that the butchery behavioral patterns reconstructed by for Schöningen were also operating in the Iberian peninsula.

The present study also elaborates on the interpretations offered for Schöningen on strategies of carcass acquisition by providing detailed data on the age profiles of the carcasses exploited by

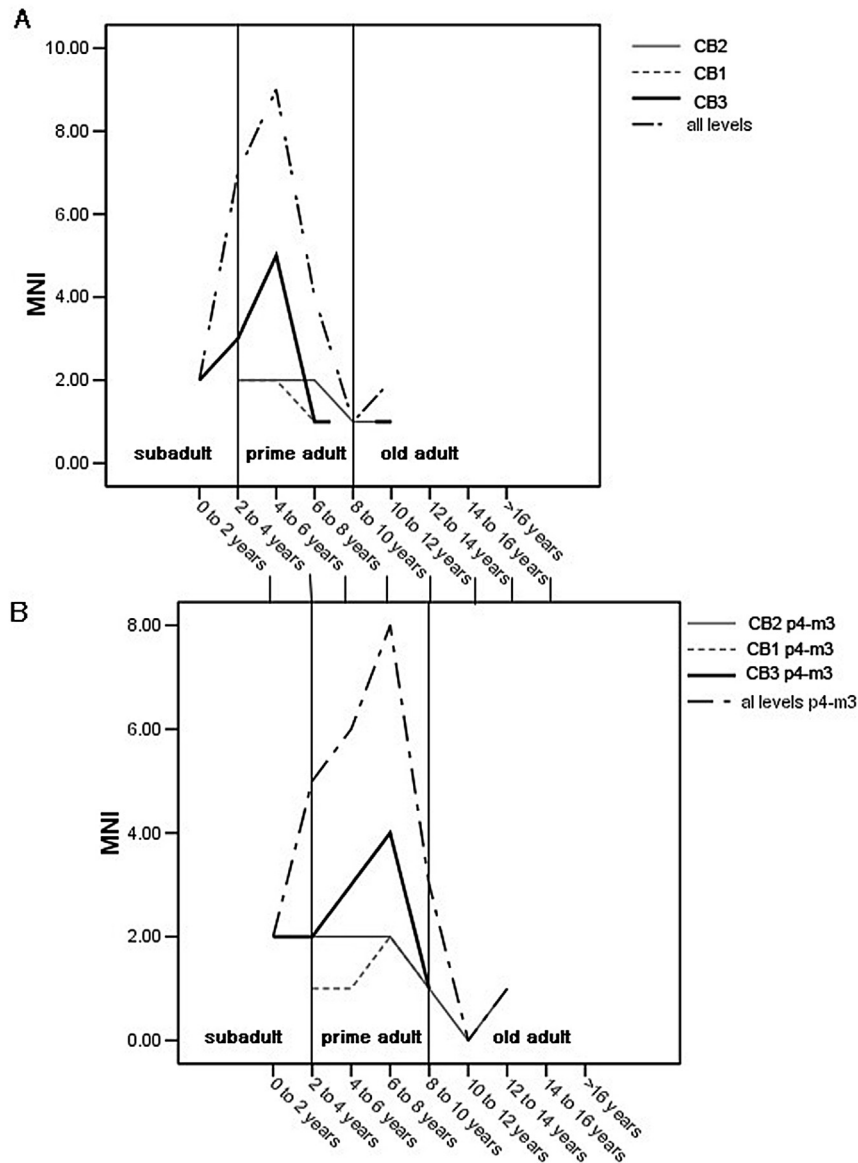


Fig. 30. Mortality profiles of equids at Cuesta de la Bajada. A, ages obtained through the wear pattern of incisors; B, ages obtained through the analysis of posterior dentition crown height. Vertical lines indicate the differentiation of subadult, prime adult and old individuals. Prime adults are constrained in between both vertical lines.

hominids at Cuesta de la Bajada. This site was formed around a pond not far from a river and contains remains of large macrofauna other than equids and cervids; these were likely deposited naturally because the setting would have acted as a magnet for animals. Proboscidea are represented by highly weathered and very few remains in all three levels, suggesting long periods of exposure and bone destruction. The representation of other taxa by a few remains per individual supports the idea that the site includes naturally-deposited carcasses. By contrast, the equid and cervid carcasses are much better represented: one could theoretically argue that they were accumulated by large carnivores (felids) and were confrontationally scavenged by hominids. However, the consideration of carcass size (equids) and possible predator size (large felids) and the age profiles of the equids and cervids do not support carnivore-first models. Rather, the high abundance of prime-adults in both taxa support a hypothesis of hominids hunting, and hunting selectively.

5. Conclusions

Cuesta de la Bajada can thus be interpreted as a kill/butchery site or, alternatively, as a consumption site, repeatedly reoccupied by hominids, who probably chose the river and pond setting since it would act as a magnet for fauna. A consumption site can be understood as a place where carcasses are processed and consumed. This could imply home base behaviors or, alternatively, near-kill locations like those of some modern hunter-gatherers (O'Connell et al., 1992). The functionality of the site can only be properly understood, like the functionality of any Pleistocene site, if a substantially larger excavation exposes an area big enough to study the spatial properties of the site, expanding the zooarchaeological analysis of the faunal assemblage to a spatial level. If CB is a butchery site, the underrepresentation of vertebrae and ribs can be properly understood as the effect of carnivore post-depositional ravaging. These are the first elements (together with compact bones) to be deleted by carnivore consumption. Abundant pelvic

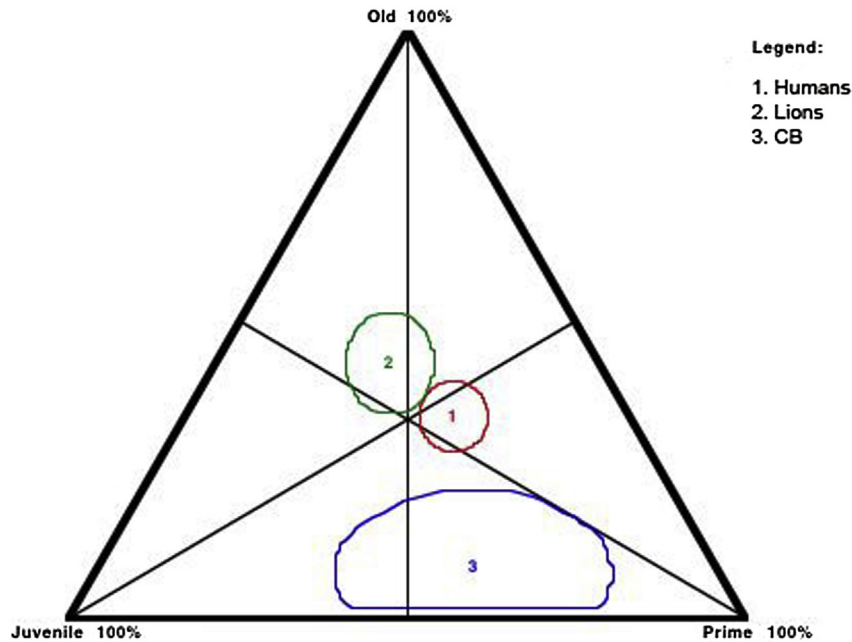


Fig. 31. Triangular graph showing the distribution of bootstrapped (10,000 re-samples) and the 95% confidence interval (density contours) for the Cuesta de la Bajada equid sample (Table 10). The profile for lion kills (lions) and for a biased human sample (human) (see text) differ essentially from that of Cuesta de la Bajada (Equid).

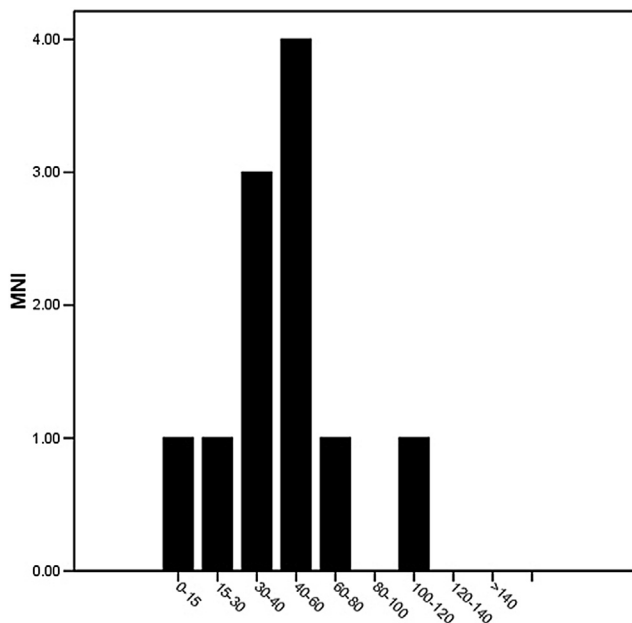


Fig. 32. Mortality profiles of the cervids from Cuesta de la Bajada. The age reconstruction was carried out through the analysis of dentition, using QCHM for dp4 and M1 (see text). Age class 1 as shown in Steele (2002) was defined as “young”; age classes 2–5 were defined as “prime adult” and the remainder were “old”.

remains would argue against this scenario, since they are more cancellous than long bones, which appear underrepresented. However, most pelvic remains are not complete. They appear mostly represented with portions around the acetabular area. In addition, pelves tend to remain with or near the axial skeleton whereas long bone portions tend to be more easily dispersed by carnivore ravaging. Since the excavation is relatively small (<90 m²), bone dispersion around the site is not properly sampled.

Regarding the paleolocation of CB, a pond near a river does not imply a dangerous location. If the size of the pond is big enough, riverine vegetation could make the location suitable for prolonged occupation, as was the case in other European Middle Pleistocene sites such as Bilzingsleben (Mania, 1990). In this type of setting, hominid predation can be opportunistic or selective, since the pond will draw enough game to afford selectivity by humans. In the case of CB, although equids are the predominant taxa exploited by hominids, an important exploitation of red deer also identified. Until a larger portion of CB is accessible via excavation, it will be very difficult to understand the site's primary functionality beyond carcass processing and consumption.

Repeated occupation (although to a much smaller extent) of the same location for equid and cervid butchery is also documented at Schöningen (Voormolen, 2008). Together with Gran Dolina TD6 and TD10 in Atapuerca (Diez et al., 1999; Rodríguez-Hidalgo et al., 2015), Bolomor Cave (Blasco et al., 2010, 2013) these sites enlarge the small number of early Middle Pleistocene sites where primary access to carcasses by hominids can be taphonomically supported.

Taphonomic analyses in several Middle Pleistocene sites in the Near East have also supported interpretations of hominids hunting. The faunas of Misliya Cave, dating to >200 ka (Yeshurun et al., 2007) and Hayonim, dating to 200–140 ka (Stiner, 2005), have yielded a wealth of hominid-modified bones, very few carnivore-modified bones and skeletal part profiles representing most anatomical areas of the fauna exploited. The recent taphonomic analysis of the early Middle Pleistocene (MIS 18) layers of Gesher Benot Ya'akov shows a paucity of carnivore-modified remains and abundant cut and percussion marks on remains of fallow deer (Rabinovich et al., 2008). The frequencies and locations of the cut marks suggest repeated primary access by hominids to fallow deer, which (given the low carnivore signal) supports the idea that they were hunted.

In summary, the present study of Cuesta de la Bajada contributes to the number of Middle Pleistocene sites which have provided taphonomic evidence that hominids were hunting during this period. It also provides a temporal perspective on hunting and

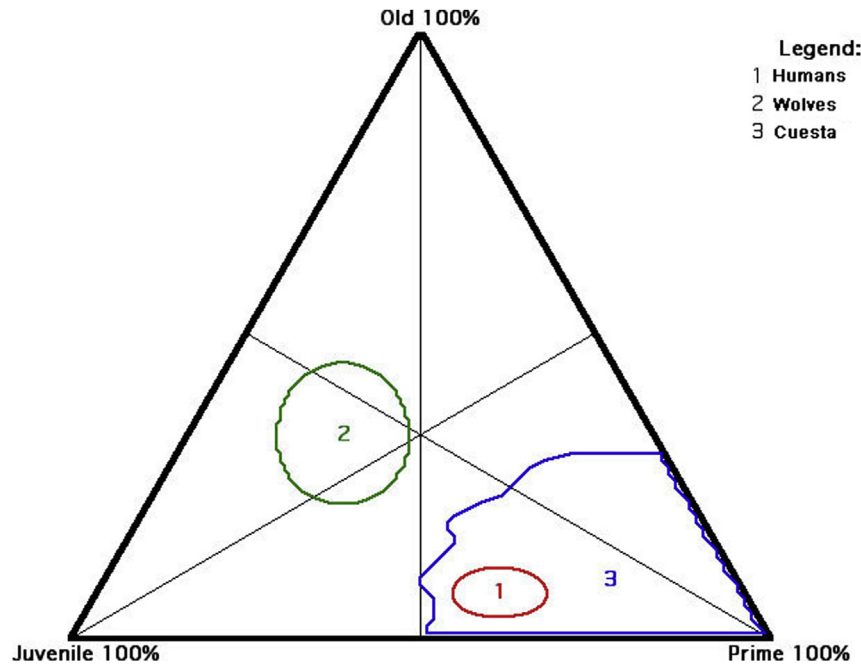


Fig. 33. Triangular graph showing the distribution of bootstrapped (10,000 re-samples) and the 95% confidence interval (density contours) for the Cuesta de la Bajada deer age data (Table 11), using QCHM for dp4 and M1 (see text) compared to data from two sample of deer: one hunted by wolves and the other one hunted by humans (data from Steele, 2002). Age class 1 was defined as “young”; ages classes 2–5 were defined as “prime adult” and the remainder were “old”.

enables us to understand the possibility of this behavior occurring in earlier periods such as the Lower Pleistocene (Domínguez-Rodrigo et al., 2007). This study also casts doubts on previous arguments that scavenging may have been the main strategy of carcass acquisition during the Middle Pleistocene (see similar interpretations as those resulting from the present study in Villa et al., 2005 and Villa, 2008). Future research should unveil the functionality of this anthropogenic site.

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