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Size matters. An evaluation of descriptive and metric criteria for identifying cut marks made by unmodified rocks during butchery

Gilliane F. Monnier*, Emily Bischoff

Dept. of Anthropology, University of Minnesota, Minneapolis, MN 55455, USA

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ABSTRACT

One of the key concerns in human evolution studies is tracing the development of stone tool use by early hominins to acquire meat. It has been suggested that the earliest tools used for this purpose might have been unmodified, naturally sharp rocks. However, it has proven challenging to distinguish marks on bones made by hominins using humanly unmodified rocks (HURs) for butchery, from marks made by natural processes. Here we present the results of a study aimed at comparing marks made by HURs during butchery, versus marks made by the same HURs through simulated natural processes, specifically, the fluvial tumbling of bones with naturally sharp rocks (replicated here using a rock tumbler). The results of this study, in which the lithological effector is held constant while the actor is varied, confirm earlier studies suggesting that many existing categorical attributes do *not* effectively distinguish between marks made by HURs versus those made by other tools or trampling. However, we also present a novel way of measuring mark depths which shows that marks made by the human actor are much deeper and longer than those made by natural processes. The size of marks, therefore, matters. This knowledge may help us assess the likelihood that marks on bone surfaces may have been produced by natural forces, as opposed to by humans using unmodified rocks for butchery.

1. Introduction

One of the single most important behavioral adaptations in human evolution is stone tool manufacture and use. The earliest recognized stone tools, consisting of simple stone flakes struck from cores using other rocks, date to ~2.5 mya at the Kada Gona and Bouri sites in East Africa (Semaw et al. 1997; de Heinzelin et al. 1999). The appearance of these tools, which is a watershed in human evolution, surely did not happen overnight, however. The first archaeologically recognizable stone tools must represent the outcome of a long-term, increasing dependence upon stones as tools, including naturally sharp rocks, before hominins began to *modify* stones to create desirable attributes. Panger and colleagues examined this issue in detail (Panger et al. 2002), and concluded that 1) since modern chimpanzees use tools, it is likely that the common ancestor of humans and chimps used tools, 2) hominins had the anatomical capacity to use *stone* tools by 3.2 mya, and 3) hominins likely *modified* stones as tools before their earliest appearance in the archaeological record 2.6 mya. They speculate that the reason we only find stone tools after 2.6 mya is because previously invisible behaviors became archaeologically visible at this time, perhaps as a result of intensification or spatial reorganization of tool-using behaviors. They suggest that a better understanding of the origins of stone tool use and modification will be achieved when archaeologists focus on better documenting use-wear patterns on stones and cut marks on bones.

Since one of the earliest known uses of Oldowan tools is butchery, as evidenced by cut marks on bones from numerous sites (Braun et al., 2010; Bunn, 1981; Bunn and Kroll, 1986; Blumenschine, 1995; Domínguez-Rodrigo et al., 2005), it is possible, if not probable, that one of the driving forces for the development of stone tools was butchery. If such is the case, it is logical to assume that the use of modified stone tools for butchery was preceded by the use of unmodified, naturally sharp rocks for the same purpose. This issue recently came to a head when two bones associated with deposits dating to ~3.4 mya at Dikika, Ethiopia, were claimed to bear stone-tool cut marks (McPherron et al. 2010). Since these deposits are almost one million years older than the oldest documented stone tools, this claim shook the field of paleoanthropology and caused considerable debate (Domínguez-Rodrigo et al., 2010, 2011; McPherron et al. 2011). The finds have been questioned on the basis of their dates, the security of their provenience, the sedimentary context with which they were associated, and, most importantly, whether the marks were

* Corresponding author. Tel.: +1 612 626 4846; fax: +1 612 625 3095.
E-mail address: monni003@umn.edu (G.F. Monnier).

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made by stone-tool using hominins, or by accidental trampling (Domínguez-Rodrigo et al., 2010, 2011). McPherron et al. suggested that the marks were made by hominins carrying out butchery activities using unmodified, sharp stones (McPherron et al. 2010).

This debate raised a question which has concerned taphonomists for many years, namely, how to distinguish marks made by stone tools used for butchery activities, versus those made by other factors not involving human behavior. Marks on bone surfaces are known to be caused by many factors, including carnivore teeth, trampling, fluvial action, microbial action, and stone tools (Bunn, 1981; Potts and Shipman, 1981; Behrensmeyer et al., 1986; Bunn and Kroll, 1986; Olsen and Shipman, 1988; Bunn, 1991; Gifford-Gonzalez, 1991; Blumenschine et al. 1996; Domínguez-Rodrigo et al., 2009). Distinguishing marks made by stone tools during butchery activities, versus those made by natural processes such as trampling of bones against angular sediments, has been particularly challenging. Yet, it is an important concern in paleoanthropology, since one of our key questions is documenting the development of meat-acquisition behaviors (e.g., scavenging and hunting).

Experiments have enabled researchers to develop lists of criteria to differentiate these marks. In one of the earliest experiments, Behrensmeyer et al. (1986) showed that brief trampling of bovid and equid bones in a stream by a human wearing soft-soled shoes can produce marks exhibiting the classic features of cut marks: a V-shaped cross-section and internal microstriations. This same experiment showed that cut marks on the bones were significantly altered by the trampling event, and rendered indistinguishable, in some cases, from trampling marks. It also showed that internal microstriations can be obliterated by trampling or even washing (Behrensmeyer et al. 1986). However, Eickhoff and Herrmann (1985) showed that internal microstriations are not exclusive to cut marks, and can result from gnawing by carnivores with broken teeth. Another experiment in which bovid and sheep bones were trampled in different sediment types with bare feet for two hours revealed somewhat different results (Olsen and Shipman, 1988). The marks created in this experiment were fine, shallow scratches with diverse orientations, and lacked internal microstriations. These marks could not be mistaken for butchery cut marks, according to the authors. Furthermore, the marks were not located in anatomically meaningful areas, and the trampling created a polish on all of the bones (Olsen and Shipman, 1988). Both of these classic studies emphasized that in order to evaluate marks, it is important to take into account the sedimentary context, the locations, orientations, and frequencies of the marks (Behrensmeyer et al. 1986; Olsen and Shipman, 1988), as well as their morphology, depth and association with polish (Olsen and Shipman, 1988).

Domínguez-Rodrigo et al. (2009) argued that the trampling experiments described above were unrealistically long, and designed an experiment in which they trampled small sections of deer bones using esparto grass-soled shoes for ten seconds or two minutes in five different sediment types. Unsurprisingly, they found that the largest sediment grains produced the most marks, and that longer trampling times produced more marks, as well. They concluded that the features previously described as typical characteristics of trampling marks (greater abundance, more random orientations, and a rounded base and a shoulder) are valid for intensive trampling, but not brief trampling episodes. They also argued that the bulk of trampling marks can be distinguished from butchery marks by multivariate application of microscopic criteria, such as mark shape, mark trajectory, trajectory of microstriations, location of microstriations, presence of a shoulder, and flaking on the shoulder.

Following the Dikika debate, Domínguez-Rodrigo et al. (2012) carried out an experiment involving the butchery of chicken and sheep bones using humanly unmodified rocks (HURs). They focused their analysis of the resulting cut-marks on four variables which they had previously shown to discriminate between most trampling and cut marks: cross-sectional shape of the mark, mark trajectory, incidence of shoulder effects, and incidence of flaking on the mark shoulder (Domínguez-Rodrigo et al., 2009), and an additional four variables which they found to discriminate between handaxe-inflicted marks and retouched flake-inflicted marks: presence of multiple-clustered marks, presence of forked marks, number of multiple-clustered marks, and number of forked marks (de Juana et al., 2010). The team's comparison of these variables across the sample of HUR butchery marks, and previously published samples of marks made using other effectors in their experiments – unretouched flakes, retouched flakes, and handaxes – showed the greatest contrast between marks made by unretouched flakes versus those made by HURs, and the greatest resemblance between marks made by retouched flakes and those made by HURs. In other words, the team's joint and pair-wise analyses of these eight variables across marks made by unretouched flakes, retouched flakes, handaxes, and unmodified sharp rocks showed that marks made by sharp rocks are similar to those made by retouched flakes, and very different from those made by unretouched flakes (Domínguez-Rodrigo et al., 2012).

It is unclear why Domínguez-Rodrigo et al. (2012) did not include trampling marks in their joint and pair-wise analyses of the variables; it would have been interesting to compare trampling marks versus those made by HURs, since those are the two mark effectors which are being debated in the case of Dikika. However, the authors did include trampling marks in one of the multiple correspondence analyses (MCA) that they ran on the data. The results of the MCA showed that the variables which explain most of the variability are driven by the marks made by handaxes (Domínguez-Rodrigo et al., 2012). They also concluded on the basis of a biplot of the MCA scores that the confidence interval of the sample of trampling marks overlaps strongly with that of the HUR marks (Fig. 5 in Domínguez-Rodrigo et al., 2012).

The strength of Domínguez-Rodrigo et al. (2012), as well as the previous studies upon which it is based (de Juana et al. 2010; Domínguez-Rodrigo et al., 2009), is that it shows that different lithological effectors – HURs, unretouched flakes, retouched flakes, and handaxes – produce different marks on bone. The overlap in morphology of marks made by HURs with marks made by the three other effectors (Figs. 3–5 in Domínguez-Rodrigo et al., 2012) is striking; it is probably best explained by the fact that the edge angles and other properties of the HURs' edges likely encompass the *range of edge angles and properties* of the other lithological effectors, from very thin and sharp (as in the case of unretouched flakes), to robust and irregular (as in handaxes). In future studies, the relationship between cut mark morphology and lithological effector will be better identified if the same care is given to documenting the properties of the stone tool edges used in the experiments, as is given to documenting the morphologies of the cut marks. Likewise, a more rigorous comparison of the similarities and differences between the marks created by trampling to those created by humanly unmodified rocks is necessary.

The type of data that we need to evaluate the Dikika cut marks, however, is not a comparison of marks made by handaxes, retouched flakes, unretouched flakes, and HURs. We need data that are specific to the question of what marks made by HURs used during butchery activities might look like, versus marks made by HURs during natural (taphonomic) processes. In other words, logic dictates the following possible causes of the Dikika marks: 1) natural forces resulting in contact between stones and bones, such as trampling, which has been documented at paleontological, Miocene-period sites (e.g., Behrensmeyer et al. 1989), or fluvial action, documented in archaeological assemblages such as Member