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CHAPTER 9

EXPERIMENTAL ZOOARCHAEOLOGY AND ITS ROLE IN DEFINING THE INVESTIGATIVE PARAMETERS OF THE BEHAVIOR OF EARLY STONE AGE HOMINIDS

TRAVIS RAYNE PICKERING AND CHARLES P. EGELAND

INTRODUCTION

In the past quarter century, zooarchaeologists have made significant contributions to our understanding of Early Stone Age (ESA) hominids. This work has been advanced in the field and laboratory, and includes: (1) the demonstration of functional linkages—in the form of butchery marks—between the world's oldest lithic technology and the reduction of animal carcasses into their constituent edible parts (e.g., Blumenschine, 1995; Bunn, 1981, 1982, 1997; Bunn and Kroll, 1986; Domínguez-Rodrigo et al., 2002, 2005, 2007; de Heinzelin et al., 1999; Pickering et al., 2004, 2007; Potts and Shipman, 1981); (2) some provisional idea of hominid dietary choices through the taxonomic identification of bones with butchery marks (compiled in Blumenschine and Pobiner, 2007). These two basic inferences have received wide-spread acceptance and, considering the vital role of diet in an animal's survival and fitness, they serve as foundational braces in models of early hominid socioecology. However, higher-order inferences, such as those concerning foraging efficiency, food sharing and group organization also are desired and have been attempted by applying actualistic results to the interpretation of zooarchaeological data. In particular, ethnoarchaeology has been one important contributor in these efforts (e.g., Bartram, 1993; Bunn et al., 1988), but we do not discuss that approach here. Instead, this chapter begins with a review of our experimental contributions to an understanding of ESA hominid carcass foraging. We summarize and discuss the implications of new datasets generated in our recent experimental programs. These results and others have been important in demonstrating that laboratory research plays a relevant role in ESA zooarchaeology. It does this first by helping to establish the interpretive limitations of actualistic results for application to an archaeological record formed in the very remote past—a record, which itself is severely limited due to preservational and other biases. Second, by recognizing these limitations, experimental zooarchaeology continues to act as catalyst in developing more apposite methods for creating models of the adaptive behaviors of our early African ancestors. We close the chapter with an opinion about the area in which these methods reside, and urge a renewed research focus in it.

BUTCHERY MARKS

The intensity by which hominids processed animal carcasses is of considerable interest to ESA zooarchaeologists. This is in no small part because carcass processing intensity probably relates directly to the over-arching issue of hominid-carnivore competition. Competition is widely recognized as an integral component of ecological communities and how they are structured, maintained and transformed (Cody and Diamond, 1975; Diamond and Case, 1986; Roughgarden, 1983; Tilman, 1982); it is at this level of inference that we could begin to have a much richer understanding of early hominid adaptations and behavior.

There are at least three zooarchaeological predictions of processing intensity that have been proposed: (1) the variable utilization of differently nutritionally ranked carcass parts (low processing intensity would be indicated by use of just the highest ranked parts, while high processing intensity would, in addition, see the use of

Table 1. Summary of essential parameters for carcass processing intensity experiments[1]

Cutmark experiment	
Hypothesis	number of defleshing cutting strokes applied to ungulate limb and cutmark frequency will covary positively
Sample	*Equus cabullus* 3 complete, fully fleshed forelimbs; 6 complete or nearly complete, fully fleshed hindlimbs. *Bos taurus* 5 complete, fully fleshed forelimbs; 2 complete, fully fleshed hindlimbs
Methods	carcass units completely defleshed using obsidian and chert flakes; number of cutting strokes required to accomplish the above counted; bones collected and cleaned; number of cutmarks (each discernable striation) counted
Test implication	Hypothesis falsified[2]

Percussion mark experiment	
Hypothesis	number of demarrowing hammerstone blows applied to ungulate limb and percussion mark frequency will covary positively
Sample	*Odocoileus virginianus* 36 complete, defleshed humeri; 38 complete, defleshed radii
Methods	bones broken across stone anvils using stone hammers until medullary cavity breeched to minimal extent that all marrow could be removed with a 12-inch pharmaceutical spatula; number of blows necessary to accomplish the above counted; bone fragments collected and cleaned; number of percussion marks counted
Test implication	Hypothesis falsified[2]

[1]*Detailed methods and results for the cutmark experiments are described in Egeland (2003), and for the percussion mark experiments in Pickering and Egeland (2006).*
[2]*See Figure 1 for graphic summary of results.*
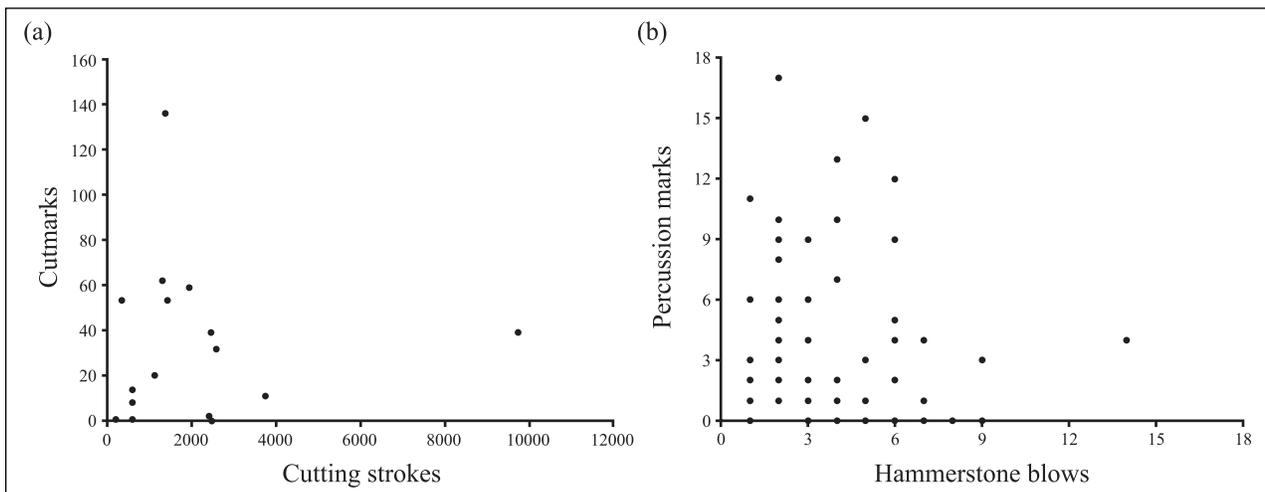
Figure 1. Bivariate scatterplots showing no significant positive correlations between (a) the number of defleshing cutting strokes and cutmark frequency on horse and cow bones ($r_s = 0.081$, $p > 0.10$) (data from Egeland, 2003), and (b) between the number of hammerstone blows and percussion mark frequency on white-tailed deer bone fragments ($r_s = -0.234$, $p = 0.045$) (data from Pickering and Egeland, 2006). Note that skeletal elements and bone specimens from the experiments that do not preserve surficial marks are not graphed in (a) and (b).

low ranking parts); (2) the extraction of marrow and/or grease in addition to meat; (3) the increased investment in removing one particular type of carcass tissue (e.g., not only defleshing major muscle masses, but also small scraps of meat adhering to bone). Among others, three of the primary zooarchaeological measures to test these predictions are: (1) skeletal part profiles; (2) quantification of bone fragmentation; (3) frequencies of butchery marks. Our most recent experimental work relates directly to the third measure and we discuss it here.

The often epiphenomenal nature of butchery marks has been highlighted most explicitly by Lyman (1992, 1994, 1995, 2005). His work on the topic, however, was largely comparative (sensu, Klein and Cruz-Uribe, 1984; i.e., it has concentrated on inter-taxonomic and inter-site comparisons of strictly archaeological materials), rather than actualistic. Inspired by Lyman's results, our efforts to discover meaningful linkages between hominid behavior and butchery damage have been, in contrast, wholly experimental.

We conducted two sets of experiments. The first, by Egeland (2003), operated under the hypothesis that the number of defleshing cutting strokes applied to a muscled ungulate limb bone (limb bones = humeri, radioulnae, femora, tibiae, metapodials [see, Pickering et al., 2003]) and cutmark frequency will covary positively—with the underlying assumption that high intensity defleshing is conducted with more cutting strokes than is low intensity defleshing. Second, Pickering and Egeland (2006) hypothesized positive covariation between the number of hammerstone blows and percussion mark frequency during the demarrowing of an ungulate limb bone. The critical parameters of both experiments are outlined in Table 1, and Figure 1 presents our results. In sum, there is not a statistically significant positive correlation between cutting strokes and cutmark frequency, nor is there one between hammerstone blows and percussion mark frequency. These experimental results falsify both hypotheses. They also lead to a conclusion that agrees with that of Lyman (2005), based on his comparative analyses: the production of butchery marks is largely contingent and fortuitous. In the wake of this conclusion, Lyman (2005) still counsels some optimism, arguing that "well-founded interpretations of frequencies of cut-marked remains [might be possible, but also] may require unique kinds of contextual data." We, however, remain more dubious. At least in the context of ESA archaeofaunas, in which hominid input into the systems is usually minimal in even the "best" assemblages (e.g., Bunn, 1982, 1997; Domínguez-Rodrigo et al., 2007; Pickering et al., 2004, 2008), linking butchery mark frequency causally to carcass processing intensity is a long shot for success.[1]

A potentially more ESA-applicable observation on butchery mark frequency emanating from our combined experimentation is that 77.0 % of the total limb bone minimum number of elements (MNE) demarrowed display at least one percussion mark (Pickering and Egeland, 2006) and 87 % of the total limb bone MNE defleshed displayed at least one cutmark (Egeland, 2003). We believe these results provide a baseline standard against which an ESA archaeofauna might be compared to assess its hominid contribution. If independent data lead to the hypothesis that the fauna is primarily hominid-derived, our results predict that in that case at least 75% of the total limb bone MNE should be butchery marked. In doing so, the experimental approach highlights the inferential utility of the MNE as a zooarchaeological measure of skeletal element abundance. Previous work by Rapson (1990), Bartram (1993) and Abe et al. (2002) has emphasized butchery mark frequency data based on number of identified specimens (NISP) counts are highly sensitive to differential bone fragmentation, whereas MNE-based counts are much less so and thus preferable for most behavioral analyses.

BONE FRAGMENTATION

The MNE played another essential role in falsifying the hypothesis that high levels of ungulate limb bone fragmentation necessarily indicate a high intensity of carcass processing (Pickering and Egeland, 2006). A standard zooarchaeological measure of bone breakage is the fragmentation ratio NISP:MNE. Our hammerstone fragmentation of ungulate humeri and radii (see Table 1) resulted in markedly different NISP:MNE ratios for the two elements, even though each individual bone was broken to the minimal extent necessary for marrow removal. In other words, even though processing intensity was held constant in each case, the radius sample (NISP:MNE = 21.3) is more heavily comminuted than is the humerus sample (NISP:MNE = 13.1). Two other measures of bone breakage, including distribution of fragment sizes (Figure 2) and the proportion of epiphyseal (humerus $n = 74$; radius $n = 91$) to non-epiphyseal specimens (humerus $n = 401$; radius $n = 720$) corroborate the same significant difference between humeri and radii, with greater reduction of radii. We conclude that the variable that best explains this disparity is the more robust structure of the radius diaphysis compared to the thin-walled shaft of the humerus. More effort was required to breech radii sufficiently to attain the goal of complete marrow extraction. It is important to stress that in this case effort is *not* synonymous with intensity, the latter of which was held constant as breaking each bone to the *minimal extent necessary for marrow removal*. Thus, as demonstrated in so many other contexts (e.g., Brain, 1967, 1969; Lyman, 1984; Carlson and Pickering, 2003), it is an intrinsic property of bone that is mediat-

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[1] We note here that studies by Pobiner and Braun (2005) and Domínguez-Rodrigo and Barba (2005) found positive correlations between cutmark frequencies and the size of the carcass that is butchered. So, we admit that cutmark frequencies do seem to hold some explanatory power for at least one component of understanding early hominid carcass foraging, and are thus not completely epiphenomenal.
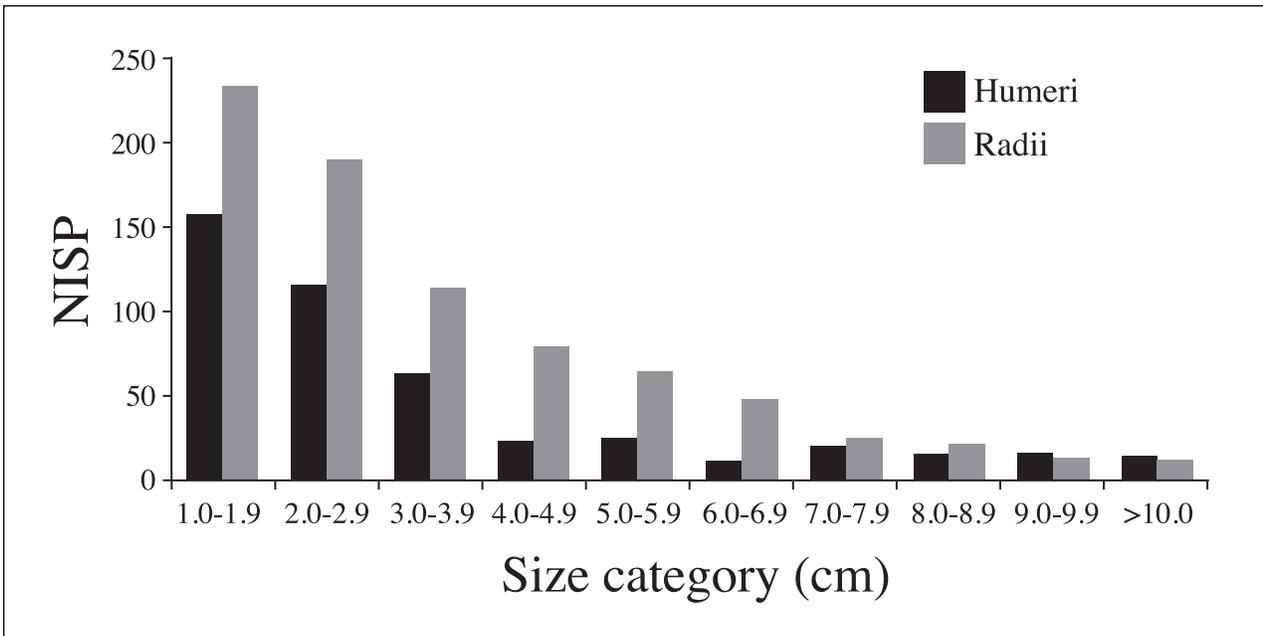
Figure 2. *Inter-element distribution of fragment sizes for hammerstone-percussed humeri and radii (data from Pickering and Egeland, 2006). The radius sample contains a higher number of small fragments than does the humerus sample, corroborating the assertion that the former is more heavily comminuted than is the latter. NISP = number of identified specimens.*

ing a zooarchaeological pattern of bone specimen representation. Such phenomena obscure or at least confound any underlying behavioral patterning (in this case, carcass processing intensity) in a fauna.

RETURN TO A PREVIOUS DIRECTION

Our experimental results summarized above conclude pessimistically about the probable success of using butchery mark frequencies and bone fragmentation to accurately infer the intensity by which Plio-Pleistocene hominids utilized ungulate carcasses. It thus seems to us that this avenue for investigating hominid-carnivore competition in the earliest ESA leads to a dead end. However, we certainly do not mean to imply that the dynamics of prehistoric competition are inexplicable. Indeed, many previous experimental efforts, as well as other approaches, have been devoted to modeling hominid-carnivore competition. One of the best known of these earlier studies is that of Blumenschine (1988).

His research maintained a focus on surface marks on ungulate limb bones. A concentration on these skeletal elements is particularly useful from an archaeological standpoint because their midshaft portions have been shown to better survive the rigors of density-mediated attrition than most other element portions; thus, limb bone presence in an archaeofauna (calculated by shaft inclusive methods of quantification) very likely reflects their original abundances with considerable fidelity (Bunn, 1982, 1986; Cleghorn and Marean, 2007; Marean and Cleghorn, 2003; Pickering et al., 2003).

Blumenschine's field experiments, carried out in the Serengeti and Ngorongoro (Tanzania), simulated

two general scenarios. In the first scenario provisioned ungulate carcasses are processed completely and exclusively by human experimenters using cutting tools or by wild carnivores (referred to, respectively, as "hominid-only" and "carnivore-only"). When carnivores (mainly hyenas) process complete limb bones they break them open to access marrow and grease. This results in tooth mark frequencies on midshaft segments of between 50%−80% (Blumenschine, 1988, 1995; Capaldo, 1995, 1997). Hominid-only samples derive from both experimental and ethnoarchaeological settings. Data generated on those samples indicate that hominid butchery results in cutmark and percussion mark frequencies that range between 15%−40% (Blumenschine and Selvaggio, 1988, 1991; Bunn, 1982; Domínguez-Rodrigo, 1997, 1999a; Domínguez-Rodrigo and Barba, 2005; Lupo and O'Connell, 2002; Pickering and Egeland, 2006; Pobiner and Braun, 2005). Blumenschine's second scenario simulates the sequential utilization of carcasses in "dual-" or "multi-patterned" models (Blumenschine and Marean, 1993; Capaldo, 1995). When human hammerstone breakage and marrow extraction is followed by carnivore ravaging, limb bone midshaft segments are tooth-marked at rates of only 5%−15% (Blumenschine, 1988, 1995; Blumenschine and Marean, 1993; Capaldo, 1995, 1997). The reason for this is relatively straightforward: hammerstone-broken midshafts no longer contain nutrient-rich marrow and therefore scavenging carnivores have little or no reason to put them between their jaws and incidentally tooth-mark them. Therefore, tooth mark frequencies on midshaft fragments can be used to differentiate primary from secondary access to ungulate carcasses by *bone-crushing carnivores.*

That the data of Blumenschine and his colleagues derive mainly from hyenas is important given that Domínguez-Rodrigo et al. (2007) demonstrate that tooth mark frequencies similar to "hominid-to-carnivore" models can be produced when felids rather than hyenas are the primary agent of carcass modification. Felids, especially medium-sized leopards and cheetahs, impart many fewer tooth marks on midshaft sections because they lack the bone-crushing ability of hyenas. This issue of potential equifinality in carnivore tooth mark frequencies highlights the need to consider taxon-specific variability in carcass modification abilities among carnivores. In addition, it stresses that *only hominid-imparted surface marks* can be used to directly infer the nature of hominid involvement with carcasses.

With the demonstrations that butchery mark frequencies are a doubtful source of accurate behavioral inferences, we return to our well-published assertion that it is the *anatomical patterning of butchery marks* that is instead of primary importance in faithfully modeling hominid carcass use. Specifically, defleshing cutmarks on limb bone midshafts of ungulates are good evidence for the butchery of fully fleshed limbs and, by extension, early access to carcasses (Bunn, 1982, 1986, 1991, 2001; Bunn and Kroll, 1986; Domínguez-Rodrigo 1997, 1999a, 2002; Domínguez-Rodrigo and Pickering, 2003; Pickering and Domínguez-Rodrigo, 2007; Pickering et al., 2004, 2008). Observations of abandoned lion kills—on which flesh scraps are never or rarely present on the previously meat-bearing midshafts of humeri, radii, femora and tibiae—strengthen this claim (Domínguez-Rodrigo,1999b). Thus, hominids relegated to passively scavenging felids kills would have no reason to impart cutmarks on bone sections (i.e., humeri, radii, femora and tibiae midshafts) that are usually completely defleshed by those primary-access felids. Cutmarks on pelves and ribs, the flesh of which is also consumed early in the carnivore consumption sequence (Blumenschine, 1986), are also indicative of early access by hominids to animal carcasses.

There is no longer any excuse to consign the importance of these observations. First, they have been tested actualistically and, unlike mark frequency data, are upheld as inferentially utilitarian. Second, the ESA archaeological record preserves an abundance of durable limb bone midshaft specimens, as well as other pertinent fossils. The very earliest zooarchaeological traces from Gona and Bouri, Ethiopia, at 2.6 – 2.5 million years (Myr.) ago, are scant, but we still believe it is telling that the few butchered specimens recovered so far from that time include ungulate upper and intermediate limb bone midshafts, as well as a rib with cutmarks on its ventral surface (Domínguez-Rodrigo et al., 2005; de Heinzelin et al., 1999). The minimalist nature of these Pliocene occurrences has led some researchers to conclude that early access to carcasses by hominids was only firmly established in the Early Pleistocene (Bunn, 2007). Although we certainly agree that the Pliocene sample of butchered ungulate remains is small and that early access is undoubtedly reflected in some Early Pleistocene assemblages, it is perhaps significant in this context that renewed analyses of the Early Pleistocene Bed I occurrences at Olduvai Gorge reveal FLK *Zinj* as the only assemblage between 2.5–1.5 Myr. ago with evidence of *systematic* butchering of carcasses by hominids (Domínguez-Rodrigo et al., 2007). These data indicate regular and early access to carcasses at 1.8 Myr. ago. We therefore suggest as an alternative that it might have been the *regularity* with which hominids acquired carcasses and not necessarily the *method* of access that differed between the Pliocene and the Early Pleistocene (and beyond).

Regardless, it still seems to us that this rather basic approach—a focus on the anatomical patterning of cut- and percussion marks—to the interpretation of hominid butchery damage stills holds the most potential to elucidate accurately the question of hominid-carnivore competition in the ESA. In at least one sense, the characterization of early hominid foraging capabilities and strategies provided by the approach are quite unambiguous and specific in being unclouded by reference to surficial bone damage imparted by other taphonomic agents and processes. As such these characterizations serve as an appropriate base upon which a sophisticated model of early hominid socioecology and cognition can be built.

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