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Relative frequency of butchering cutmarks produced by obsidian and flint: an experimental approach

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Abstract

An experimental approach was used to determine how stone tool materials affect the frequency of observed cutmarks. Five whitetail deer were butchered by an expert butcher using flint and obsidian tools and the skeletons were prepared and analyzed. The authors found that the deer butchered with obsidian tools generally displayed fewer incidents of cutmarks than their flint-butchered counterparts. Consideration of this variable may prove to be important to archaeologists attempting to answer questions of specialization or when making comparisons of cutmark data between sites.

Keywords: Zooarchaeology; Butchering; Stone tools; Cutmarks

1. Introduction

The study of cutmarks on bone is a long established area of inquiry in archaeology. Researchers have attempted to answer a wide variety of questions about human behavior through analysis of cutmarks. In a recent paper, Lyman [11] notes that while a substantial body of work on cutmarks exists, there is a dearth of studies examining the tremendous variation in the frequency of cutmarks observed in archaeological assemblages. Lupo and O'Connell [8] also call for more actualistic studies that examine "potentially critical variables" [8, p. 104] that affect the cutmark frequency. We believe tool material to be a potentially critical variable. Using experimentally derived data, we attempt to determine if the tool material, in this case flint and obsidian, has any effect on the frequency of observed cutmarks on bone.

Over the last half-century, a large body of literature has been produced concerning tool marks on bone. Cutmarks, in particular, have garnered a large share of the attention, and many studies – archaeological, ethnoarchaeological, and actualistic – have been published. The literature on cutmarks is vast, and the approaches are varied, thus a complete review is beyond the scope of this article. For thorough overviews of cutmark research, see Lyman [10] and Fisher [4].

Gifford-Gonzalez [6] offers useful terminology for understanding the nature of marks on bone. The *actor* operates within ecological and behavioral contexts. The actor may be a human butchering a deer, a dog chewing a bone, or a bison herd trampling the earth. The actions of the actor create marks on a bone's surface. The *effector* is what actually, physically, creates the mark: a stone tool, a carnivore's tooth, or a pebble in the ground. Set into motion by the actor, the effector leaves the *trace* [6, p. 228] we observe in the archaeological record. In this complex system, many variables exist that affect the type of trace left, its qualities and morphology, and its frequency.

In a study of Steller's sea lion (*Eumetopias jubatus*) and harbor-seal (*Phoca vitulina*) bones from two archaeological sites on the Oregon coast, Lyman [9] found that the larger Steller's sea lion remains displayed a greater frequency of cutmarks than the smaller harbor-seal and suggested that the

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variation in cutmark frequency was a function of variation in carcass size. Egeland [3] employed an actualistic approach to address the relationship of processing intensity (defined as the number of tool strokes) to cutmark frequency and found no correlation between butchering intensity and frequency of observed cutmarks.

2. Approach

The present paper utilizes an experimental approach in a preliminary effort to understand how the variable of tool material affects the frequency of cutmarks. There are two approaches, both valid, for doing experimental archaeology. In the first, one may try to isolate variables in closely controlled experiments focused on the nature of the material. The second approach uses naturalistic experiments that more closely resemble past activities. We chose the latter approach because the physical properties of flint and obsidian are well understood, but how they play out in butchering is not.

The senior author spent 12 years working as a professional chef before starting studies in anthropology. During this time considerable experience in butchering sheep, pigs, cows, deer, and a variety of birds was developed. Additionally, the senior author spent 2 years working as a butcher for a venison processor during deer season, butchering over 150 whitetail deer (a conservative estimate) during this period. This expertise coupled with ready access to deer placed us in a unique position to undertake the study presented below. Two weeks were spent practicing stone tool butchery and five whole deer and several fore and hindquarters were butchered with flint and obsidian tools before starting the study. These deer were not included in the study sample. We stress the development of expertise because it is a potential variable affecting the cut frequency [1, p. 480]. Prior skill and practice with stone tools permitted the senior author to approach the deer included in the study with a uniform skill level.

One reviewer suggested that a better approach might have been to hire several professional butchers to do the actual butchering in the interest of limiting bias through a blind study. While it is perhaps not ideal for the cutmark observer to do the butchering, in this case we had no choice given the training of contemporary American supermarket butchers. A survey of professional butchers in our area ($n = 7$) revealed only one who possessed extensive experience in processing whole carcasses; most butchers surveyed only had experience with reducing large primal cuts (i.e. fore and hindquarters) into smaller cuts of meat. Additionally, all of the butchers had been trained to cut meat according to modern cutting standards, meaning heavy use of saws and cleavers to cut through bones rather than filleting the meat from them. Given the senior author's extensive experience with whole-carcass reduction, practice with the stone tools, and the fact that most of the deer processed each year required the meat to be totally filleted from the bones rather than processed into familiar modern cuts, we felt that the 'noise' introduced from the efforts of a less-experienced butcher would be far more problematic and prone to bias the results than doing the butchering ourselves. In any case, the investigator serving as butcher and observer is not without precedent [3].

3. Materials

Whitetail deer (*Odocoileus virginianus*) were provided by hunters through Broken Antler, a local venison processor in Ithaca, New York. The four males and one female included in the study were all healthy subadults ranging from 130 to 180 pounds (field-dressed weight). All deer had a postmortem interval (PMI) of approximately 36 h from death to butchery.

Dr. Dan Evett of Cornell University created a large assemblage of both flint and obsidian flakes in various shapes and sizes – no bifaces or tools requiring extensive knapping were used. Modern butchers use a variety of knives throughout the butchering process, depending on the task. Given the ease of making practical stone flakes (assuming ready access to raw materials) and the nature of their manufacture (i.e. variously-sized pieces are knocked off with each strike of the hammerstone), it is reasonable to infer that ancient butchers also chose tools of particular shapes and sizes for particular jobs. In this study, the maximum length of the tools' cutting edge ranged from 45 to 80 mm. Large, sturdy flakes were used for tough jobs like skinning and cutting through large muscle masses and connective tissue, and smaller flakes for more delicate operations The range of tool shapes and sizes used on the left and right sides of the deer was kept as consistent as possible. An average of four flakes per side were used during butchering.

4. Methods

4.1. Butchering

The deer were donated by the hunters as a part of an annual venison donation program. Because the meat was destined for distribution and human consumption, certain processing standards had to be met. The deer had to be maintained at a temperature below 40 °F, had to be hung or kept on tables during skinning and butchering, all the meat had to be filleted from the bones to ready it for grinding, and the feet had to be removed before they entered the cutting room.

All deer arrived at the facility field dressed (gutted) by the hunter. Only deer that had been dead for at least 24 h and not more than 40 h were selected. Butchering an animal killed a day or two ago is a very different experience from butchering a freshly killed one. Freshly killed carcasses (within 2–3 h of death) are warm and very pliable with a volume of slippery fluids and blood. As the animal passes through rigor mortis (typically within 24 h), the tissues initially stiffen and then slightly relax and the slick bodily fluids dry up. The warmth and flexibility of the carcass can aid butchery, though the blood and fluids make holding tools and getting a good grip on the carcass quite difficult. Once the animal has passed through rigor, the resulting firmness and relative dryness of the carcass makes handling it easier, but tight joints and very cold carcasses may give some difficulty. As all the deer in the study arrived after having been dead for more than 5 h, we felt it prudent to stay within this postmortem interval range in the interests of maintaining consistency in conditions. Any deer with injuries that had extensive bone involvement (i.e. destruction of one or more elements) were rejected. These criteria, especially the latter, drastically limited the sample size.

To maximize both the sample size and consistency of butchery conditions, each deer was butchered with flint and obsidian tools, using flint to butcher the left side and obsidian the right. The goal of each butchering episode was to reduce the carcass and thoroughly deflesh the bones in an efficient manner, working as quickly as possible without rushing. No attempt was made to produce "modern" cuts of meat. Left and right sides were butchered first on alternate deer.

4.2. Skeleton preparation and analysis

A variety of methods may be used to prepare skeletons for study, such as water maceration (hot or cold), enzyme maceration, dermestid beetles, or composting [7,12,13,15]. Each method has unique advantages and disadvantages that affect variables such as bone preservation and the amount of money, time and labor required for preparation. Hot water maceration followed by degreasing struck the best balance between cost, labor intensity, time, and most importantly, bone quality. Each skeleton was prepared individually to prevent commingling.

When dry, individual skeletons were analyzed for cutmarks with the aid of a magnifying lamp and dissecting microscope. Each bone was viewed under the magnifying lamp and observed cutmarks were circled with a pencil. Ambiguous marks were additionally viewed under the dissecting microscope at $10\times$ magnification to determine their origin. Blumenschine et al. [2] found that even inexperienced observers could correctly identify the effector [6] of marks on bone with a high degree of accuracy using only hand lenses and low-power light microscopy. Because our focus was the frequency of marks rather than their quality, morphology, or identification of the effector, we feel that our system sufficed.

Generally, stone flakes used for butchering are shorter in length than most steel butcher's knives. The shorter cutting edge of the stone tool often requires a "sawing" motion, or repeated short cutting strokes to sever muscles and connective tissue. This activity results in the cutmarks displaying as clusters of individual marks. Lyman [10] notes the difficulty of counting cutmarks and offers this solution "...tally each discrete, non-adjacent (>1 cm apart), and non-overlapping mark as an instance of force application." [10, p. 304]. We adopted this method (with a minor variation) and termed each quantified unit of cutmarks an "incident." For example: a group of closely spaced horizontal cutmarks were counted as one cutmark incident. Parallel cutmarks spaced more than 5 mm apart were counted as separate incidents.

5. Results

Cutmark incidents were tallied for individual deer and for the tool material as whole. A total of 197 cutmark incidents were counted and the results are presented in Fig. 1. In four of the five deer, the sides butchered with flint tools displayed more cutmarks than the obsidian-butchered sides. The only exception was deer 001, a 185-pound ten-point buck that displayed 23 cutmark incidents on the right (obsidian) side and 22 on the left (flint) side. Flint-produced marks ranged from a low of 13 to a high of 46, while obsidian-produced marks ranged from 7 to 26 per deer. As Fig. 1 shows, the frequency of cutmarks on individual deer stayed within a relatively narrow range, with deer 005 being a notable exception. Deer 005 displayed 35% more cutmarks than deer 001, which was second in cutmark frequency. This discrepancy may be attributed to the relative temperature of the deer: 005 was butchered on a very cold day in December while all others were butchered in more temperate conditions.

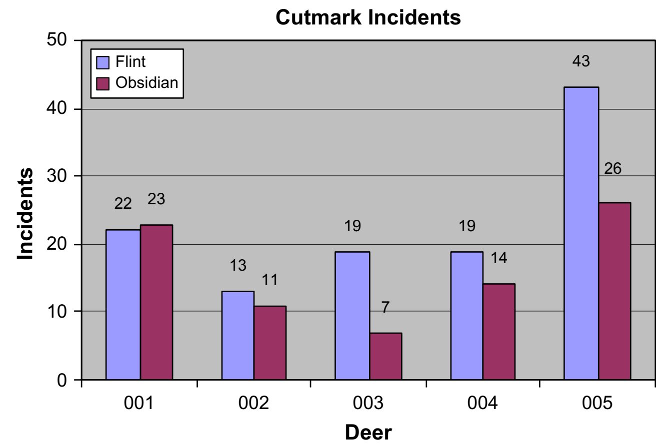

Fig. 1. Cutmark incidents by deer.

6. Discussion

Chi-square analysis indicated that the results were not statistically significant given the small sample size so correlation between tool material and cutmark frequency could not be proven conclusively. However, a host of valuable observations about the relative merits and disadvantages of flint versus obsidian tools were made during the course of the study. Two of these observations may help to explain how tool materials may affect the cutmark frequency.

Sharpness of edge, either steel or stone, is a major factor in how a tool performs a butchering task. Without exception, sharper is better and makes for easier butchering. A sharp tool readily slices through hide, fat, flesh, and sinew and does not require the user to apply much force to the tool. The smooth cutting action of a very sharp tool reduces the probability of bone/tool involvement. A very sharp tool also forces the user to cut with great care, as a slip can cause serious injury. Obsidian flakes are incredibly sharp, much more so than their steel counterparts, with edges that in theory can be as thin as a single molecule [14, p. 123,16, p. 243]. The smooth, thin, razor-like edge of the obsidian flakes used in the study generally made butchery easier than when flint flakes were used. The sharpest flint flakes in the study assemblage did not even approach the degree of sharpness of the obsidian flakes and consequently greater force often had to be applied. Using flint, it was sometimes necessary to bear down hard and saw through tough connective tissue and ligaments that the obsidian flakes severed with just a pass of the blade.

The durability of a stone tool also affects how it is wielded by the user. Obsidian flakes, while extremely sharp, are also very fragile: edges can crumble if they contact bone with only moderate force. Additionally, the brittle obsidian can withstand very little side-to-side torque before snapping. Whether an edge is crumbled by bone contact or snapped by torquing it, the end result is the same: a tool damaged to the point of uselessness, and flakes of glass in the meat.

In contrast, flint makes very durable tools. The thicker, albeit duller, edges of the flint flakes could withstand repeated bone contact without breaking. In fact, throughout the course of the practice sessions and the experimental butchery no flint flake edges broke. Bone contact also did not immediately dull the tools enough to make them difficult or impossible to use, as it did to several obsidian flakes.

The two characteristics of sharpness and durability are a product of the material from which the tool is made. These characteristic influence how a butcher uses the tools, which in turn affects the traces that they leave. Beyond razor-sharp, fragile obsidian slices easily through tissue, and fosters a light-handed technique that naturally minimizes bone/tool contact. Sturdy flint, with its less keen edge, requires more force and motion to use effectively, and even when the user consciously tries to avoid striking bone to preserve the edge (as we assume all butchers do, prehistoric or modern), the nature of the tool and the technique it requires makes cutmarks inevitable.

7. Conclusions

Many factors affect the frequency of cutmarks produced during butchery. Carcass size [5,9] may be one such variable, as well as the size of the portions to which the carcass is reduced. Stiffness of the carcass due to rigor or freezing will tend to increase cutmark frequency. Skilled butchers are less likely to leave cutmarks, so that assemblages with few cutmarks might indicate the presence of specialist butchers or frequent meat consumption. We believe that tool material is another such variable. Tools with less keen edges require more force to use, and therefore are more likely to leave marks on the bone. Though our sample size is small, the pattern is compelling and warrants further research. Future studies need to have larger sample sizes and consider variables such as number of tool strokes and the amount of time needed to butcher similar-sized carcasses. Ideally, other variables that may affect butchery such as carcass and ambient temperature would also be controlled.

Taken on its own, the observation that butchering with obsidian tools may produce fewer cutmarks than butchering with flint seems unimportant. However, consideration of this variable may prove to be critically important to archaeologists attempting to answer questions of specialization or when making comparisons of cutmark data between sites.

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