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Human cannibalism in the Early Pleistocene of Europe (Gran Dolina, Sierra de Atapuerca, Burgos, Spain)

Human remains belonging to at least six individuals were found in an exploratory excavation made at the site of Gran Dolina (Sierra de Atapuerca, Burgos, Spain). These remains were recovered from the Aurora Stratum of Unit TD6. This stratum has a thickness of approximately 30 cm. The area of the exploratory excavation is about 7 m^2. According to palaeomagnetic analyses, Unit TD6 shows reversed polarity, which is considered to belong to the Matuyama chron. This unit is immediately below TD7, where the Matuyama–Brunhes boundary has been detected, indicating an age of around 780,000 years BP.

There is no specific distribution, treatment, or arrangement of the human remains, which were found randomly mixed with abundant faunal remains and stone tools. Most of the faunal and human fossil bones from the Aurora Stratum have human induced damage. Stone tool cutmarks are frequent, and peeling (a type of fracture similar to bending a fresh twig between the hands) provides a specific breakage pattern together with percussion marks and chopmarks. Both non-human and human remains show similar intensive exploitation. Slight differences, however, have been observed between fauna and humans (e.g., peeling frequent in humans, rare in fauna), that appear related to different musculature, weight, and bone structure. The characteristics of this fossil assemblage suggest that it is solely the result of consumptive activities as there is no evidence of ritual or other intention. The possibility of distinguishing between dietary *vs.* survival cannibalism is discussed here.

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Assessing cannibalism

Cannibalism has been documented in several different human groups and civilizations through time, based on written references, oral tradition or remains of the victims. Many myths, tales and legends narrate acts of cannibalism involving real or fictitious creatures. Although the term *cannibalism* derives from the Caribbean peoples, references to cannibal practices have been mentioned all over the world in both prehistoric and historic periods.

Human cannibalism in anthropology and palaeontology is a controversial topic that provokes contradictory reactions. During the middle of the ninteenth century the influence of Darwin's *Origin of the Species* induced important reactions in science. The first human like fossils discovered in the Neander Valley (Germany, 1856 ca. 40–50 ka) were considered from an anthropocentric point of view—everything was made by and for hominids. Contrary beliefs were that the ancient humans were ''barbarian savages'' and ''cannibals by definition''. The first report of cannibalism (Gorjanovič-Kramberger, 1909) was made soon after the discovery of hominid remains at Krapina (Croatia 1895–1905, ca. 130 ka). Claims of cannibalism were gradually linked with ''cults of skulls'' in the 1930s with the discovery of skulls in Steinheim (Germany, 1933, ca. 250 ka), Monte Circeo (Italy, 1939, ca. 50 ka), and Zhoukoudian (China 1928–1937, ca. 400–500 ka). These remains, whose cranial bases were missing, were considered to be remains of cannibalistic feasts at which the brains had been consumed. However, later studies have shown that the lack of the cranial base is common since this part of the skull is fragile.

Raymond Dart thought that the lack of the front teeth on a specimen of *Australopithecus* (Makapansgat 1948, ca. 3 m.y.a.), and broken long bones, demonstrated some manner of violent death. Again, taphonomic studies showed that this damage was not the result of cannibalistic practices, but was caused by hyaenas seeking fat-rich marrow.

Subsequent discussions of cannibalism have been characterized by either permissive tolerance (e.g., Blanc, 1961) or extreme criticism (Arens, 1979) and disapproval of cannibalism claims. Several authors have demanded more scientific rigour (e.g., Jacob, 1972; Binford, 1981; Askenasy, 1994).

In his book *The Man-eating Myth: Anthropology and Anthropophagy*, Arens (1979), presents an exhaustive analysis of claims for cannibalism in several societies at various times. His main conclusion was that there is no convincing evidence for human cannibalism (except for survival in extreme conditions of starvation). This work was particularly important at the time since so many uncritical publications had previously accepted that cannibalism was practised by many tribes and ancestors. However, Arens, as well as his followers, neglected or ignored some of the best evidence. Since 1979, taphonomic studies of bone remains have demonstrated the validity of a number of claims for cannibalism. It is not our intention to review the literature related to historic cannibalism. Discussions among social anthropologists and extensive compilations of cannibalism claims can be found in Binford (1981), Villa *et al.* (1996*a*,*b*), Villa (1992), White (1992) and Turner & Turner (1995).

Cannibalism, in spite of the origin of the word, occurs not only in humans but also in many other species that use it as a means of population control, a source of food, or as a sign of authority and strength by the dominant member. Cannibalism occurs among various orders of mammals, insects and birds, and there are some accounts of such occurrences among omnivorous primates (Bygot, 1972; Goodall, 1979), and bears (Kurt,1976). A cannibal is therefore defined as a person or animal that eats any type of tissue of another individual of its own kind.

Cannibalism cannot be established on the sole basis of cutmarks. This is the case for Bodo (Ethiopia, ca. 600 ka) and Goughs's cave (England, ca. 12 ka). White (1985) and Cook (1986) studied these sites, respectively, and could not reach conclusive interpretations. Remains from both sites bear undeniable cutmarks, indicating that the skeletons were intentionally defleshed, although not necessarily eaten.

Figure 1. Map of the Iberian Peninsula. The black arrow points out the location of the sites, near the town of Burgos.

Some of the functional types of potential human cannibalism are:

(1) *Nutritional*

(a) *incidental*: survival (periods of food scarcity or due to catastrophes, i.e., starvation-induced).

(b) *long duration*: gastronomic or dietary (humans are part of the diet of other humans).

(2) *Ritual, magic, funerary* (in relation to beliefs or religion).

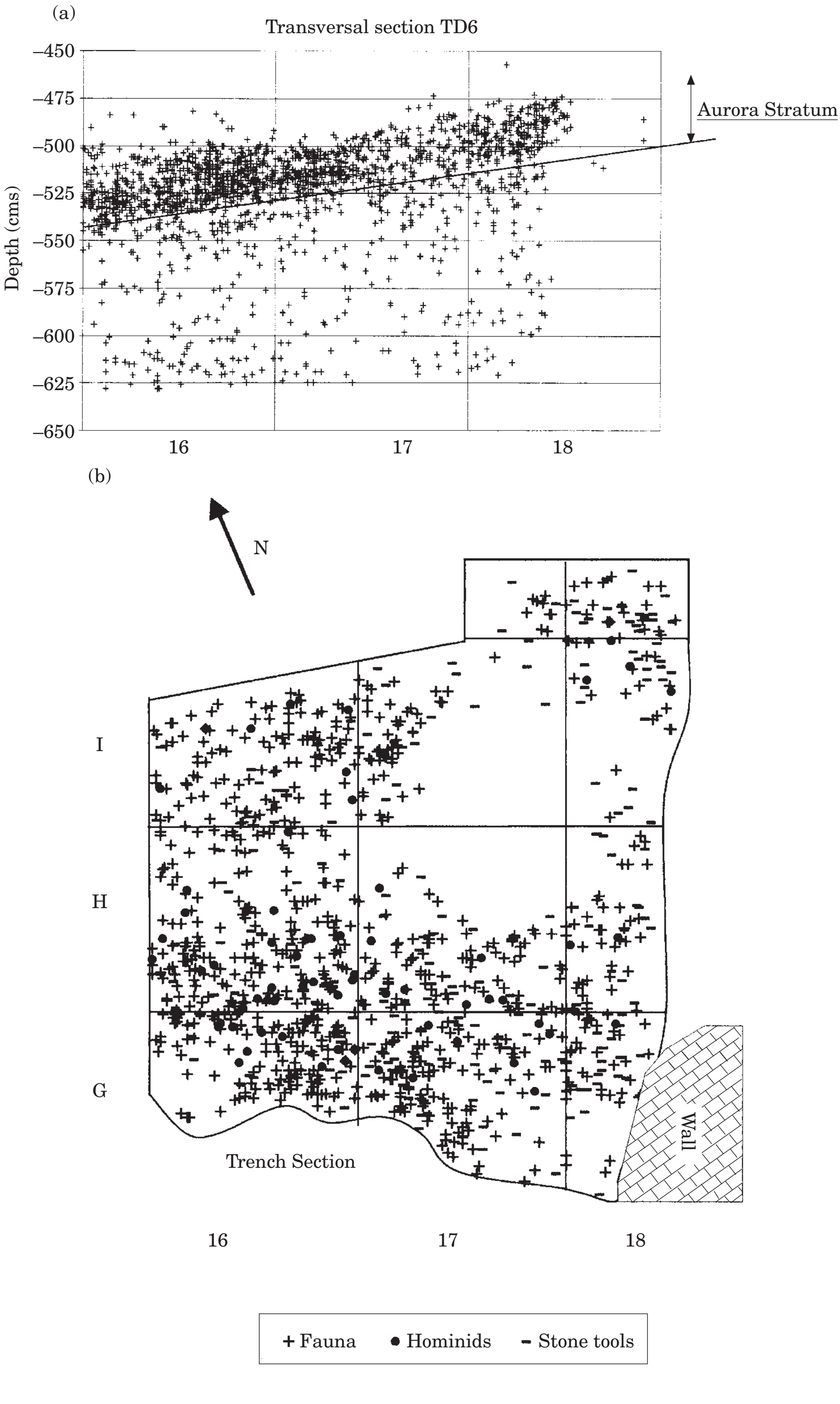
(3) *Pathological* [mental disease: *parapathic* defined by Reverte (1981); for political reasons, as referred to by Zheng Yi (1997), in China].

These functional types of cannibalism have also been sub-divided into social divisions that include *aggressive* (consuming enemies) *vs. affectionate* (consuming friends or relatives), or *endocannibalism* (consumption of individuals within the group) *vs. exocannibalism* (consumption of outsiders).

The identification of nutritional, as opposed to ritual, cannibalism, is based on a combination of indicators, the main criterion being the comparison of human and animal remains from the same archaeological context. According to Villa *et al.* (1986*a*), these indicators are:

- similar butchering techniques in human and animal remains. Thus frequency, location and type of verified cutmarks and chopmarks on human and animal bones must be similar, but allowance should be made for anatomical differences between humans and animals;
- similar patterns of long bone breakage that might facilitate marrow extraction;
- identical patterns of post-processing discarding of human and animal remains;
- when applicable, evidence of cooking; if present, such evidence should indicate comparable treatment of humans and animal remains.

However, when human and nonhuman animal remains are found in separate contexts, with different patterns of exploitation and distribution, ritual or some other interpretation should be considered as an alternative cause of cannibalism (Villa *et al.*, 1986*a*; Villa, 1992; White, 1992; Turner & Turner, 1995).


(a)
Transversal section TD6
Aurora Stratum
Depth (cms)
–450
–475
–500
–525
–550
–575
–600
–625
–650
16
17
18
(b)
N
I
H
G
Trench Section
Wall
16
17
18
+ Fauna
● Hominids
- Stone tools

Sierra de Atapuerca, Gran Dolina site, TD6—"Aurora Stratum"

The site of Gran Dolina belongs to the southern part of the karstic site complex of the Sierra de Atapuerca. This is a small mountain, 1079 m above sea level, 15 km from the town of Burgos in northern central Spain (Figure 1). The area is in the Duero Basin, bounded by the Demanda mountain range to the east and by the Arlanzón River to the south. The Gran Dolina site is one of seven sites systematically excavated in this area since 1980. Six of these sites are presently exposed in an abandoned railway trench, which was opened at the beginning of the twentieth century.

Gran Dolina is an 18 m-thick cave infilling. Eleven sedimentary levels have been distinguished in the sequence, many of them yielding abundant fossil fauna assemblage, as well as many stone implements, both of which have provided important information on human behaviour (Carbonell *et al.*, 1995*a*). An exploratory excavation of the whole section, from the uppermost zone of the stratigraphical sequence to the base of the infilling, has been made since 1992. Human remains have been recovered from a distinctive stratum of the unit TD6 named "Aurora" [Figure 2(a)], after the archaeologist who discovered the first human fossils at TD6, Aurora Martín Nájera. It is a 30 cm-thick layer that slopes down towards the southwest.

The human remains from Gran Dolina

The Gran Dolina TD6 site has recently yielded human remains of six individuals found mixed together with stone tools and nonhuman fauna remains (Carbonell *et al.*, 1995*b*). These humans come from the subunit Aurora Stratum in particular. Their age is more than 780 ka (Parés and Pérez-González, 1995). These human fossils have been assigned by Bermúdez de Castro *et al.* (1997) to the new species *Homo antecessor*. The first human remains were discovered in 1994, and were soon afterwards recognized as having been cannibalized (Fernández-Jalvo *et al.*, 1996). As the exploratory excavation of the Aurora Stratum has finished, it is now possible for a detailed taphonomic analysis of the fossil of this subunit to be undertaken, as well as reconstructing the processes of the site formation (Díez *et al.*, 1999). We will discuss in this paper the evidence that may allow us to specify the type of cannibalism (nutritional *vs.* ritual), and whether it is possible to distinguish between dietary and survival cannibalism.

Results of the present study are then compared with sites that have also been taphonomically analysed and where modern methods of excavation have been used, as in Atapuerca TD6. These study areas and sites are Fontbrégoua (France—Neolithic—Villa *et al.*, 1986*a*,*b*), Mancos (from Colorado—AD 1100–1150—White, 1992) and throughout the Southwest Amerindian area (Arizona) by Turner & colleagues, 1970–1999. It has to be kept in mind, however, that the ages of these sites are not comparable to the Aurora Stratum, and, therefore, social attributes and behaviours cannot readily be inferred or considered analogous. Furthermore, the number of human remains from the Aurora Stratum (92 NISP) and the excavated area (7 m^2) are smaller than

Figure 2. (a) Transversal section (E–W) of the prospective excavation area at TD6 (Gran Dolina) showing the findings of the unit. Notice the high fossil density on top of the unit TD6 identifying the Aurora Stratum. (b) Aerial plan of Aurora Stratum showing the excavation coordinates; G-H-I (from South to North of the excavation) and 16-17-18 (from West to East of the excavation). Note that humans, fauna and implements are randomly dispersed throughout the excavation area.

Table 1 Identified human specimens from Aurora Stratum

Label	Age	Element	Area	Side	Individual
ATD6-1	Juvenile	Tooth	Canine	Lower left	I
ATD6-2	Juvenile	Tooth	Incisor	Left l2	I
ATD6-3	Juvenile	Tooth	Premolar	Right LP3	I
ATD6-4	Juvenile	Tooth	Premolar	Right LP4	I
ATD6-5	Juvenile	Mandible	Body	Right side (M1-M3)	I
ATD6-6	Juvenile	Tooth	Canine	Right lower	I
ATD6-7	Juvenile	Tooth	Premolar	Right UP3	I
ATD6-8	Juvenile	Tooth	Premolar	Right UP4	I
ATD6-9	Juvenile	Tooth	Premolar	Left UP4	I
ATD6-10	Juvenile	Tooth	Molar	Right UM1	I
ATD6-11	Juvenile	Tooth	Molar	Left UM1	I
ATD6-12	Juvenile	Tooth	Molar	Right UM2	I
ATD6-13	Juvenile	Maxilla	Alveolar	Left	I
ATD6-14	Inf.	Maxilla	Alveolar	Left (dc-dm1)	II
ATD6-15	Juvenile	Skull	Frontal	Right	
ATD6-16	Juvenile	Skull	Temporal	Right	
ATD6-17	Adult	Skull	Temporal	Right	
ATD6-18		Skull	Petrous-temporal	Left	
ATD6-19	Adult	Skull	Zygomatic arch	Right	
ATD6-20		Skull	Parietal	Left	
ATD6-21	Juvenile	Radius	Diaphysis	Left	
ATD6-22	Adult	Patella	Complete	Left	
ATD6-23	Adult	Carpal	Distal	Hamate (left)	
ATD6-24	Adult	Carpal	Complete	Capitate	
ATD6-25	Adult	Metatarsal	Proximal end	Mtts. 2–3 left	
ATD6-26	Adult	Metacarpal	Distal condyle	2 mtcp., left	
ATD6-27	Adult	Phalange	Diaphysis	Hand, 1 phal.-finger 2–3	
ATD6-28	Adult	Phalange	Complete	Hand, 2 phal.	
ATD6-29	Adult	Phalange	Distal	Hand, 1 phal.	
ATD6-30	Adult	Phalange	Complete	Foot, 1 phal. toe 1, right	
ATD6-31	Adult	Phalange	Complete	1 phal. finger 1	
ATD6-32	Adult	Phalange	Distal	Foot, 1 phal.	
ATD6-33	Adult	Phalange	Complete	Foot, 2 phal. toe 2, left	
ATD6-34	Adult	Phalange	Complete	Foot, 2 phal. toe 2–3	
ATD6-35	Adult	Phalange	Complete	Foot, 2 phal. toe 4–5	
ATD6-36	Adult	Phalange	Distal apical tuber.	Foot, 3 phal.	
ATD6-38	Juvenile	Vertebra	Body	Lumbar	
ATD6-39	Adult	Rib	Complete		
ATD6-40	Juvenile	Vertebra	Spinous process	Thoracic	
ATD6-43	Juvenile	Radius	Diaphysis	Left	
ATD6-44	Juvenile	Phalange	Diaphysis	Hand, 2 phal.	
ATD6-45	Adult	Vertebra	Transverse process	Lumbar	
ATD6-46	Adult	Phalange	Prox. + diaphysis	Hand, 2 phal	
ATD6-48	Juv-ad	Tooth	Crown	Left lower incisor 2	IV
ATD6-49	Juvenile	Maxilla			
ATD6-50	Juvenile	Clavicle	Complete	Right	
ATD6-51	Adult	Vertebra	Complete	Cervical	
ATD6-52	Juv-ad	Tooth	Incisor	Left lower l1	V
ATD6-53	Juvenile	Phalange	Complete	Hand, 2 phal.	
ATD6-54	Inf.	Vertebra	Lamina	Axis	
ATD6-55	Inf.	Clavicle	Lateral	Left	
ATD6-56	Juvenile	Patella	Complete	Right	
ATD6-57	Juvenile	Skull	Temporal		
ATD6-58	Adult	Skull	Zygomatic + maxilla	Left	
ATD6-59	Adult	Metacarpal	Dist. + diaphysis	2 mtcp. left	

Table 1 ***Continued***

Label	Age	Element	Area	Side	Individual
ATD6-60	Adult	Skull	Pterion	Left	
ATD6-62	Juvenile	Skull	Crista galli	Ethmoid	
ATD6-63	Adult	Mandible	Mental protuberance		
ATD6-64	Juvenile	Clavicle	Diaphysis	Right	
ATD6-66	Adult	Rib	Prox. + diaphysis		
ATD6-67	Inf.	Phalange	Dist. + diaphysis	Hand, 1 phal.	
ATD6-68	Juvenile	Phalange	Complete	Foot, 3 phal.	
ATD6-69	Juvenile	Maxilla	Alveol-frontal process	(L P3, M1-M3 & R I2-M1)	III
ATD6-70	Adult	Metatarsal	Distal epiphysis	2 mtts left	
ATD6-71		Skull	Frontal?		
ATD6-72	Juvenile	Skull	Frontal?		
ATD6-73	Adult	Skull	Fragment	Indet	
ATD6-74	Inf.	Vertebra	Body	Thoracic	
ATD6-75	Adult	Vertebra	Lamina	Cervical	
ATD6-76	Juvenile	Femur	Prox. + diaphysis		
ATD6-77	Adult	Skull	Occipital condyle		
ATD6-78	Juvenile	Skull	Frontal?		
ATD6-79	Adult	Rib	Head + diaphysis		
ATD6-80	Adult	Vertebra	Lamina	Cervical	
ATD6-81	Juvenile	Skull	Sphenoid		
ATD6-82	Adult	Phalange	Dist. + diaphysis	Hand, 1 phal.	
ATD6-84	Juvenile	Skull	Zygomatic arch		
ATD6-85	Adult	Rib	Diaphysis		
ATD6-87	Adult	Skull	Parietal		
ATD6-88	Adult	Rib	Head + diaphysis	ii–iii	
ATD6-89	Adult	Rib	Diaphysis	ix–x	
ATD6-90	Juvenile	Vertebra	Complete	Atlas	
ATD6-91	Adult	Skull	Apophysis mast. + temp.		
ATD6-107	Adult	Metatarsal	Ep. prox. + diaph.		
ATD6-108	Adult	Rib	Diaphysis	i	
ATD6-206	Adult	Rib	Head + diaphysis		
ATD6-251	Juvenile	Rib	Diaphysis		
ATD6-307		Vertebra	Body	Thoracic	
ATD6-308		Rib	Head		
ATD6-308		Rib	Diaphysis		
ATD6-309	Adult	Vertebra	Lamina	Cervical	
ATD6-312	Inf.	Tooth	Incisor	Left Ul2	VI

some of the sites with which they will be compared.

Materials and methods

Accessory experimental work

Two of us (IC and JR) were involved in butchering the carcass of a chimpanzee that had recently died. It was provided by the local Animal Protection Association of Tarragona (Spain). We found that skinning, dismembering and defleshing this animal helped us to understand better some of the cuts observed on the human remains from the Aurora Stratum.

We experimented with flakes made from limestone, quartzite, Cretaceous flint and Neogene flint, the different raw materials used at Atapuerca to make the stone tools associated with the Aurora Stratum fossils. Two lamb forelimbs were butchered by one of us (YFJ), using implements made with these four types of stone. Analyses of this experiment are in progress and the results will be published soon.

Fossil assemblage

The human collection of TD6-Aurora Stratum consists of 92 fossils that include dental, cranial and postcranial elements (Table 1). Nonhuman faunal remains from TD6-Aurora Stratum have also been studied following identical methods of analysis. Results from this analysis have been included in a separate paper (Díez *et al.*, 1999) to interpret site formation processes.

Spatial co-ordinates (X, Y, Z) are noted during excavation for every fossil, stone tool, coprolite, concretion, limestone rock (bigger than 10 cm), small mammal accumulation, or artefact, and plotted on to a map. Slope, orientation, measurements and descriptions are noted for a given square. Animal remains have been labelled according to the square where they were found and the related number of the find, whereas human fossils have been labelled with ATD6- followed by the number of the specimen [Figure 2(b)].

All sediment were wet screened (from 5–0·5 mm mesh). Fossils recovered during the 1994 season were systematically immersed in a preservative solution (Paraloid, a synthetic resin). The use of preservative may cause problems for the analysis of cutmarks or superficial damage using scanning electron microscope (SEM). This problem was anticipated, so fossils were examined in the field laboratory through a binocular light microscope before treatment. This revealed that the highly mineralized condition of the TD6 fossils made it unnecessary to strengthen them, so immersion in perservative was discontinued.

The fossil collection from the Aurora Stratum (faunal and human) was examined with the aid of a Leica Wild MZ8 from 6·3 to 50 × binocular microscope. Some specimens were analysed using scanning electron microscopy (SEM). Two different SEMs were used. A Philips XL20 housed at the Museo Nacional de Ciencias Naturales (Madrid) and an ISI ABT55 SEM fitted with an environmental chamber, operating in the back-scattered electron emission mode at 20 kV, which is housed at The Natural History Museum (London). This type of microscope enables specimens to be directly analysed with no necessity for coating (Taylor, 1986), and it has been extensively used.

High-resolution replicas were made using EXAFLEX CG Injection type. Positive replicas were then made using an epoxy resin (Nural-23). These replicas were coated with gold-palladium and analysed using the Philips XL20 secondary electron emission mode at a standard accelerating voltage of 10 kV.

Identification of anatomical elements

Each human fossil has been identified as follows:

- body part;
- segment and portion (diaphysis, proximal end, and distal end; complete; lateral; body; process; arch);
- age (juvenile/adult/infantile) determined from dental eruption and wear, as well as epiphyseal fusion and bone texture.

The large mammal faunal composition, identified in TD6 Aurora Stratum are as follows, *H. antecessor, Mammuthus* sp., *Ursus* sp., Canidae indet, *Vulpes* sp., *Panthera* sp., *Felis* sp., Muselidae indet, stenoid *Equus, Stephanorhinus etruscus, Cervus elaphus, Megaloceros* sp., *Dama dama* sp., *Capreolus* sp., *Sus scrofa, Bison* sp (García and van der Made, pers. com.). Anthropologists from the Atapuerca research team identified the human remains (listed in Table 1). The minimum number of individuals has been calculated to be six according to detailed dental analysis (Bermúdez de Castro, pers. com.).

With regard to the rest of the fauna, we have been working according to the following size classes: small (<115 kg), medium (115–350 kg), large (>350 kg) (see Díez *et al.*, 1999 for site formation). For the analysis performed on the faunal remains to identify the site formation processes, the human collection and "possible Homo" have been assigned to the small size class.

The relative abundances of skeletal elements have been calculated by comparison with the expected numbers of each element multiplied by the minimum number of individuals.

Fracture

- *Length/width/thickness* were measured on all fossils with a micrometry calibre.
- *Peeling*. This was described by White (1992) and Turner & Turner (1999). Peeling is a type of fracture that occurred frequently in the Mancos assemblage and has also been seen in the Aurora Stratum fossil assemblage. It is defined as a roughened surface with parallel grooves or fibrous texture produced "when fresh bone is fractured and peeled apart similar to bending a small fresh twig from a tree branch between two hands" (White, 1992:140). Peeling was recorded as present/absent for each fossil.
- *Percussion pits*. These are pits of variable sizes and depths (Leroi-Gourhan & Brezillon, 1972; Blumenschine & Selvagio, 1988). They are considered to be the impact point where a stone or any solid matter struck the bone cortex and scarred the surface. Percussion pits are usually accompanied by abrasions and scratches caused by friction of the bone against the stone raw material that hammered it, or the anvil surface where the bone was resting when it was struck. Scratches may occur inside the pits as well as the surrounding area [Figure 3(a)], with all scratches having the same direction. These pits and striae have been named "percussion striae" (White, 1992), "contrecoup" or "hammerstone/anvil scratches" (Turner, 1983). These pits and scratches were recorded as present/absent.
- *Adhering flakes*. This term refers to bone flakes that adhere to the fracture surface of a specimen. Curving incipient fracture lines, often hairline, which are subparallel to the fracture edge, set off these flakes. This condition was also recorded as present/absent.
- *Conchoidal percussion* scars have been described and measured, following the nomenclature traditionally used in lithics (deep, marginal, cortical direct, inverse, medular flake, cortical flake, concave, convex, straight).

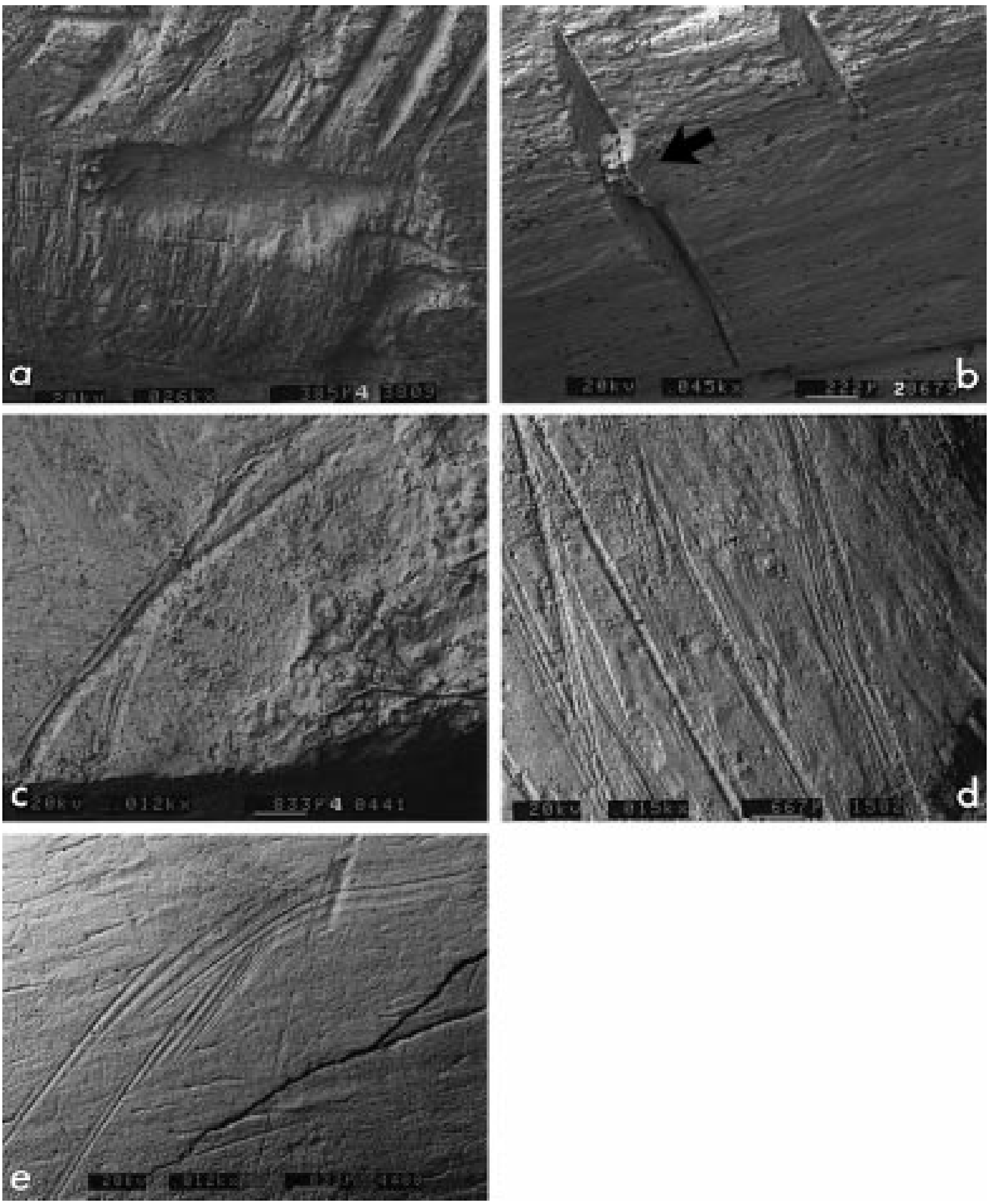
Tool-induced surface modification

Description of the cut emplacement on the bone (metaphysis, epiphysis, diaphysis, articular area) and arrangement (distribution: isolated marks/grouped/generalized and orientation: oblique/transversal/longitudinal) were recorded for every cutmark, chopmark or scrapemark, according to the size of the mammalian species. Lengths of striations have also been measured (maximum and minimum lengths when sets of cuts occurred).

Cutmarks. Incisions or slicing marks have been analysed separately from saw cuts. Incisions or slicing marks were differentiated according to Schick & Toth (1993) as: incisions made with a flake edge without retouching, edge retouched on one face, and edge retouched on both faces [see Figures 3(b) and 3(c).

Microscopic morphology of cutmarks is not the only discriminating trait from other types of nonhuman induced striations. Cutmark arrangement (position and number of marks), placement on the element (e.g., muscle and ligament attachments), as well as the species affected, are additional factors (Fernández-Jalvo *et al.*, 1999; Olsen & Shipman, 1988), that may also indicate the objective of the processing activity (dismembering, defleshing, skinning).

Chopmarks. These marks are the result of striking the bone surface with a sharp stone tool, leaving a deep, wide V-shaped scar. The action is related to cutting strong muscle attachments or dismembering.



White (1992) states that the definition of chopmarks is ambiguous and is rather similar to percussion pits because both are the result of directed blows on the bone. White suggests that when percussion by a V-edged hammer stone fails to crack a bone, a V-shaped pit may result, which is similar to a chopmark. Percussion blows are applied directly to the bone (the stroke is transmitted through the bone) with the main intention being to break it, while chopmarks occur when the bone is still covered by soft tissue that absorbs the blow. Hence, chopmarks are probably related to dismembering activities. Consequently, percussion blows leave a much rougher and less regular internal form than that seen in chopmarks.

Scraping marks. These are the result of periosteal and muscle removal by scraping the bone surface. This activity leaves a concentrated series of parallel and superficial striations on a broad area of the bone [Figure 3(d)]. When scraping-marks occur on long bones, they usually run parallel to the longest axis of the bone. Scraping marks have been experimentally obtained by a variation in the angle of the flake edge when a tool is positioned oblique rather than perpendicular to the bone (Delpech & Villa, 1992) but the width of the area affected is more reduced and a single incision can be recognized [Figure 3(e)].

Figure 4 shows the % of survival (Brain, 1969) represented at Aurora Stratum

$$\%Si = (MNEi/NixMNI) \times 100,$$

where $\%Si$=percentage of survival of element i, MNEi is the Minimum Number of Element i found in the sample, Ni is the expected number of element i in the skeleton, and MNI is the Minimum Number of Individuals, which has been estimated at six based on dental traits.

Results

The human sample

The minimum number of elements, and the percentage of survival are represented in Figure 4. Phalanges, isolated teeth, metapodials, ribs and vertebrae are the most common elements as these are the most abundant elements in the human skeleton (56 phalanges, 32 teeth, 20 metapodials, 24 ribs and 24 vertebrae). The completeness of anatomical elements is shown in Table 1.

Figure 3. (a) Scanning electron micrograph. ATD6-97. Detail of an impact notch or percussion mark showing scratches made during percussion. Several indications suggest this is a percussion mark (to break the bone already defleshed, for marrow extraction) instead of a chopmark (to dismember a bone still covered by meat). Scratches surround the impact mark indicating that the bone was already clean of meat. Cut-marks are interrupted by the impact mark, indicating that dismembering and filleting already occurred. Finally the impact mark appears parallel to the broken edge of the bone fragment suggesting that this was a failed try. (b) Scanning electron micrograph. ATD6-55 Infant clavicle and incisions made by an non-retouched flake edge. Notice the lateral irregularities have been recorded only along one side of the cut (right in this case), caused by resistance of the bone to the cut friction, and displaced bone on the side of the striations. The lateral shoulders or "herzinian cones", in this case still attached to the bone (indicated by a black arrow), are directionality criteria. (c) Scanning electron micrograph. G17, n. 212 fragment of long bone of unidentified species. The typical X shape is produced by a stone tool edge retouched at both sides. The irregularity of the edge produces an X in a single motion as the angle of the tool changes during the cutting stroke (see Schick & Toth (1993)). (d) Scanning electron micrograph. H16, n. 166. Long bone fragment of a medium-sized animal showing abundant striations on the surface. The fragment was longitudinally broken, but in this case, striations are not associated to impact marks. These are scraping marks and they are associated with grease extraction or periosteum removal. (e) Scanning electron micrograph. Scraping mark obtained when a tool incises obliquely rather than perpendicularly on the bone surface. Note the scraped area is more reduced and a single incision can be recognised.

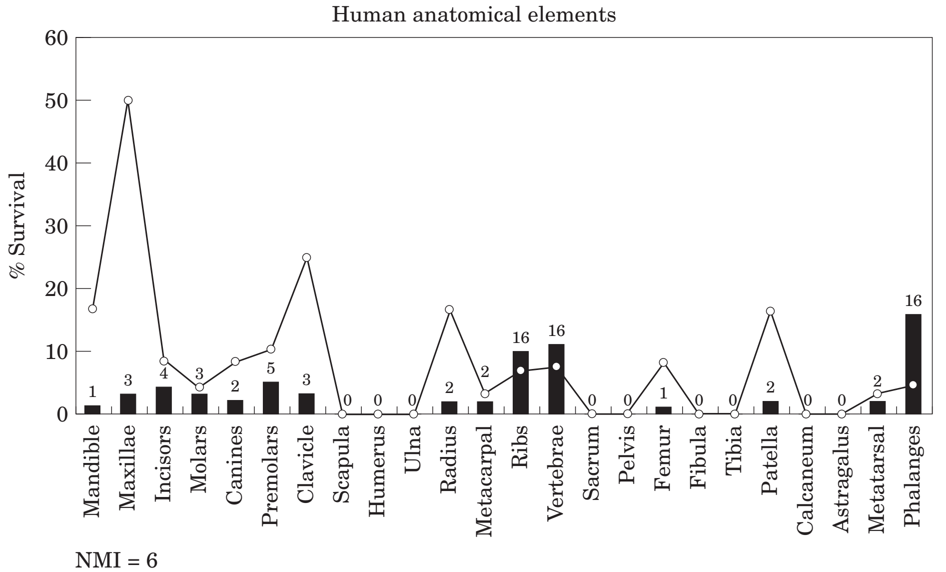


Figure 4. Percentage of survival circles (lines) and Minimum Number of Elements (black bars) of the human remains recovered from Aurora Stratum.

Table 2 Fragment dimensions

Crania	Range (mm)	Mean (mm)	S.D.
Length	10–76	35	17
Width	8–45	20	12
Thickness	4–25	10	6
Axial			
Length	24–256	69	63
Width	10–68	24	15
Thickness	5–23	15	11
Arms/legs			
Length	36–220	95	25
Width	16–42	26	8
Thickness	4–20	4	6
Hands/feet			
Length	11–128	30	77
Width	5–33	16	12
Thickness	4–26	10	5

No complete cranial element (skull vault, mandible or maxilla) has been found in the Aurora Stratum. Teeth are the only complete elements of the cranial skeleton, excepting incisor ATD6-48, which is badly broken. There are very few complete elements from the axial skeleton. One cervical vertebra and one rib of an individual, together with the atlas and a clavicle of a juvenile individual, are complete. Similarly, only two patellae represent complete limb elements. The skeletal parts with more complete elements are hands and feet (mainly foot phalanges).

The fragment dimensions of the Aurora Stratum human fossil assemblage are shown in Table 2. Despite the differences in natural size of these anatomical elements, averages of the different fragments appear to us to be sufficiently similar to suggest that there was an intense breakage activity that led to a high degree of element destruction.

Human modification of human fossil bones

Breakage of the human bones could not be analysed using Villa & Mahieu's (1991) methodology because it is based on long bones. As there are very few of these elements (one fragment of femur and two radii fragments), the resulting values obtained when applying Villa and Mahieu's methodology were unreliable. Our qualitative fracture analysis, however, considers peeling, percussion marks, conchoidal scars and adhered flakes (Table 3).

Crania. Heads are mainly represented by various skull fragments, two small fragments of mandible and four fragments of maxillae. The most complete specimens are a frontal fragment (ATD6-15) and a left zygomatic arch attached to a complete maxilla (ATD6-69). Nuchal skull bones are commonly affected by fracture (e.g. percussions, adhered flakes). The sides of the cranial vault are heavily cutmarked (e.g. temporal processes, occipital condyles and at pterion) corresponding to the biggest muscle attachments, such as sternocleidomastoid. The other group of cranial elements affected by cutting and percussion is the face (jaws and zygomatic arches), which also has various firm muscle attachments. Only two small mandible fragments were in the assemblage. Peeling and scraping marks occur on one of them (ATD6-63), indicating dismembering and removal of the periosteum and overlying tissue from the fragment.

A small temporal bone fragment (ATD6-16) shows a concentration of cutmarks running along the ridge where the sternocleidomastoid muscle attaches, joining the head and the trunk [Figure 5(a)], though it does not show traces of human breakage. On the contrary, the face of a juvenile individual, specimen ATD6-69 represents a good example of fracture induced by humans [Figure 5(b)]. This specimen (ATD6-69) shows strong impact marks along the zygomatic bone and the orbital margin of the left side, and fracture edges also bear adhered flakes. Apart from that, the bone is heavily cutmarked, with long and intersecting incisions that affect several muscle attachments (nasalis, buccinator, levator labii superioris, levator anguli oris, and zygomaticus minor). The type of cutmarks observed on ATD6-69 suggest incisions and sawing motions, with the former extended all over the face, probably to cut the levator muscles, and the second type (sawing), concentrated on the orbits and base of the zygomatic arch, associated with the position of origin of the masseter muscle. Most zygomatic arches from the Aurora Stratum are fractured, as they are in human remains from Native American sites and Fontbrégoua. White (1992) suggests that this patterned breakage is the result of either general percussion of the vault or a specific action to gain access to the temporalis muscle.

Another area from the skull, which is also heavily cutmarked is the pterion (ATD6-60). this skull area bears several long cutmarks running obliquely all over its surface, as well as several conchoidal scars.

Peeling is also present in several skull fragments (Table 3) such as temporal, zygomatic, mandible and occipital condyle.

Impact marks have been observed on five dental elements from the lingual side between the root and the crown (Table 3). All these teeth belong to the same individual (I). The teeth were discovered lying close to each other in anatomical position, although no maxillary bone was preserved around them.

Axial skeleton. The elements represented are 11 ribs, 11 vertebrae (including one atlas and one axis) and three clavicles. No sacra, pelves or scapulae have yet been found.

Articular heads with or without epiphyses or just epiphyses are the most frequent remains of the ribs (Table 3). One rib (ATD6-39) is almost complete and displays many marks of human processing. The inner part of the rib has percussion marks and obliquely grouped incisions going from top right to bottom left, seemingly related to the intercostal membrane and muscles. A few scraping marks running longitudinally along the costal groove are possibly related to extraction of thoracic contents. The

Table 3 Bone surface modifications on human remains related to anthropic breakage

	Conchoidal scars	Percussion	Peeling	Adhering flakes
Cranial (25)	ATD6-17. Temp		ATD6-17. Temp	
9 fractured	ATD6-19. Zygom. arch	ATD6-14. Maxillar, nasal	ATD6-84. Zygomatic	
7 tool-marked	ATD6-49. Maxillar		ATD6-63. Mandible	
	ATD6-58. Malar		ATD6-77. Occipital condile	
	ATD6-60. Pterion			
		ATD6-69. Alveo-frontal		ATD6-69 Alveo-frontal
Axial (25)		ATD6-39. Rib	ATD6-45. Lumbar vertebra	ATD6-44. Axis
5 fractured			ATD6-75. Cervical vertebra	
9 tool-marked			ATD6-79. Rib.	
			ATD6-80. Cervical vertebra	ATD6-80. Cervical vertebra
Hands/feet (23)		ATD6-46. II Phal. hand	ATD6-46. II Phal. hand	
3 fractured	ATD6-107. II Mtts		ATD6-59. II Mtcp.	
5 tool-marked				
Long-bones (5)			ATD6-43. Radius	
2 fractured				
2 tool-marked	ATD6-76 Femur	ATD6-76. Femur.		
Dentition (14)		ATD6-1. Left LC (lateral)		
5 fractured (indiv. 1)		ATD6-8. Right UP4 (lingual)		
		ATD6-9. Left UP4 (lingual)		
		ATD6-10. Right UM1 (lingual)		
		ATD6-11. Left UM1 (lingual)		
		ATD6-52. Left LI1 (occulusal)		

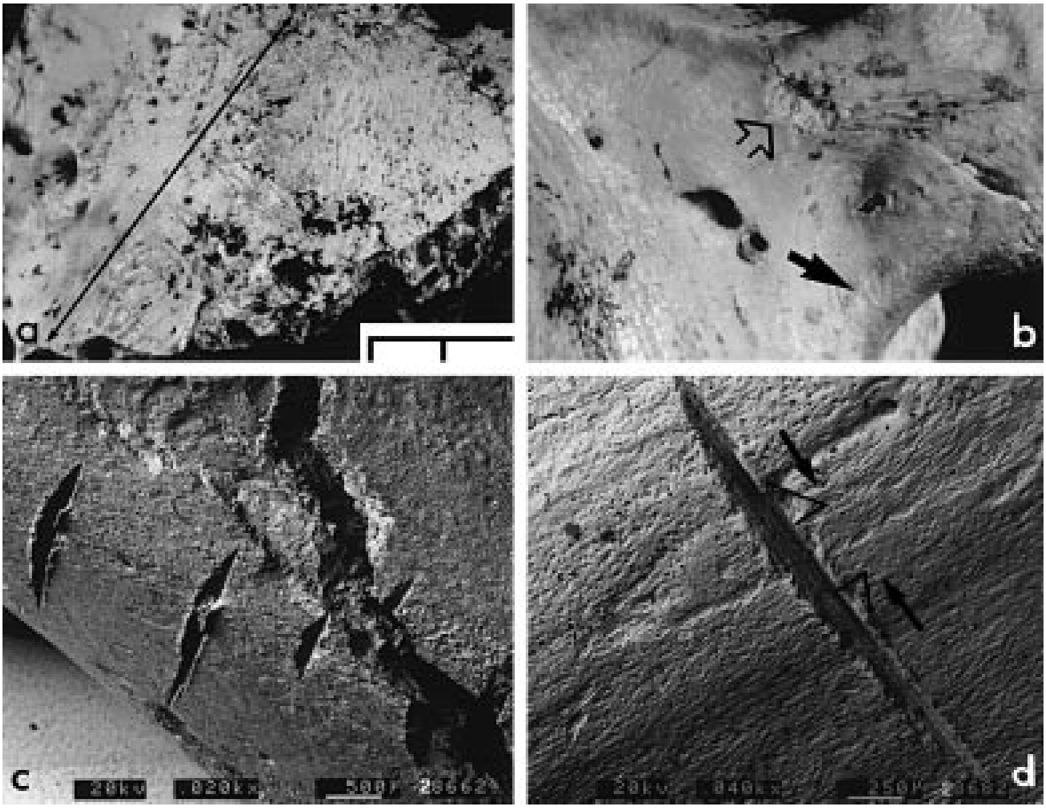


Figure 5. (a) ATD6-16. Fragment of temporal, showing numerous cutmarks transversally along the both ends arrow. These cutmarks affect the mastoid crest where the sternocleidomastoid muscle is attached. Location and distribution of cut marks are suggestive of dismembering (detachment of the head) and defleshing activities. (b) ATD6-69. Holotype of *Homo antecessor*. The face of this young individual shows intensive cut marking on its surface to detach meat from bone and cut all muscles associated to gesture movements. Slicing and sawing marks are frequent (black arrow), together with several failed impacts (empty arrow) to separate the face from the zygomatic processes. (c) Scanning electron micrograph. ATD6-55 Infant clavicle. This specimen shows several parallel cutmarks and transversal fracture made when the bone was still fresh. These deep and precise cutmarks affect attachments of deltoid and pectoralis major muscles from the chest. The trapezius attachment (the neck muscle) from this clavicle is also heavily affected. (d) Scanning electron micrograph. ATD6-55. Cutmark directionality (see Bromage & Boyde, 1984). Frequently cuts are unidirectional, but here it is an example of precise sawing motion. The lateral ''Hertzinian cones'' at the right side of the striation and marked by black half triangles and black arrows indicate opposite directionality and suggest the cut was made in at least two motions going up and down.

articular end of a rib (ATD6-79), also almost complete, shows peeling. Two other rib fragments (ATD6-85 and ATD6-251) have cutmarks. ATD6-85 has cutmarks on both outer and inner surfaces of the rib, with incisions (4·5–5 mm) forming groups along the diaphysis that could also be related to viscera extraction with ATD6-39.

Among the vertebrae four are cervical (one complete atlas, two laminae and one transverse process); three are thoracic (one spinous process and two bodies); and two are lumbar (one transverse process and one vertebral body). Three vertebrae are affected by peeling, one at the lamina edge of a cervical vertebra, and two at the transverse


a
b
c
d

processes of a lumbar and a cervical vertebra. Adhering flakes appear at the spine of the axis and the lamina of another cervical vertebra. Two vertebrae show slicing marks that are grouped and could be related to the butchering of the semispinalis capitatis muscle.

Each of the three clavicles has marks that were made by stone tools. The complete clavicle of a juvenile (ATD6-50) has a single incision affecting the trapezius muscle attachment. The infant half clavicle (ATD6-55) is intensively cut along the edge where the subclavius muscle attaches [Figure 5(c)], and there are a few cutmarks on the attachment of pectoralis major. All of these cutmarks appear to be related to removal of muscle to permit disarticulation of the clavicle. These cuts show sawing motions [Figure 5(d)] according to directionality criteria (Bromage & Boyde, 1984). The infant clavicle is broken at about mid-shaft, lacking the medial half, where the strong sternocleidomastoid muscle attaches. The broken edge and the type of fracture is congruent with breakage during dismembering, though no adhered flakes or peeling can be distinguished. There is an oblique fissure that could be the result of trauma from the breakage process during dismembering.

Legs and arms. Apart from the two patellae (ATD6-22 and ATD6-56), a small femur fragment (ATD6-76) and two radii fragments (ATD6-43 and ATD6-21) are the only representatives of the appendicular skeleton. Neither of the patellae displays evidence of human modification. However, humans seriously damaged the radius shaft ATD6-43. This element was found complete but diagenetically broken *in situ*. Peeling affects the distal end of this radius [Figure 6(a)]. Incisions run obliquely from the top right to the bottom left, covering the anterior border of the diaphysis, with a higher density of cutmarks towards the distal metaphysis affecting the pronator quadratus, as well as the attachment of flexor digitorum. Cutmarks are interrupted by the characteristic fibrosity of peeling.

Finally, the only long bone of thick diameter recovered from the small area of excavation is a fragment of femur shaft (ATD6-76). This fragment has been hit heavily producing spiral fractures at both ends and multiple and successive percussion marks on both posterior and anterior sides [Figure 6(b)]. The strong hammering action on this piece has also produced striations (anvil abrasions according to Turner and White) associated with percussion scar marks. These scar marks seem to be associated with longitudinal breakage of the shaft, probably to extract bone marrow. Damage due to percussion has been so heavy that possible cutmarks have been obscured.

Hands and feet. No tool damage or intentional breakage has been found on the two carpals found in the Aurora Stratum, a complete capitate (ATD6-24) and a distal hamate fragment (ATD6-23). There are 16 phalanges and five metapodials. The human damage observed on these elements is not

Figure 6. (a) ATD6-43 human radius. This specimen has abundant cutmarks (empty arrow) from right top to left down all along the length of the bone affecting the pronator quadratus, as well as the attachment of flexor digitorum. The distal end of the radius has been broken showing peeling (black arrow). The bone was *not* longitudinally opened to extract any marrow content. (b) ATD6-76 Femur fragment. This bone was heavily hit to break it in order to open the shaft and extract the marrow. Black arrows point out some of the impacts. (c) ATD6-59 human metacarpal showing cutmarks all along the anatomical lateral (and two ends arrow) edge where dorsal interosseous muscle attaches. (d) H16, n.3 Impact pits on tibia of bovid. Impact scars (some of them pointed out by black arrows) are similar to those seen in Figure 6(b) of a human femur. Marrow extraction seems to be the purpose of this heavy damage.

homogeneous, with some of the elements heavily affected and others unaffected. One metacarpal has been damaged at the proximal end by peeling (ATD6-59) and one metatarsal shows conchoidal scar marks at the distal diaphysis (ATD6-107). Only one phalanx (second hand phalanx) has been broken (ATD6-46), with both peeling and percussion marks at the proximal diaphysis probably done during dismembering. Cutmarks have been observed on ATD6-59, ATD6-107, and ATD6-46 and on two more phalanges, ATD6-53 second hand phalanx and ATD6-30 first toe phalanx. Incisions are present all along the anatomical edge of the second metacarpal ATD6-59 [Figure 6(c)] at the insertion of the first dorsal interosseous muscle. Incision marks on phalanges ATD6-30 (first toe phalanx) and ATD6-53 (second hand phalanx) are oblique and mainly concentrated at the metaphyses. Those cuts at the diaphysis are transverse in orientation.

Discussion

The ages and number of hominid individuals from TD6 Aurora Stratum based on dental traits (see Bermúdez de Castro *et al.*, 1999) are as follows: two infants of 3–4 years old (individuals II and VI); two adolescents, one of about 14 years and another of about 11 years (individual III, the holotype of *H. antecessor*, Bermúdez de Castro *et al.*, 1997); and two young adults about 16–18 years old (individuals IV and V). The spectrum of age amongst large mammals in the Aurora Stratum is predominantly juvenile and infant individuals, and the total MNI has been estimated at 22 (see Table 4 and Díez *et al.*, 1999 for discussion).

Skeletal parts

Human anatomical elements are representative of all major skeleton areas (heads, axial, hands/feet, arms/legs), although they are not fully representative of the whole skeleton, element-by-element. Some anatomical elements are scarce or absent. Only one fragment of a femur, 2 radii and 2 patellae are representative of limbs. No humerii, tibiae, ulnae nor fibulae have been recovered. The presence of other limb elements such as phalanges, metapodials (from both hands and feet) and radii and femur would suggest that this lack could be sampling error due to the small area of excavation (2·8 × 2·5 m) rather than to any selection of skeletal elements made during butchering. Furthermore, there is great difficulty in identifying those elements that are highly fragmented and appear mixed with other taxa of similar size and fragmentation rate. As a result, there are many fragments that could be human, but their identification remains uncertain at present.

As with the human material, other mammal skeletal parts are relatively well represented at Aurora Stratum. Large sized mammals, however, show an apparent low representation of axial elements in all taxa. This has been considered by Díez *et al.* (1999) to be the result of anatomical part selection by hominids to facilitate the transport of the carcass into the site (see Díez *et al.*, 1999, for further implications).

Damage and cutmarks on limb bones

Human anatomical elements that have a small diameter with little marrow content appear almost unbroken. Radius ATD6-43 is almost complete and the other shaft (ATD6-21) lacks most of the ends but it has not been longitudinally opened for marrow extraction. This has also happened with six ribs, three clavicles, two vertebrae (out of 11), the two patellae and 13 of the 16 phalanges among the human remains. The most damaged elements are skulls, mandibles, all maxillae, the femur fragment, and vertebrae (plus four ribs, one metacarpal and two metatarsal that are transversely broken).

Table 4 **Number of remains (NR) and minimum number of individuals (MNI)**

TD6-Aurora	NR	MNI	Age (Inf/Jv/Ad/Sen)	Total weight (kg)
Proboscidea	2	1	1Inf	1415
Stephanorhinus	7	2	1Inf/1Jv	759
Bison	56	2	1Inf/1Ad	682
Equus	18	3	1Inf/1Jv1Sen	706
Megaloceros	8	2	1Jv/1Sen	587
Indet. large size	52	—		
Total large size	143	10		
Cervus	15	2	1Inf/1Ad	206
Cervidae	95	1		
Indet. middle size	202	—		
Total middle size	312	3		
Dama	20	2	1Jv/1Ad	138
Sus	1	1	1Ad	55
Capreolus	5	2	1Inf/1Jv	10
Homo	92	6	2Inf/2Jv/2Ad	239
Possible *Homo**	103	—		
Indet. small size	82	—		
Total small size	303	11		
Total small size without *Homo*	211	5		
Carnivorous	11	—		
Indet.	287	—		
Total	1056	24	8Inf/8Jv/6Ad/2Sen	4797

Age estimation and weight of the individuals represented in the site. The weight of each animal has been calculated according to Millar (1977, 1981) formula ($NM = 0{\cdot}045\ m^{0{\cdot}89}$), with *NM* as the weight of a neonate and *m* as the adult weight and $GR = 0{\cdot}04\ m^{0{\cdot}69}$, with *GR* being the weight increment calculated in gr/day. The adult weight has been obtained from Rodriguez (1997). The age of the animals, as well as the MNI, has been estimated considering tooth eruption and born out.

Similarly, this patterning is also observed on the fossil nonhuman animal remains from the Aurora Stratum. A humerus of a small mammal (H16, n. 164) is almost complete, as are most phalanges. Large- and medium-sized mammals have few unbroken remains with only carpal–tarsal bones remaining complete. However, a bovid phalanx, of potentially low marrow content, is broken (see Díez *et al.*, 1999).

The patterning of the destruction of nonhuman animal and human bones in the Aurora Stratum is consistent with those bones that held the most nutritional value. With regard to humans, the only femur fragment (ATD6-76) has been struck and badly broken, providing the strongest evidence for marrow extraction observed in the fossil human assemblage. Similarly, intensive percussion pits and impact scars have also been observed on a fragment of bovid tibia (H16, n.3), also for the marrow extraction [Figure 6(d)]. Conchoidal scars are frequent on both nonhuman animal and human remains in similar proportions (Figure 7).

Peeling has been observed to be most common on small sized animals and humans from the Aurora Stratum (Figure 7), whereas percussion marks and adhered flakes are more abundant on large and medium-sized animals. The origin of peeling, related to breakage and dismembering when bending the bones between the two hands, suggests that this difference in

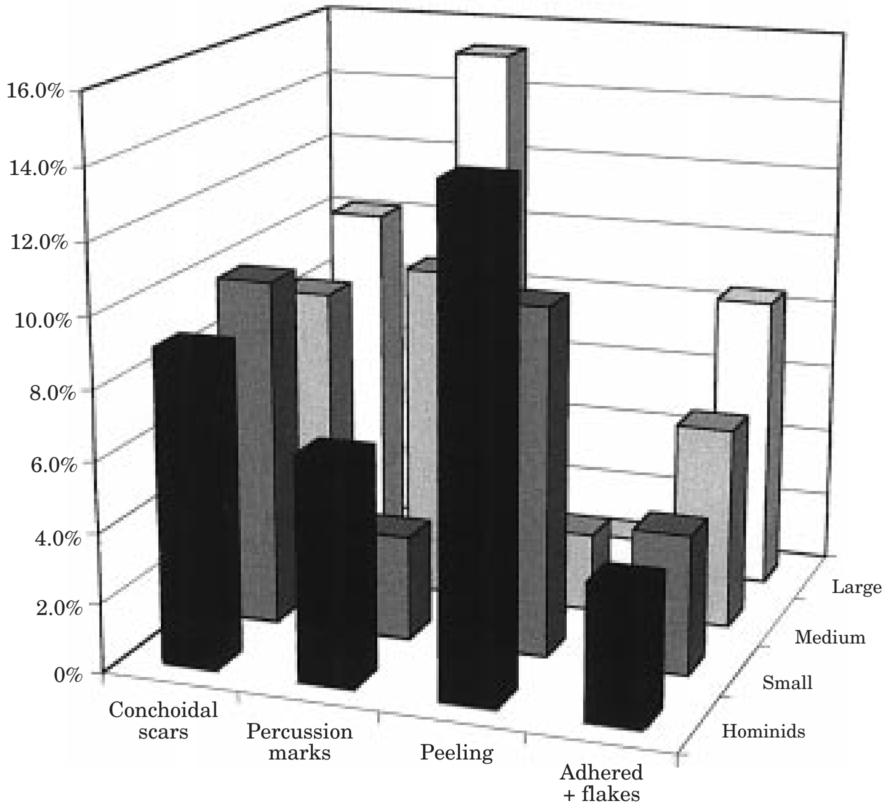


Figure 7. Small-medium-large-sized of mammals and hominids are compared taking into account human induced damage mainly caused by fracture. Note that adhered flakes and percussion marks are inversely abundant from large to small mammals (where humans are excluded and represented apart). These differences seem to be related to different musculature and especially to different weights. Humans like small-sized mammal animals, have higher abundance of peeling which can be done by bending the bone between both hands, while percussion marks and especially adhered flakes indicate the use of a stone hammer to smash the bone.

patterning can be related to the weight of the animal and bone size.

Peeling is observed at the distal end of the radius ATD6-43. Peeling interrupts cutmarks related to tendon and muscle cutting. This indicates that incisions were made before dismembering when the wrist and probably also the hand were still connected. Similarly, superimposition of peeling over cutmarks has also been observed at Fontbrégoua, Mancos, and sites in Arizona, indicating that this is a common butchering sequence.

Phalanges from the TD6 Aurora Stratum bear cutmarks, a characteristic observed here but absent from any of the assemblages compared with the Aurora Stratum (Villa *et al.*, 1986*a*,*b*; Turner & Turner, 1990; White, 1992). Two phalanges (ATD6-53, hand, and TD6-30, toe) have cutmarks as the metaphyses, which are associated with the dismembering process. Another phalanx (ATD6-46) displays peeling at the proximal end and percussion at the diaphysis, associated with crushing and dismembering [Figure 8(a)]. Metapodials also show cutmarks, especially on the lateral diaphysis of ATD6-59 that bears several oblique slicing marks associated with dismembering when cutting the dorsal interosseous muscle, and peeling at the proximal end [Figure 6(c)]. The metatarsus ATD6-107 shows slicing marks also associated with the dismembering process. All this evidence indicates an intensive dismembering process of, at least, some of the hands and feet represented at the site. Amongst the animal bones, only a bear phalanx (I16, n. 43) shows a cutmark on its surface [Figure 8(a)]. This is interesting because both bears and humans walk on the metatarsals and phalanges, and they have similar tendon and muscular attachments and, therefore, they are cut up similarly.

It is difficult to interpret a set of striations observed on the dorsal side of a human phalanx ATD6-46 [Figure 8(b)]. Crushing of phalanges and metapodials has been described by White (1992) at Mancos and interpreted as a dismembering process. Our butchery of a complete chimpanzee showed the great difficulty of dismembering fingers and toes by a single butcher. Assistance was required for this and the difficult process yielded almost no meat or marrow. Cutmarks from ATD6-46 were clear when observed under the light microscope, although our SEM examination showed that these marks were atypical, different from most cutmarks observed on other specimens. They were similar to trampling marks, or to hammerstone–anvil abrasion described by Turner and White in the human assemblages from American Southwest Arizona. Phalanx ATD6-46 has a percussion mark on the palmar side of the diaphysis and peeling breakage at the proximal end. These atypical marks, therefore, could have resulted from dismembering damage (hammerstone–anvil abrasion).

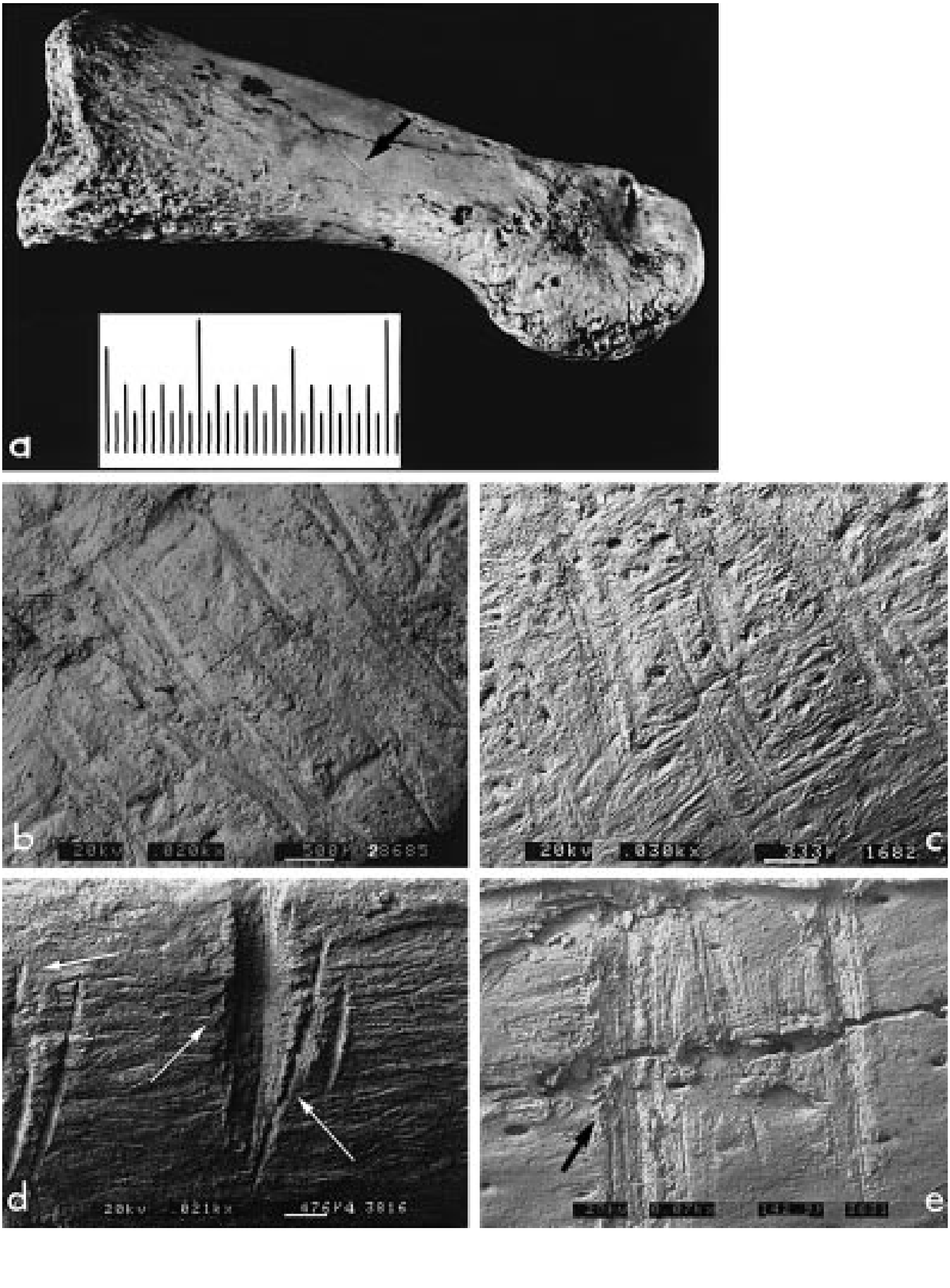
Experimental cutmarks

Due to the presence of limestone stone tools associated with the Aurora Stratum fossils, we carried out an experiment using tools made from different raw materials, including limestone on bones of a lamb. The experimental cutmarks using limestone stone tool showed a strong similarity to striations on ATD6-46 [Figure 8(c)]. In light of this experiment and the butchering of the chimpanzee carcass, these marks are suggested to be the result of holding the complete or almost complete finger between the teeth and cutting small amounts of meat while feeding. From the TD6 assemblage (ATD6-52) known so far, there is one human tooth that has oblique cutmarks like those described by Bermúdez de Castro *et al.* (1988) that could be interpreted as accidental cutting during feeding. The discovery of cutmarks made by limestone tools similar to trampling marks (Andrews and Cook, 1985) or hammerstone–anvil abrasions (Turner, 1983) is important and further analysis is necessary, especially at sites where limestone is used as lithic raw material.

Marks similar to those experimentally made with limestone stone tools occur on long bones of small-sized animals from the Aurora Stratum [H16, n. 62, Figure 8(d)]. These are located along the edges of the fractures. The experiment of cutting lamb limb bones with limestone tools showed that their edges were good enough to cut a few grams of meat, but they soon became blunted, making further cutting difficult. These cutmarks are not isolated, but are found in clusters [Figure 8(e)] suggesting difficulties in cutting, and they are wider than cuts made with quartzite or flint.

Damage and cutmarks on crania

Human and nonhuman skulls are broken. Cutmarks are frequent at the strongest muscle attachments (face muscles, temporalis and sternocleidomastoid). While the human vault has almost no cutmarks, facial bones have an abundance of stone tool marks. We interpret this abundance of


a
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cutmarks on the face, and that found on the temporal and the nuchal areas, as evidence of meat extraction and of the dismembering processes, respectively. There is, however, a single cutmark on the ATD6-15 frontal that might suggest skinning processes. Four skull fragments of small-sized animals also have cutmarks, probably related to skinning. Peeling is frequent on human skull fragments and it is also present on one of the two mandible fragments. Among nonhuman animals, peeling has been observed on skulls of small- and medium-sized herbivores, but there is none in the skulls of large-sized animals.

At other sites with evidence cannibalism, there are more complete skulls than at TD6. The abundance of cutmarks on temporal bones and facial bones at TD6 has also been observed at Fontbrégoua (Villa *et al.*, 1986*b*), while White (1992) described a higher incidence of cutmarks on the vault than on the facial area. Turner & Turner (1992) also found extensive facial damage at several sites from Arizona (Pollaca Wash, Leroux Wash, House of Tragedy, Canyon Butte, and others). Villa *et al.* (1986*a*,*b*) found more marks on human facial bones than on animal faces. These differences were interpreted by these authors as possible ritual, also indicative of exocannibalism. Turner & Turner (1992) make a similar suggestion regarding exocanibalism, and based on the intensive facial damage, proposed violence and destructive intent of mutilation of a possible enemy. White (1992) suggests that the destruction of faces is also the result of gaining access to the brain.

White (1992:207) proposes the following processing technique at Mancos, "... the head was heated while intact. Percussion followed heating and was presumably directed toward removal of the brain tissues. The route of the easiest entry, through the frontal and/or parietal, was followed. Percussion-related abrasion, and damage of the dentition, were coincident with fracture of the vault." Turner has shown that crania involved in violence, but not cannibalism, have facial damage of various sorts and degrees. This noncannibalistic massive facial damage is abundantly illustrated in Turner & Turner (1999). However, White observes that most cutmarks seen on the vault suggests that the scalp was removed at least from some heads before burning, either to avoid the smell of burnt hair or as a trophy acquisition. Less facial damage and abundant intact mandibles at Mancos could therefore be explained by heating which would make face and head muscle attachments easier to remove.

Villa *et al.* (1986*a*,*b*) found that the Neolithic people from Fontbrégoua did not use fire during body processing, so that

Figure 8. (a) I16, n.43 cut mark on bear phalange, the only nonhuman phalange with cutmarks. (b) Scanning electron micrograph of scratches at ATD6-46 showing transversal striations affecting the whole surface. These scratches cut the flexor digitorium tendon attachment, apparently related to dismembering tasks, probably while eating. The striations have a flat cross section and organized as random clusters (see text for discussion). (c) Scanning electron micrograph of experimental cutmarks made with limestone implements on lamb limb bones. Marks were made when filleting. These cutmarks are not isolated, but organized forming clusters as a result of difficulties experienced in cutting. During the experiment, the edge was not retouched to analyse the microwear traits, but in natural conditions the edge probably had to be retouched several times to be effective. (d) Scanning electron micrograph. H16 n62 long bone fragment of a small-sized animal. This specimen has several sets of striations all along the broken edge. As obtained experimentally, several cuts may form wide grooves with a wide diameter, formed by several incisions. Sometimes individual cut marks (shown by white arrows) can be distinguished. Note that these individual incisions show irregularities at both sides of the cut, indicating that the implement was retouched on one side (see Methods, Types of incisions). (e) Scanning electron micrograph of experimental cut marks made with a limestone artefact. The striation is much wider than striations made with flint or quartzite, forming clusters of several incisions (as the groove marked by a black arrow).

damage to the faces and skulls is similar to that observed in the Aurora Stratum.

Breakage and cutmarks found on the Aurora Stratum human faces suggest detachment of the cheeks, strongly affixed to the bone by muscles (levators, buccinator, and nasalis). Breakage of the zygomatic arches is necessary in order to remove the temporalis muscle so as to open the vault for access to the brain tissues. Cutmarks on temporal bones indicate separation of the head from the trunk. Our chimpanzee butchering produced cutmarks on the face and skull similar to those observed on the Aurora Stratum hominids. Unfortunately, this animal had been autopsied (trepanation) so breakage of the vault or face to gain access to the brain could not be performed to compare with the Aurora Stratum hominids.

Cutmarks and damage on skulls and faces from TD6 Aurora Stratum are similar to those from Fontbrégoua. We believe that differences between human and nonhuman animal treatments are due to differences in muscle arrangement and attachment, and the result of accessing the brain, cutting meat and skin off the heads, with no ritual, trophy or violence involved. A different process is observed on the Bodo skull (Ethiopia) with marks around the eye sockets (White, 1985), instead of sawing and intensive cutting as described for the specimens from Aurora Stratum.

Apart from differences due to the use of fire during processing, White (1992) also mentions that the nuchal region has a low frequency of cutmarks (abundant at TD6) suggesting to him that the upper cervical vertebrae were removed from the body along with the head.

White (1992) also describes tooth damage as a result of burning, but some as a result of hammerstone–anvil abrasion. Several human teeth from the Aurora Stratum (Table 3) have been found to have impact scars at the crown–root interface on the lingual sides, and on the occlusal surface. This damage pattern could be explained as the result of blows on top of the vault (frontal and/or parietal) while the teeth rested against a hard stone surface. This scenario could explain the fact that several teeth from individual I (were affected by percussion at the lingual interface of crown–root (ATD6-8, 9, 10, 11). They were found close to each other, almost in anatomical connection, with no remains of the maxillary bone. Differential preservation of bone/teeth is unlikely given that fragile infant remains have been preserved, as well as their perimortem modifications [Figure 5(c)].

Damage and cutmarks on the axial skeleton

Other ribs, vertebrae and clavicles represent the human axial skeleton at Aurora Stratum, since no pelves and scapulae have been identified. Again, the small area of excavation may explain the absence of missing skeletal elements (e.g. presence of femur but absence of pelvis and tibia, or presence of most elements of the shoulder girdle but absence of scapulae). The clavicle is one of the best represented anatomical elements from the Aurora Stratum. All have signs of human activity. Ribs and vertebrae are also well represented, with much evidence of peeling and/or percussion breakage, as well as cutmarks indicating muscle cutting and torso dismemberment, and accessing of the viscera. Similar processes have been identified on animal remains (Table 5), with abundant peeling and percussion on vertebrae and ribs of all these size classes.

Turner observed that there was an absence of vertebrae or that most of them were crushed at the prehistoric Arizona sites studied by him (Turner & Turner, 1995). Turner has considered this absence of vertebrae as a characteristic trait of cannibalism. He explains the low representation of vertebrae as a result of their having first been crushed on an anvil stone and the fragments

Table 5 Aim of the action deduced from the type of mark, cutmark organization and bone area affected

Butchering	Large	Medium	Small	Homo
Heads		1 mandible (F)	4 skull frags. (1F, 4S)	2 maxillae (2F) 1 mandible (F) 4 skull frags. (2F, 2D, 1S)
Axial	2 ribs (1F, 1E)	9 ribs (8F, 1D) 1 vertebra (D)	13 ribs (11F, 2E) 3 vertebrae (2F, 1D)	4 ribs (4F, 2E) 3 clavicles (2F, 1D) 2 vertebrae (1F, 1D)
Limbs	3 femurs (3F) 2 humerii (1F, 1P) 3 tibiae (2F, 1M) 1 radius (F) 3 long bones (2F, 1P) 6 metapodials (4F, 1P, 1M)	2 femurs (1F, 1P) 1 ulna (F) 2 humerii (2F) 2 tibiae (1F, 1D) 11 long bones (9F, 2P) 1 scapula (F) 1 coxal (F) 2 metapodials (2F)	1 femur (F) 2 tibiae (2F, 1P) 1 ulna (F) 1 long bone (F) 1 scapula (F) 3 flat bones (3F)	1 femur (F, M) 1 radius (F, D)
Extremities	2 phalanges (2D)	1 sesamoid (D) 1 phalanx (F)		2 metapodials (2D, 1P) 3 phalanges (3D)

S=skinning; F=filleting; D=dismembering; M=marrow extraction; E=evisceration; P=periosteum removal.

then boiled to facilitate oil extraction. He suggests this hypothesis based on ethnographic descriptions of the boiling of animal bones for marrow extraction. White (1992) has also commented on the reduction of vertebrae from Mancos. It is interesting to see that this absence does not occur at Atapuerca. In fact vertebrae are in similar proportion to or even higher than metapodials or phalanges. As there is no evidence of fire at Atapuerca in the Aurora Stratum, we would not expect vertebrae reduction. Absence of vertebrae is evident in the Neolithic assemblage from Fontbrégoua, which Villa *et al.* (1985) consider as due to humans having moved the discarded bones into ‘‘amas’’ (discard features). Small elements, like vertebrae, could have been lost during discard of butchered bones. Vertebral damage in the Aurora Stratum material is frequent, with specimens affected by cutmarks, peeling, or vertical arches broken due to percussion. This is considered mainly due to dismembering, defleshing and crushing the spongy bone portions.

Comparison with other sites

Finally, we have compared all tool-induced modifications observed on the human remains of the Aurora Stratum with other sites as far as the data provided by different authors (Turner’s studies, Villa *et al.*, 1986*a*,*b*; White, 1992) allow. Differences regarding cutmarks on human remains have been discussed by White (1992:327), who compared several sites studied by Turner (between 1% and 4·6% of cutmarked fossils) and Fontbrégoua (46·4%), with sites analysed by himself (Mancos 5MTUMR-2346 11·7% and Yellow Jacket 5MT-3 2·6%). In the Aurora Stratum, 25% of the human remains display cutmarks. White feels the very high percentage seen in Fontbrégoua is because these data were obtained after refitting, while the other sites were recorded before refitting. Our data from Aurora were obtained before refitting. Cutmarks are more abundant in the Aurora Stratum, probably because most anatomical elements recovered are bones with little meat and strong attachments (such as faces, clavicles, ribs and phalanges). This is congruent

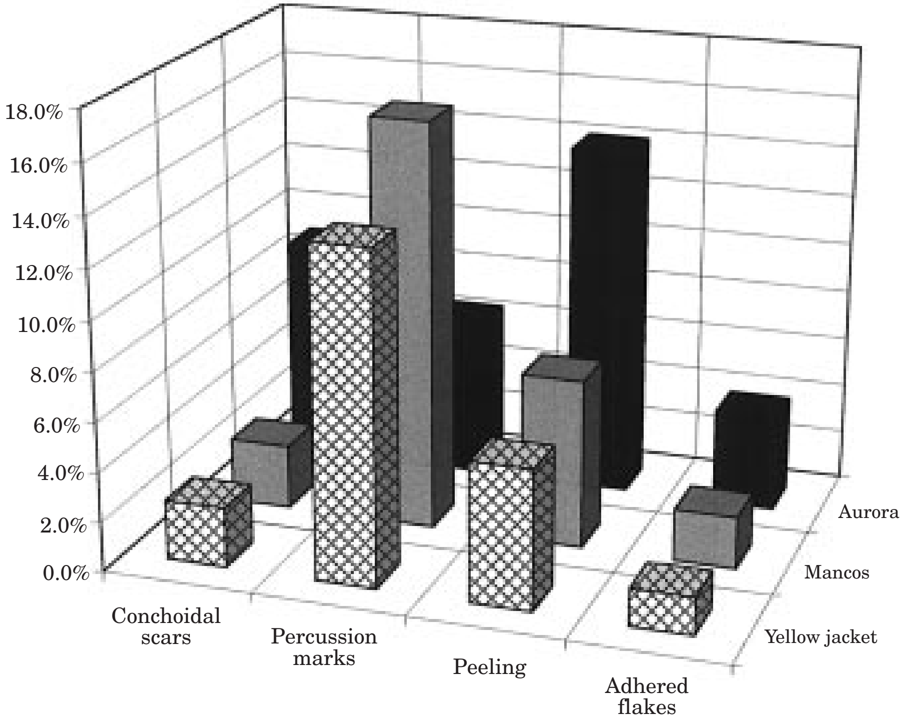


Figure 9. Diagram of human induced damage due to fracture in Mancos (Colorado), Yellow Jacket (another cannibalistic site from Colorado) and in TD6 Aurora Stratum. Note that the tendency observed in Figure 7 is followed for adhered flakes, which is less frequent at the Arizona sites compared with TD6 site. Peeling, however, is not as common as in small-sized animals and humans in TD6, but it is still higher than in large and medium-sized animals at TD6 (see Figure 7). Percussion marks have been marked much more on the bone surface of the Arizona sites than at TD6, inversely to conchoidal scars which are more frequent at TD6. These differences seem to be related to the influence of fire at Mancos and Yellow Jacket, facilitating dismembering processes and reducing breakage tasks. Further, bones subject to heating and boiling become softer and ductile (Mayne, 1990) and percussion marks are more easily recorded on their surface as observed at Mancos and Yellow Jacket assemblages.

with observations made by White's (1992) analysis of element-by-element occurrence of cutmarks (see White, 1992:328; Figure 12.28) as well as the influence of fire, as discussed above and below.

Descriptions of the processing of different anatomical elements is described by each of these authors, although data for conchoidal scars, percussion marks, peeling, and adhering flakes are scarce or incomplete. In Figure 9 we compare types of breakage in the Aurora Stratum human remains with comparable data provided by White (1992) from Mancos 5MTUMR-2346, and another cannibalized human assemblage named Yellow Jacket 5MT-3 from Colorado (1025-50 AD, also of the Anasazi culture). Differences between the Aurora Stratum and the Anasazi assemblages are conspicuous and understandable. Conchoidal scars, adhered flakes and peeling appear more abundant in human remains from the Aurora Stratum, in contrast to percussion marks, which are more abundant on human bones from Mancos and Yellow Jacket. This, in our opinion, indicates different treatment and damage due to the lack of fire among the early Pleistocene hominids of the Aurora Stratum. The influence of fire on the late prehistoric American Southwest

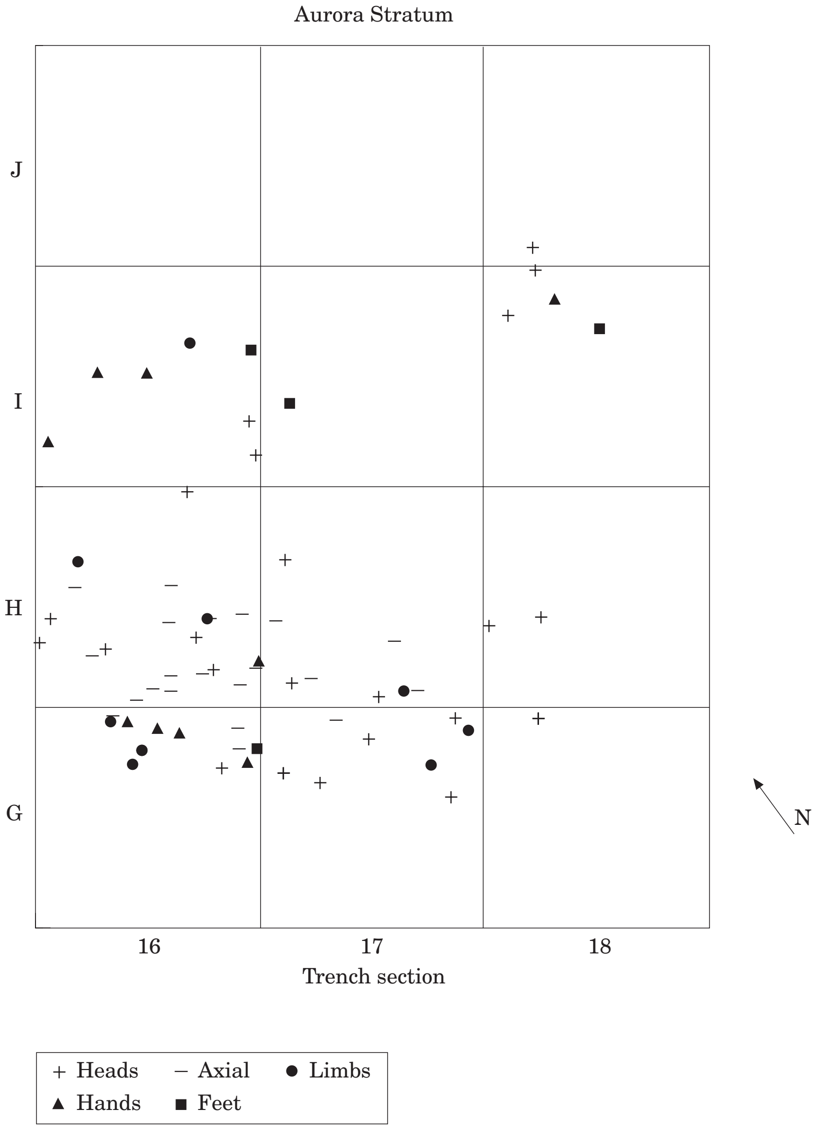
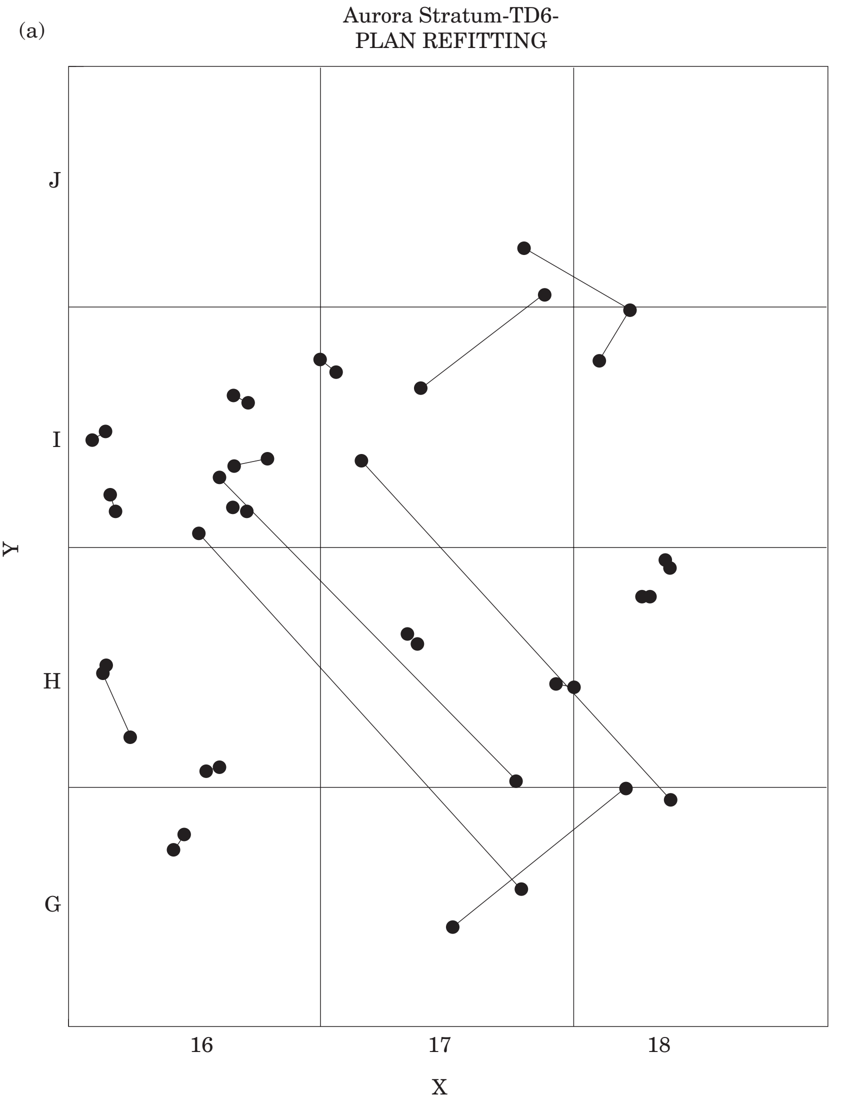


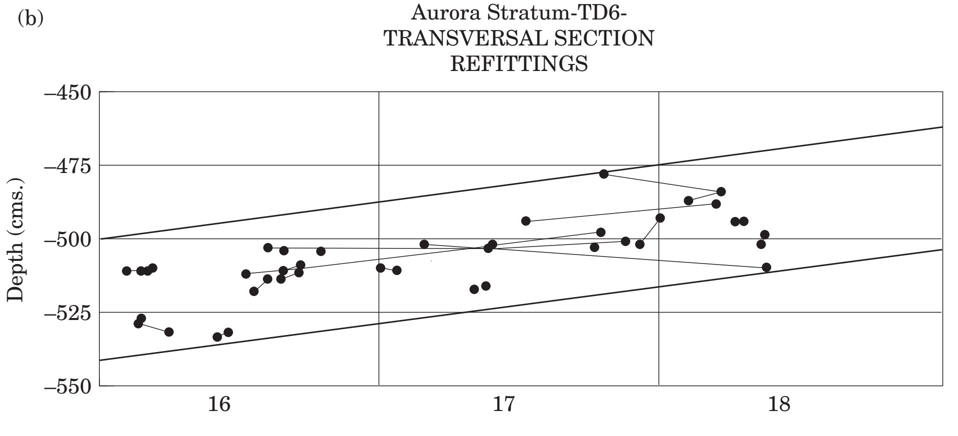
Figure 10. Plan of human fossil bones. Heads/axial/limbs/feet and hands are represented separately. No organization or differential distribution of any of those skeletal elements can be differentiated. The distribution is random and mixed.

assemblages helped to make muscle attachments easier to remove, facilitating dismembering processes and, therefore, reducing cutting and breakage tasks associated with dismemberment. Indication of this effect has been already discussed above with regard to skull treatment, which showed a lower incidence of cutmarks compared to Aurora. Further, osseous tissues subjected to heating and boiling become softer and more ductile (Mayne, 1990) and percussion marks are more easily recorded on their surface as observed at Mancos and Yellow Jacket assemblages.

(a)


Aurora Stratum-TD6-
PLAN REFITTING
J
I
H
G
Y
16
17
18
X

(b)


Aurora Stratum-TD6-
TRANSVERSAL SECTION
REFITTINGS
–450
–475
–500
–525
–550
Depth (cms.)
16
17
18

Bone distribution of human and nonhuman animal remains (pattern of post-processing discard)

The distribution of human remains from the Aurora Stratum seems to be random in the area of excavation. They are mixed with the rest of the fauna and artefacts (Figure 2). There is no clear pattern in the distribution of the different parts of the human skeleton (Figure 10), even though axial elements have not been recovered from the northern part of the excavation area. It is also true that fragments of vertebrae and ribs are the most difficult anatomical elements to distinguish from other taxa of similar body size especially at a site such as the Aurora Stratum, where breakage has such a high incidence. It can therefore be said that a random arrangement characterizes the distribution of human and faunal remains. The under-representation of axial elements in some parts of the excavation does not have any particular taphonomic or behavioural implication.

Bone fragments of both nonhuman animal and human remains have been refitted both horizontally and transversely [Figure 11(a) and (b)], with some vertical refitting of more than 10 cm against the slope. These refittings suggest that the site was not abandoned for long periods, and supports a relatively short period of time for sedimentation.

During excavation, human remains seemed to be in a slightly higher abundance at the intermediate part of the Aurora Stratum thickness, and this was especially evident at the west-central side of the excavation (less than 0·5 m^2). Apart from this zone, human fossil bones have been recovered from the whole thickness of the Aurora Stratum. Further extension of the excavation area would test this observation. No differences with regard to the distribution of other taxa have been detected, with a rather homogeneous distribution of all sizes classes amongst humans, throughout the whole thickness of the Aurora Stratum.

Type of cannibalism

The Aurora Stratum, therefore, is characterized by: (1) *analogous butchering techniques in humans and nonhuman animals* such as skinning, filleting, dismembering, marrow extraction, evisceration and periosteum removal (Table 5). *However, we should allow for anatomical differences between humans and animals*. A higher frequency of peeling appears on small-sized animals and hominids (Figure 7), probably because bones from these gracile groups can be broken and bent using both hands. Large- and medium-sized animals are much more robust and hand strength is not enough to dismember and bend bones. Human faces have been seen to have strong muscle attachments that make them likely to have more cutmarks and modifications than other animals. (2) *Similar breakage patterns to extract the marrow*. Percussion and conchoidal fracture has been observed on large, medium- and small-sized animals and humans, as a result of breaking the bone to extract the marrow (Figure 7). Particularly, a tibia of bovid and the human femur fragment have both been heavily struck [Figure 6(b) and (d)] in order to break them and extract the marrow. (3) *Identical pattern of post-processing discard of humans and animals*. Remains of human and nonhuman animals are randomly dispersed with no special arrangement of any one of the taxa [Figure 2(b)]. (4) Comparison between the Aurora Stratum human samples and butchered human assemblages from other sites

Figure 11. (a) Plan section of Aurora Stratum (horizontal refitting). (b) Longitudinal section (vertical refitting).

more recent in age, where cannibalism has been considered to be proven (American Southwest; Neolithic of Fontbrégoua, France), show similar butchering techniques. There are, however, some differences that have been related to the influence of fire. The use of fire, and the fact that boiling and roasting of bones facilitates muscle detachment from the bone, reduces the amount of cutting needed to deflesh a carcass. The softer texture of both boiled meat and bone means that impact marks are left more easily than on bones that were not cooked or heated. Fire also helps in dismembering and breaking the bone.

In summary, butchering techniques observed in the Aurora Stratum were aimed at meat and marrow extraction. The human remains recovered from the Aurora Stratum cave deposit suggest that they were the victims of other humans who brought bodies to the site, ate their flesh, broke their bones and extracted the marrow, in the same way as they were feeding on the herbivores also preserved in this stratum.

No ritual treatment can be suggested in this assemblage. *Nutritional* purposes are presumably the cause of this case of cannibalism. This type of cannibalism is divided by definition into (a) *survival*, where cannibalism is incidental or a short-term measure, and (b) *dietary or gastronomic* cannibalism, which is associated with long periods in which humans are feeding on other humans, as part of their regular diet.

With our present state of knowledge, there are unanswered questions that make it difficult to distinguish between survival and gastronomic cannibalism. For instance, the exact time span (number of years) represented by Aurora Stratum, or the actual number of individuals exploiting the human and animal remains recorded at the site cannot as yet be rendered precisely.

Some other indications may help to provide better answers. Mediterranean pollen (*Pistacea* and *Olea*) has been found at TD6, suggesting that the climate was not severe but temperate. The mammal community structure suggests an holartic forest as the environment for TD6 (Rodríguez, 1997), cooler than suggested by the sedimentology (Aguirre & Hoyos, 1992) and pollen (García Antón, 1995), but still temperate. The species diversity (see Table 4) recorded in the Aurora Stratum is the richest found at any level from Atapuerca. Large, medium and small-sized herbivores were butchered. At least 22 individuals, with infants, juveniles and young adults as the main age spectrum, and only two senile individuals of large-sized animals, have been recognized. The weight of this food supply has been estimated at almost 5 metric tons, including bones and meat (Table 4, see Díez *et al.*, 1999).

If it is assumed that the Aurora Stratum represents a single incidental and short event, then the environmental conditions, the high diversity of fauna available to humans, and the potential food supply found in the site apparently do not justify a starvation period that could have forced them to consume other humans as a survival strategy. This should then be considered gastronomic cannibalism. Equally, if the Aurora Stratum event represents a biologically long period of time (tens or hundred of years), then the distribution of butchered hominids through the whole thickness of the Aurora Stratum indicates that humans were repeatedly feeding on other humans for this period of time. This also can be modelled as gastronomic cannibalism by its definition, indicating that humans were part of the diet of other humans.

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