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Mammal bone surface alteration during human consumption: An experimental approach

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ABSTRACT

The study of human tooth marks on bones remains constitutes a promising line of research of high archaeological interest. Most taphonomic studies assume that tooth marks in bones are evidences of carnivore intervention. However, human beings, regardless of the use of lithic artifacts, access to animal nutrients through their masticatory system producing bite marks. In order to solve equifinality problems of the marks left during consumption, a study with volunteers has been carried out. Ten volunteers ate meat from the scapulae, radii and phalanges of *Ovis aries*, trying to bite the bones and extract the meat as much as possible. Each piece was consumed raw, roasted and boiled by the same people in order to differentiate marks according to bone and the type of cooking treatment. A significant number of marks were observed including types, morphologies and metric values. Differences between raw and cooked bones were also detected. These results may contribute to identify human bite marks and cooking treatment in the archaeological record.

1. Introduction

Consumption-related action on animal carcasses without recourse to technology leaves identifiable marks on the bone surface during the removal of flesh, marrow, fat and bone, as well as during digestion. This has been proven in the case of most animals whose diet includes meat protein: carnivores (Binford, 1981; Blumenschine, 1988, 1995; Capaldo, 1998; Ruiter and Berger, 2000; Selvaggio and Wilder, 2001; Domínguez-Rodrigo and Piqueras, 2003; Pickering et al., 2004; Pokines and Kerbis-Peterhans, 2007; White and Toth, 2007; Andrés et al., 2012; Rodríguez-Hidalgo et al., 2013, 2015; Sala et al., 2015), omnivores (Saladié et al., 2013a; Sala and Arsuaga, 2013; Arilla et al., 2014), birds (Lloveras et al., 2014), insects (Backwell et al., 2012; Dirrigl and Perrotti, 2014) and even herbivores (Cáceres et al., 2011; Hutson et al., 2013). Most of the works have had more directed toward other predators, but the need for referential from humans is obvious in archaeology. Thus, human chewing, as with other primates (Pickering and Wallis, 1997; Plummer and Stanford, 2000; Pobiner et al., 2007) and bunodonts (Saladié et al., 2013a; Sala et al., 2014; Arilla et al., 2014), leaves marks on bones during the consumption of soft tissue. This has been established in experiments with humans (Díaz, 2007; Delaney-Rivera et al., 2009; Lloveras et al., 2009; Sanchis et al., 2011; Saladié et al., 2013b; Romero et al., 2015) and also in ethnographic work (Binford, 1981; Brain, 1981; Oliver, 1993; Elkin and Mondini, 2001; Andrews and Fernández-Jalvo, 2003; Landt, 2004, 2007; Martínez, 2007, 2009). In addition, it has been detected in the archaeological record (Cáceres et al., 2007; Blasco, 2008; Fernández-Jalvo and Andrews, 2011; Saladié et al., 2014; Pickering et al., 2013; Martín et al., 2014; Thompson and Henshilwood, 2014).

Understanding the effects of consumption processes on hard animal materials is of great importance for archaeological interpretation and moreover for specific lines of research related to taphonomy, in particular the effects of human chewing on bone surfaces, which can help to detect anthropogenic interventions in the formation and disturbance of bone assemblages. This is all the more so bearing in mind that carcass consumption does not necessarily require the use of technology or leave unequivocal traces of its use, either because the animals or portions thereof in question can be processed and consumed without the aid of tools due to their size or other factors, or because the particular case is in a pre-technological context.

Similarly, studies of alterations caused by human chewing of bones can be used to document the consumption of certain types of prey by

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prehistoric societies. This aspect is particularly important in cases such as cannibalism (Turner, 1983; White, 1992; Botella et al., 2000; Andrews and Fernández-Jalvo, 2003; Cáceres et al., 2007; Saladié et al., 2013b, 2014; Bello et al., 2015) and the ingestion of carnivores (Martín et al., 2014) or small prey such as tortoises (Blasco, 2008; Thompson and Henshilwood, 2014), birds and lagomorphs (Sanchis, 2012; Cochard et al., 2012; Romero et al., 2015).

In this line, more or less controlled experiments can help to ascertain the taphonomic consequences of a number of variables. Carcass processing (or its absence) prior to consumption (Roberts et al., 2002) provides a wide range of possibilities. Observations of this type have been made in archaeology (Martín et al., 2014; Thompson and Henshilwood, 2014) and experiments with the effect of cooking meat (roasting or boiling) on the marks left by humans on bones (Lloveras et al., 2009; Saladié et al., 2013b). Observation of food processing can yield valuable information about the social and learning systems of hominin groups.

This line of study lies in the context of research into the intervention of hominins in archaeological and paleontological assemblages, bearing in mind that one of the aims of experimentation in taphonomy is to solve problems of equifinality (Gifford-González, 1991; Lyman, 2004; Pickering et al., 2004) such as the distinction between consumption marks caused by humans and other animals on bone surfaces.

In light of the above, the objectives of the present study are to: a) improve understanding of human bite marks on the basis of the experimental consumption of animal carcasses; b) analyse the effects of the variables used in this experiment such as processing and the distribution of damage on different types and areas of bones; c) improve our descriptive knowledge of these types of alteration with a view to its application to Pleistocene and Holocene archaeological sites; and d) detect the presence or absence of certain types of culinary treatment in archaeological assemblages.

2. Materials and methods

The experimental nature of this work obliged us to reproduce a hypothetical situation of meat consumption by a population in order to observe metrical and morphological patterns of tooth marks inflicted on the bone material.

Ten individuals of both sexes (6 men and 4 women), all adults, were chosen for the eating experiment. The volunteers were aged between 23 and 39 years. All were somehow related to prehistory and palaeontology (staff of the University of Burgos, the Museum of Human Evolution and guides at the Atapuerca archaeological sites in Burgos, Spain). They were asked to consume all the meat on the bones used in this study (scapula, radius and phalanx) but not the marrow, but were not instructed to chew in any way. We noted the sex, age and size (weight) of each volunteer.

The chosen material was from sheep taxa (*Ovis aries*), a small sized animal that is still available. We used 18 young juvenile limbs (6 weeks of age) and 12 subadult juvenile limbs (18 months of age). The sample consisted of 90 bones of this animal. The anatomical distribution was 30 long bones (radius), 30 short bones (first phalanx) and 30 flat bones (scapula). In order to control all the variables in the meat treatment a process, one third of the sample was served raw to the consumers, another third roasted (in an electric oven at 220 °C) and the final third boiled. Thus, each individual consumed three portions of each type of bone (long, short and flat), one of which was raw and two cooked (roasted and boiled). During consumption, volunteers noted information on an analysis card about which teeth they used to chew the bones (classified into three categories: incisors, premolars – including canines- and molars).

In our study, all portions were photographed prior to consumption. The consumption process of the portions was recorded with photographs and videos made during the experiment. When the meat on each portion was consumed, we made an initial observation of the fresh bone. We then boiled the material twice (once soft boiled and then definitive), depending on the observed alterations and brittleness.

Finally, we conducted a detailed examination using an analysis card and a Nikon SMZ 1500 7.5–125× stereo microscope with a Nikon D200 digital camera and a Dino-Lite Pro AM 413ZT. We photographed each bone and mark and noted comments.

After these processes, we classified the alterations caused by human chewing, following other authors applying the terminology for these modifications found in the literature and adapting it to our requirements to a certain extent.

The typological categories were: pit (simple depression on the bone surface), puncture (when the tooth impacted on the bone tissue with major force in the most weakest areas), score (the result of teeth dragging against the bone), furrowing (partial loss of cancellous tissue on epiphyses), crenulated or saw-toothed edges (when the tooth cusp penetrates an area of flat bone, producing crenulated or serrated forms on the edges) and crushing (cracks caused by biting, with the collapse of the cortical tissue in some areas of the bone) (Maguire et al., 1980; Binford, 1981; Brain, 1981; Fernández-Jalvo and Andrews, 2011; Saladié et al., 2013b). We noted the morphology and characteristic of those with pits and punctures (outlines). In the case of scores, we differentiated (Saladié et al., 2013b) between flaking on the score edges and flaking at the bottom. We also noted the presence or absence of internal microstriations. In addition, we noted the position of the scores in relation to the bone axis (perpendicular, oblique or parallel), and we classified furrowing in degrees of intensity following Saladié et al. (2013b): a) light, b) moderate and c) heavy, according to the damage to the bone surfaces.

All such marks tend to be produced by two types of activity. We wanted to differentiate evidence of teeth from other derivative types of alteration which are not strictly traces of tooth action. Imprints of teeth were classified as primary marks, and the rest of the damage caused by chewing as secondary marks. These two types encompass all the others described above (primary: pits, punctures, scores; secondary: furrows, crenulated and saw-toothed edges, crushing). We measured the long side (length) and the width (perpendicular to the axis) in the case of the primary marks, while for the secondary marks, we only took the longest side as an expression of its maximum area. For this purpose, we used a digital calliper and recorded the measurements in millimetres to two decimals. To record the modifications by human chewing, we divided each bone (phalanges, radii and scapulae) into several areas using anatomical criteria. For phalanges and radii we used three zones: epiphysis, near epiphysis and diaphysis. We divided the scapula into several parts: acromion and glenoid cavity, neck, spine, scapular fossa and proximal side.

In each case, we also specified the position wherever possible with the following data: proximal or distal, anterior or posterior, lateral or medial and cranial or caudal. Finally, we classified the damaged bone surface depending on whether the tissue was cancellous (epiphysis) or cortical bone (diaphysis and near epiphysis) (Selvaggio, 1994; Selvaggio and Wilder, 2001; Domínguez-Rodrigo and Piqueras, 2003; Andrés et al., 2012).

3. Results

This experimental work generated 90 bones (30 phalanges, 30 radii and 30 scapulae). One radius was lost during the cleaning process, leaving the sample at 89 bone items (54 from immature animals and 35 from adults).

Tooth marks or chewing marks were found on 55 of the 89 bones (61.8%). There were 202 marks in all, 122 primary (60.4%) and 80 secondary (39.6%). The 55 bones with tooth marks or chewing marks included 27 scapulae (10 adults, 17 immature), 21 radii (6 adults, 15 immature) and 7 phalanges (2 adults, 5 immature). Amongst these elements with alterations caused by human chewing, 39 were cooked (70.9%) (20 roasted and 19 boiled) and 16 were served raw (29.1%).