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# Why are cut mark frequencies in archaeofaunal assemblages so variable? A multivariate analysis

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ABSTRACT

Cut mark frequencies in archaeological faunal assemblages are so variable that their use has recently created some skepticism. The present study analyses this variability using multivariate statistics on a set of 14 variables that involve differential skeletal element representation, fragmentation processes, carnivore ravaging impact, carcass size and tool type. All these variables affect the resulting cut mark frequencies reported in archaeological sites. A large sample of archaeofaunal assemblages has been used for this study. It was concluded that the best estimator of cut mark frequency in any given assemblage is the percentage of cut-marked long bone specimens (probably due to its better preservation than other anatomical areas), which is determined by fragmentation and carnivore ravaging. Carcass size and tool type also play a major role in differences in cut mark frequencies. Fragmentation is also a key variable determining the abundance of cut-marked specimens. It is argued that general cut mark percentages are of limited value, given the number of variables that determine them, and that a more heuristic approach involves quantifying cut marks in a qualitative manner.

## 1. Introduction

The taphonomic study of cut marks plays a crucial role in understanding hominid butchery behaviors. For decades, its potential information was overshadowed by the interpretive power cast on skeletal profiles. Despite several historical antecedents dating back to the late 19th and early 20th centuries (e.g., Lartet, 1860; Lartet and Christy, 1875; Martin, 1909; Peale, 1870), the study of cut marks remained a marginal analytical procedure until the 1980s due to the lack of interpretive frameworks. Precocious researchers like Martin (1909) underscored that the anatomical location of cut marks could be indicative of butchering behaviors. White (1952, 1953, 1954, 1955) used ethnographic descriptions of butchering to interpret archaeological assemblages and Guilday et al. (1962) expanded Martin's (1909) original approach and undertook systematic studies of cut marks on animal bones according to their anatomical distribution. Guilday et al.'s (1962) seminal work inspired more detailed anatomical studies of cut marks in archaeofaunas (von den Driesch and Boessnek, 1975; Frison, 1972; Frison, 1974; Noe-Nygard, 1977; Wheat, 1972; Walker, 1978).

However, it was in the 1980s, during the heat of the debates of Plio-Pleistocene archaeological site formation, as Lyman (1994) correctly points out, that the studies of cut marks underwent a critical development. First, the macro- and microscopic signatures of cut marks were diagnosed to differentiate them from abrasion, trampling and carnivore marks (Andrews and Cook, 1985; Behrensmeyer et al., 1986; Bunn, 1981, 1983; Fiorillo, 1984; Potts and Shipman, 1981; Shipman, 1981; Shipman and Rose, 1983, 1984; Shipman et al., 1984). Then, cut marks created by different tool and raw material types (Hannus, 1990: Walker and Long, 1977; Walker, 1978; Greenfield, 2002), as well as by metal implements in historical periods (see review in Seetah, 2008) were studied and experimentally replicated and comparisons to marks created on bone surfaces by use of bone as tools (D'Errico and Giacoboni, 1988; Giacobini and Patou-Mathis, 2002; Lemoine, 1989) were also made. Binford's (1981) pioneering work on the ethnoarchaeology of the Nunamiut set the basis for the subsequent widespread use of cut mark studies by providing the first comprehensive referential framework on the functionality of cut marks according to their anatomical location (see references in Lyman, 1994) for English-speaking academia and references in Blasco Sancho (1992), Lyman (1994), Yravedra (2006), and Giacobini and Patou-Mathis, 2002 for European academia). The use of replication in experimental archaeology during the 1980s enabled a certain optimism that cut marks could be scientifically used to infer human butchery behaviors (Binford, 1981; Bunn, 1981, 1983, 2001; Bunn and Kroll, 1986; Gifford-González, 1977, 1989; Lyman, 1987).

Binford's (1981) human butchery diagnosis has been recently refined by Nilssen (2000). In addition, butchering experiments have modeled primary and secondary access to carcass resources

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by hominids providing expanded analogs to understand archaeological cut mark patterns (Capaldo, 1995, 1997, 1998; Domínguez Rodrigo, 1997, 1999, 2008; Domínguez-Rodrigo and Barba, 2005; Selvaggio, 1994a,b). Experiments have also allowed to test whether cut marks are butchers' accidents, whether they are related to bulk meat extraction (Binford, 1985; Bunn and Kroll, 1986, 1988; Pobiner and Braun, 2005) or whether they relate to the number of strokes during butchery (Egeland, 2003). We now understand how cut mark patterns vary according to raw material type better than ever before (Choi and Driwantoro, 2007; Dewbury and Russell, 2007; Seetah, 2008) and have improved our understanding of cut mark micromorphology (Belo and Soligo, 2008). Despite the increase in resolution, cut mark studies still remain controversial, especially in their application to Plio-Pleistocene sites because of gaps in currently available interpretive frameworks. Some argue that opposite butchery behaviors may yield similar cut mark patters (Capaldo, 1995, 1997, 1998). For others, such equifinality is methodological (Domínguez Rodrigo, 2002). Others would use the same cut mark patters to infer passive scavenging on defleshed carcasses from carnivore kills (Selvaggio, 1994a,b), a mixed strategy of early, intermediate and late access to variously fleshed carcasses (Lupo and O'Connell, 2002), or primary access to fleshed carcasses unmodified by carnivores (Domínguez Rodrigo, 1997, 2002, 2003; Domínguez Rodrigo and Pickering, 2003; Pickering et al, 2004). Most of these divergent interpretations stem mostly from different analytical approaches (see extensive discussion in Domínguez Rodrigo, 2008).

A major problem that partly accounts for the diversity of interpretations is that cut mark studies have traditionally focused more on total frequencies of cut-marked specimens in any given assemblage, rather than on the qualitative distribution of marks. Cut mark frequencies can range from <1% to >30% in archaeological assemblages irrespective of their chronology and cultural period. This tremendous range of variation in frequencies and anatomical distributions of cut marks across multiple assemblages prompts skepticism that the behavioral meaning of cut marks could be effectively inferred from prehistoric assemblages (Lyman, 2005). Lyman (2005) illustrates this in a comparison between cut mark frequency and distribution on the joint portions of bones from the appendicular skeleton from two artiodactyls genera in two North American sites. One could argue about the validity of addressing such a general issue with such a small sample (two sites and only joint portions, discarding the remainder of the skeleton), especially when cut marks on joints are mostly related to disarticulating behaviors. These behaviors (and the resulting cut mark patterns) are highly variable in modern hunter-gatherers, not only depending on the experience of the butcher but also on site functionality (Bunn, 2001; Lupo and O'Connell, 2002). Since site functionality at the two sites that Lyman uses is inferred but not known, the comparison of the inferential premises (sensu Domínguez Rodrigo and Pickering, 2003) is not warranted. The cut mark variation observed by Lyman could also be partly accounted for the differential representation of bone ends according to density. If selecting the least dense portions of humeri, radii, femora and tibiae and dividing them by the densest ends in each of those elements, the more cancellous ends are preserved differently (0.52 versus 0.75) at both sites. Since cut mark frequencies on limb bones vary according to the end type in each long bone (Bunn, 2001; Nilsen, 2000), the different cut mark pattern at both sites could be an artefact of taphonomic preservation. Thus, Lyman (Lyman, 2005, p. 1722) is right when admitting that "well-founded interpretations of frequencies of cut-marked remains may require unique kinds of contextual data".

Padilla (2008) has shown that cut mark frequencies in butchery experiments vary according to the degree of skill of butchers. However, even highly skilled butchers intentionally defleshing carcasses with the goal of minimizing the number of cut marks on bones leave diagnostic traces in specific anatomical sections (Padilla, 2008). Taphonomic processes affecting sites may further determine the frequency of surviving cut marks. This type of marks may therefore be subjected to so many variables that their variability may deter some analysts from using them for interpreting past butchery behaviors. However, this wide range of variability has not been properly explained until now. The understanding of this variability is necessary if interpretations of anthropogenic butchery at sites where cut marks are rather marginal can be achieved or if interpretations of different butchery processes at other sites where they are very abundant can be supported.

In the present work, our goal is to analyze a large set of sites for which taphonomic studies have unveiled an anthropic origin, searching for the underlying reasons of cut mark frequency variability. This will help archaeologists to understand the reasons of differences in cut mark frequencies and relate them to specific human behaviors (linked to site functionality) or taphonomic processes affecting the properties of archaeofaunal assemblages.

## 2. Sample and method

The list of sites used for the present study includes 44 archaeological levels from a total of 28 sites, spanning a chronology as diverse as from Early Pleistocene Oldowan to historic Middle Ages (Table 1). This is the first time a sample this large was used for the purpose of understanding cut mark patterns. All the assemblages included in the present analysis have been studied by at least one of the authors, and the methodology applied has been the same. The sites have been taphonomically identified as having been accumulated and modified primarily by humans.

The analytical variables used were the following:

(1) Total frequency of cut-marked specimens in all skeletal specimens (cm-NISP)
(2) Total frequency of cut-marked specimens on long bones (cm-LB)
(3) Total frequency of cut-marked specimens on long bone shafts (cm-MSH)
(4) Percentage of axial (rib and vertebrae) NISP/total NISP (axialNISP).
(5) Percentage of axial (rib and vertebrae) MNE/total MNE (axialMNE).
(6) Percentage of appendicular long bone NISP/total NISP (limbNISP)
(7) Percentage of appendicular long bone MNE/total MNE (limbMNE)
(8) Percentage of bone fragmentation (NISP/MNE)
(9) Epiphysis:diaphysis NISP ratio (EP-MSH-NISP).
(10) Long bone epiphyseal MNE:long bone shaft MNE ratio (EP-MSH-MNE)
(11) Percentage of tooth marked NISP/total NISP (TMNISP)
(12) Percentage of tooth marked long bone NISP/total long bone NISP (TMLB)
(13) Butchering tool type
(14) Carcass size

The first three variables can be used as the alternating criterion variables. The remaining predictor variables comprise taphonomic and behavioral criteria. Differential skeletal representation, either through selection by humans or by bone deleting by post-depositional agents, may influence the resulting cut mark patterns preserved in any given assemblage. Thus, variables 4–7 will provide estimates as to the evenness of skeletal representation and its relation with cut mark frequencies, especially when comparing the most fragile anatomical elements (axial bones) to some of the densest ones (long bones). These variables will consider NISP and