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NUMBER 2

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BREATHING LIFE INTO FOSSILS:

Taphonomic Studies in Honor of C.K. (Bob) Brain

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COVER CAPTIONS AND CREDITS.

Front cover, clockwise from top left.

Top left:
Artist's reconstruction of the depositional context of Swartkrans Cave, South Africa, with a leopard consuming a hominid carcass in a tree outside the cave: bones would subsequently wash into the cave and be incorporated in the breccia deposits. © 1985 Jay H. Matternes.

Top right: The Swartkrans cave deposits in South Africa, where excavations have yielded many hominids and other animal fossils. ©1985 David L. Brill.

Bottom right: Reconstruction of a hominid being carried by a leopard. © 1985 Jay H. Matternes.

Bottom left: Photograph of a leopard mandible and the skull cap of a hominid from Swartkrans, with the leopard's canines juxtaposed with puncture marks likely produced by a leopard carrying its hominid prey. © 1985 David L. Brill.

Center: Photo of Bob Brain holding a cast of a spotted hyena skull signed by all of the taphonomy conference participants. © 2004 Kathy Schick, Stone Age Institute.

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CHAPTER 15

BUTCHERING BACKSTRAPS AND BEARING BACKBONES: INSIGHTS FROM HADZA FORAGERS AND IMPLICATIONS FOR PALEOLITHIC ARCHAEOLOGY

HENRY T. BUNN

ABSTRACT

This paper examines the dynamics of carcass transport by Hadza foragers near Lake Eyasi, Tanzania, and considers the archaeological implications for interpreting past human behavior from skeletal proportions in ancient bone assemblages. The Hadza possess a boiling technology (cooking fires and pots) for rendering edible fat from cancellous bones, which provides the incentive to transport defleshed backbones and some other axial and girdle elements to camps, where they are chopped into pot-sized pieces and boiled. Shifting temporal and technological contexts to the beginning of the Paleolithic, there is no evidence of a boiling technology, and, thus, no incentive for hominin transport of most axial and girdle elements from animal death sites to central locations ("home base" sites). An abundance of diverse large animals and an abundance of butchered limb elements in assemblages at sites formed over short time intervals, illustrated best at FLK Zinj, indicate that hominins selectively transported meaty portions of carcasses to such sites for further butchery, sharing, and consumption. The paucity of vertebrae, and consequently of the potential evidence of butchery damage to them, at such sites constrains consideration of how Plio-Pleistocene hominins may have used those carcass portions for food, but it is unnecessary to argue that hominins would have regularly transported many axial and girdle elements in the first place.

INTRODUCTION

Known colloquially as backstraps to many in rural America, t-bone, loin, and tenderloin to steak lovers, longissimus and psoas muscles to anatomists, and as loins in this paper, these major, elongate muscles running along the dorsal surfaces of the backbone and ventral surfaces of the lower back, are a prime cut of meat. Attached as they are to the backbone (and dorsal rib shafts) of an intact animal, the loins present a challenge in butchery, particularly when the animal is large. Moving a large carcass by manual labor requires segmenting of it into transportable portions guided by consideration of animal size, size of labor force, animal anatomy, and so on. Basic division of a carcass into one or more axial and girdle portions and the four limb portions is typical, with decisions for further division and, if the entire carcass is not to be transported, for selective transport of only some portions, as options. The axial/girdle portions of a carcass are rich in edible meat and fat but more awkward and unwieldy to transport than the meaty limb portions. The question of how prehistoric foragers resolved such subsistence challenges is addressed through observation of modern-day foragers and through analysis of archaeological bone assemblages.

Skeletal proportions in archaeological bone assemblages offer a tantalizing yet challenging opportunity to reconstruct aspects of ancient foraging behavior, including carcass transport, site function, and many others. One of the commonest analytical measures employed since the late 1800s (Lartet and Christy, 1865-75), is the use of disproportions in limb and axial element representation to distinguish sites that are a product of selective transport of carcass portions by humans (i.e., base camps high in limb elements) from sites that are not (i.e., *in situ* death, kill, or butchery sites high in axial and girdle elements). One writer has rejected this interpretive principle stating repeatedly that it "lacks empirical support" which "places at risk" many archaeological reconstructions, including those at Plio-Pleistocene sites in East Africa (O'Connell et al., 1988, 1990). Consulting mainly his own short-term observations of carcass transport by Hadza hunter-gatherers and unique but inappropriate analytical approach, O'Connell has more recently alleged that the well-known home base (or central place) sites of the Plio-Pleistocene are actually *in situ* animal death sites exploited by hominins on the spot without transport of carcass portions or bones (O'Connell et al., 2002). But is that really so, or does empirical evidence in context (i.e., the real world) actually contradict what O'Connell has alleged? I address these questions herein by reviewing empirical evidence from African ethnography, particularly from the Hadza, and from natural and cultural landscape settings where carcass and bone distribution patterns have been measured.

TAPHONOMY AND AFRICAN FORAGERS

During the past quarter century, taphonomic studies have documented some of the bone-related dynamics of carcass acquisition and use by several extant African forager societies. These include the !Kung (Yellen, 1977, 1991) and Kua (Bunn, 1983; Bartram et al., 1991; Bartram, 1993) in southern Africa, and the Hadza (Bunn et al., 1988, 1991; Bunn, 1993; O'Connell et al., 1988, 1990), Okiek (Marshall, 1993), and Aka Pygmies (Hudson, 1993) in eastern and central Africa. These studies have provided a wealth of empirical data and an informative array of insights for archaeologists. For present purposes, several salient points will suffice. Unsurprisingly, the dynamics of carcass transport are complex and often unknowable from ancient archaeological evidence. Factors influencing decision making by humans in field butchery and transport of carcasses include: (1) size and condition of carcass; (2) distance from death site to intended base camp (or other) destination; (3) number and strength of available carriers; (4) various logistical considerations, including time of day, weather, hunger level, and perceived competition from carnivores. Because most of these factors are hard to identify from archaeological data, fairly general statements about carcass transport are a prudent research objective.

The general tendency that stands out strongly in these studies is the intent to transport entire carcasses of all but the largest taxa and the successful realization or near realization of that objective most of the time. In other words, the food item for these forager societies is the entire, field-butchered carcass, not its constituent parts. Among the Hadza, this transport pattern is particularly strong and well documented (Bunn et al., 1988; Bunn, 1993), *contra* O'Connell et al., (1988, 1990), who employ an inappropriate analytical method and thereby mistake measurement of bone abandonment for measurement of the process of carcass transport. Bunn (1993) combined carcass transport data from the mid to late 1980s observations of Bunn (1986, 1988) and of O'Connell (1985. 1988) and presented skeletal profiles. Sample size from the independent research differed markedly, particularly for the commonest Hadza prey, impala (MNI: 24 in Bunn's research and 12 in O'Connell's) and zebra (MNI: 32 from Bunn and 10 from O'Connell). Although full discussion of these data is beyond the scope of this paper, Figure 1 illustrates the general outcome. The Hadza transport all skeletal elements more than 90 percent of the time, except crania (82%), mandibles (83%) and ribs (82%), which indicates a dominant pattern of whole-carcass transport.

How does the finding of whole-carcass transport among the Hadza and other African foragers impact the interpretive principle of measuring carcass transport archaeologically with limb/axial bone representation? Does it validate that analytical measure? Or, does it mean a lack of empirical support? To answer those questions, a closer look at the dynamics of carcass transport and processing by the Hadza is required.

DYNAMICS OF CARCASS TRANSPORT BY HADZA FORAGERS

Hadza foragers acquire a variety of large mammal prey by several hunting and scavenging strategies. Male hunters use powerful wooden long bows and an array of arrows in two principal contexts: (1) hunters construct blinds near water holes and wait in concealment to ambush water-dependent prey during the daytime and on moonlit nights during the dry season; (2) hunters encounter prey more opportunistically on daytime foraging walks from the base camp. Approximately 20 percent of carcasses are acquired by opportunistic scavenging during daily foraging activities either by small groups of hunters or by groups of women foraging for plants. Power scavenging is by far the most productive scavenging method, simply because it yields mostly intact carcasses and avoids the loss of most edible tissues to hyenas. Any form of late-access or passive scavenging from abandoned carcasses is generally unproductive, because in such contexts most edible tissues are consumed rapidly by scavenging hyenas.

Prey animal death sites thus occur in diverse locations on the landscape, and this poses diverse challenges regarding carcass transport. Prey animals may die within sight of a base camp. Given the occasional (but uncommon) paralyzing arrow shot to an animal's spine, animals may die adjacent to a hunting blind. Most commonly, however, prey animals run long distances after being shot, up to five kilometers or farther before falling dead, and that poses a recurring challenge to the Hadza: how to transport a large carcass a significant distance from the middle of nowhere in the bush to the larger group of individuals at the base camp.

As discussed above, the dynamics of carcass transport are complex, and although the degree of difficulty varies with each carcass, major trends do emerge. For example, with small to medium-sized carcasses (i.e., size

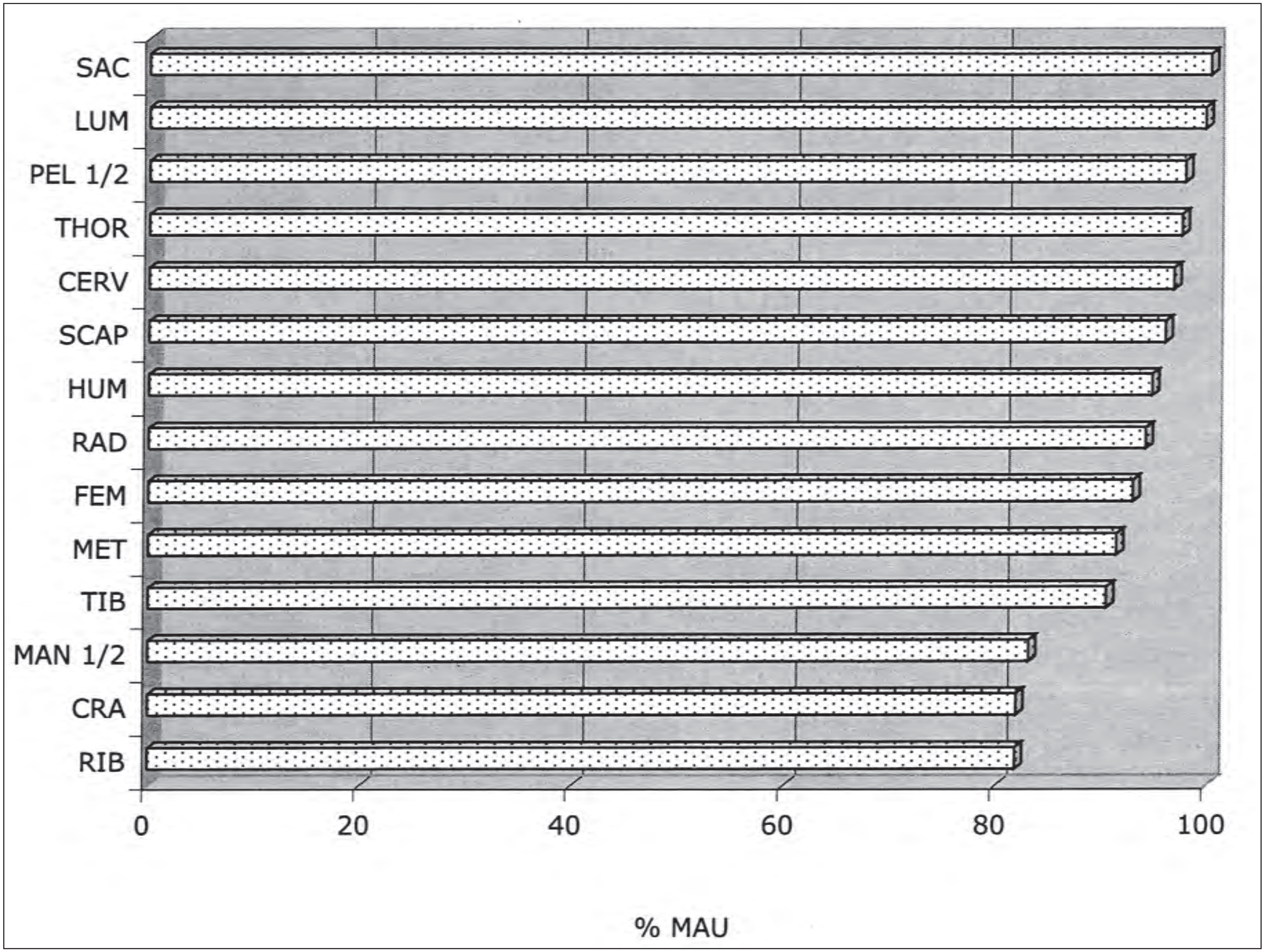


Figure 1. Skeletal profile of Hadza carcass transport data combining all taxa, as observed by Bunn et al. (1988; Bunn, 1993). The Hadza transport all carcass portions from animal death sites to camps more than 90% of the time, except skulls and ribs, indicating a dominant pattern of whole-carcass transport. Adapted from Bunn (1993). Skeletal element abbreviations: SAC = sacrum; LUM = lumbar vertebra; PEL 1/2 = half of pelvis; THOR = thoracic vertebra; CERV = cervical vertebra; SCAP = scapula; HUM = humerus; RAD = radius; FEM = femur; MET = metapodial; TIB = tibia; MAN 1/2 = half of mandible; CRA = cranium; RIB = rib.

group 1 = up to 50 lb live weight; size group 2 = 50-250 lb live weight; e.g., Brain, 1981; Bunn et al., 1988), transport from death site to base camp of entire carcasses, either intact or in field-butchered units, is routine. One to three carriers can easily achieve this even with significant transport distance. If necessary, one individual can transport an impala by splitting it longitudinally and mounting the halves onto a pole that can be carried on the shoulders. Similarly, with large carcasses (size group 3 = 250-750 lb), such as zebras and uncommon alcelaphine bovids (wildebeest, hartebeest), transport of entire field-butchered carcasses is a common and successfully realized objective of the Hadza. The Hadza successfully achieve this by enlisting additional carriers, with 7-10 individuals considered adequate. Deviations from this pattern have much more to do with particular Hadza attitudes about food quality (i.e., marrow) and about food sharing, than with concerns about reducing the energetic costs of food transport, *contra* O'Connell et al. (Bunn et al., 1988; Bunn, 1993; O'Connell et al., 1988, 1990). The Hadza's different handling of alcelaphine bovids (hartebeest and wildebeest) and zebra, all size group 3 taxa, illustrates this most simply. Some limb bones of alcelaphines (MNI = 4 from Bunn, 3 from O'Connell) are broken for marrow and abandoned at animal death sites, whereas axial and girdle elements, along with some limbs, are transported to camp. According to O'Connell et al., this means that transported bone assemblages at base camps should be dominated by scapulae, vertebrae, and pelves, and that the pattern should persist regardless of the mix of taxa in transported assemblages. According to O'Connell, this finding is what places at risk interpretations of Plio-Pleistocene sites high in limbs as transported assemblages. According to O'Connell et al., the partial abandonment of alcelaphine limb bones at kills results from a Hadza objective of reducing energetic transport costs, and they claim a similar pattern with even smaller impala carcasses.

According to the Hadza themselves, however, the partial abandonment of alcelaphine limb bones at kills results from the poor quality ranking of alcelaphine limb bone marrow by women and children who would be its likely recipients if transported to camp; the men compliantly eat some of the marrow and abandon some limb bones at kills.

These alternative explanations of cause and effect relationships governing transport dynamics can be restated as testable hypotheses and then tested with additional Hadza data. (1) If, as reasoned by O'Connell et al., the desire to reduce carcass transport cost leads the Hadza to abandon limbs at kills, then carcasses similar in size to the alcelaphines with correspondingly similar transport costs should be treated the same (i.e., abandonment of limbs). (2) If, as explained by Hadza informants, it is the poor quality of alcelaphine limb marrow that causes abandonment or non-transport of their limb bones, then carcasses similar in size to alcelaphines but with high quality marrow should be treated differently than alcelaphines (i.e., transport of limbs).

Zebra provide an ideal test case. They are abundant in the combined sample of Hadza transport data (MNI = 32 from Bunn et al., MNI= 10 from O'Connell et al.). Their meat is widely regarded as the favorite of the Hadza, and their limb marrow is ranked highly for its quality and sweetness. Like the alcelaphines, zebra are in size 3, but zebra are larger and heavier than either hartebeest or wildebeest; zebra, therefore, have higher transport costs. If a need to reduce transport costs of size 3 carcasses influences Hadza decisions in a meaningful way, at least as many, if not more, zebra limb bones should be abandoned at kills. The skeletal profile of zebra carcass transport shows that *all* zebra elements are transported by the Hadza more than 90 percent of the time from kill to camp except skulls and ribs (77-81 percent of time) (Bunn, 1993). Even though transport cost for zebra carcasses is higher than for alcelaphines, the Hadza routinely transport nearly entire zebra carcasses with only rare, negligible abandonment of limb bones. When it comes to transporting size group 3 carcasses, the Hadza could not care less about reducing transport costs.

With the selective, differential transport of very large, size group 4 and larger carcasses, a significant threshold is crossed in Hadza transport objectives. More carriers, up to 20-25 adults, may be enlisted, but unless transport distance is insignificant (i.e., less than one km. or so), many more skeletal elements are abandoned at kills. The progressive abandonment of more bones with carcass size increase is informative regarding transport decisions by the Hadza. With these largest of carcasses, there is a ranking of skeletal elements based on transport cost, further processing cost, and food yield. With Cape buffalo carcasses (size group 4), limbs are carried, but most axial elements and the pelvis are abandoned at the kill after being defleshed. Specifically, the loins are stripped from both sides of the backbone, gluteal muscles from the pelvis, and sheets of muscle from the ribs. With even larger giraffe carcasses (size group 5), most or nearly all skeletal elements are abandoned (again, unless distance to camp is short), including axial and girdle elements and now, limb elements, as well. Large packages of meat alone are the principal transported items.

Several salient points emerge from this review of the dynamics of carcass transport by the Hadza.

1. For small through large carcasses of zebra/wildebeest size (size group 3, up to 750 lbs), the Hadza regard the entire carcass, not its constituent parts, as the food item.
2. The dominant objective of transport (by far, unless poor food quality intervenes) is to move whole carcasses (minus a few snack items, such as skulls, ribs, and the occasional limb element) from kill to camp site.
3. Smaller carcasses are transported intact; larger carcasses are field-butchered into readily transportable units.

4. Some meat is separated from adjacent bones and the two transported independently. This involves some organ meat and superficial muscles from various elements but notably is extreme with the backbone.
5. The backstraps, or loins (certainly over 90 percent of attached meat), are routinely defleshed from the backbone at the kill. Yet backstraps and defleshed backbones are both transported from kill to camp sites (Figure 2).
6. Boiling technology (fires and large cooking pots) provides the incentive to transport defleshed backbones and other axial/girdle elements (pelves and ribs), which are chopped into pot-sized pieces and boiled to salvage contained fat and adhering bits of meat.
7. Even with the boiling technology, the Hadza rarely transport defleshed backbones of Cape buffalo, although, in principle, these could be carried to camp, chopped into pot-sized pieces, and rendered for fat. Evidently, the Hadza rank fully fleshed buffalo limbs for transport to camp but defleshed buffalo backbones for abandonment at kills.

The first question to consider from this review is: what would happen to the incentive to transport defleshed backbones if boiling technology were deleted from the Hadza's foraging adaptation? Given the obvious cause-effect relationship between boiling technology and the transport of defleshed axial elements for boiling among the Hadza, it is undeniable that a lack of boiling technology would greatly reduce the incentive to expend energy transporting defleshed backbones from kill to camp. Why carry defleshed backbones to a more secure or convenient location, such as a camp, if the contained fat cannot be readily used? Following that logic parsimoniously, the actual transport of defleshed axial and girdle elements, at least of medium and larger carcasses, would likely be reduced, and a relative abundance of limbs and elevated limb/axial ratio would result in bone assemblages produced by repeated carcass transport.

What O'Connell wishes to do is to take the effect (observed transport of defleshed backbones) out of the ethnographic context of the cause (boiling technology) in which it occurs. Hence, O'Connell's statements that

Figure 2. Defleshing of loin meat from backbone at animal death site. (a) Backstrap meat from one side of zebra carcass being separated cleanly from backbone for transport to base camp as an independent meat unit. (b) Defleshed backbone and pelvis unit awaiting transport from death site to camp, where it will then be chopped into pot-sized fragments and boiled to extract fat and adhering meat scraps.

interpretations of Plio-Pleistocene sites as locations to which carcass portions (abundant meaty limbs) were transported "lack empirical support" and are "at risk". O'Connell et al. (2002) consequently imagine Plio-Pleistocene sites abundant in limbs to be *in situ* death sites lacking significant transport, but that reveals a complete misunderstanding of the relationship between Plio-Pleistocene MNI values (ranging up to four dozen at FLK Zinj [Bunn and Kroll, 1986]), *in situ* carcass accumulation rates in modern analogue settings, and the restricted period of Plio-Pleistocene site formation (Bunn and Kroll, 1987). If, instead, a rudimentary attempt is made to contextualize transport dynamics appropriately for the Plio-Pleistocene boundary, then out go boiling technology and the incentive to transport defleshed backbones, and the interpretive problem regarding limb and meat transport that O'Connell wishes to construct simply collapses from a lack of any support.

A bias against backbones … and against backstraps

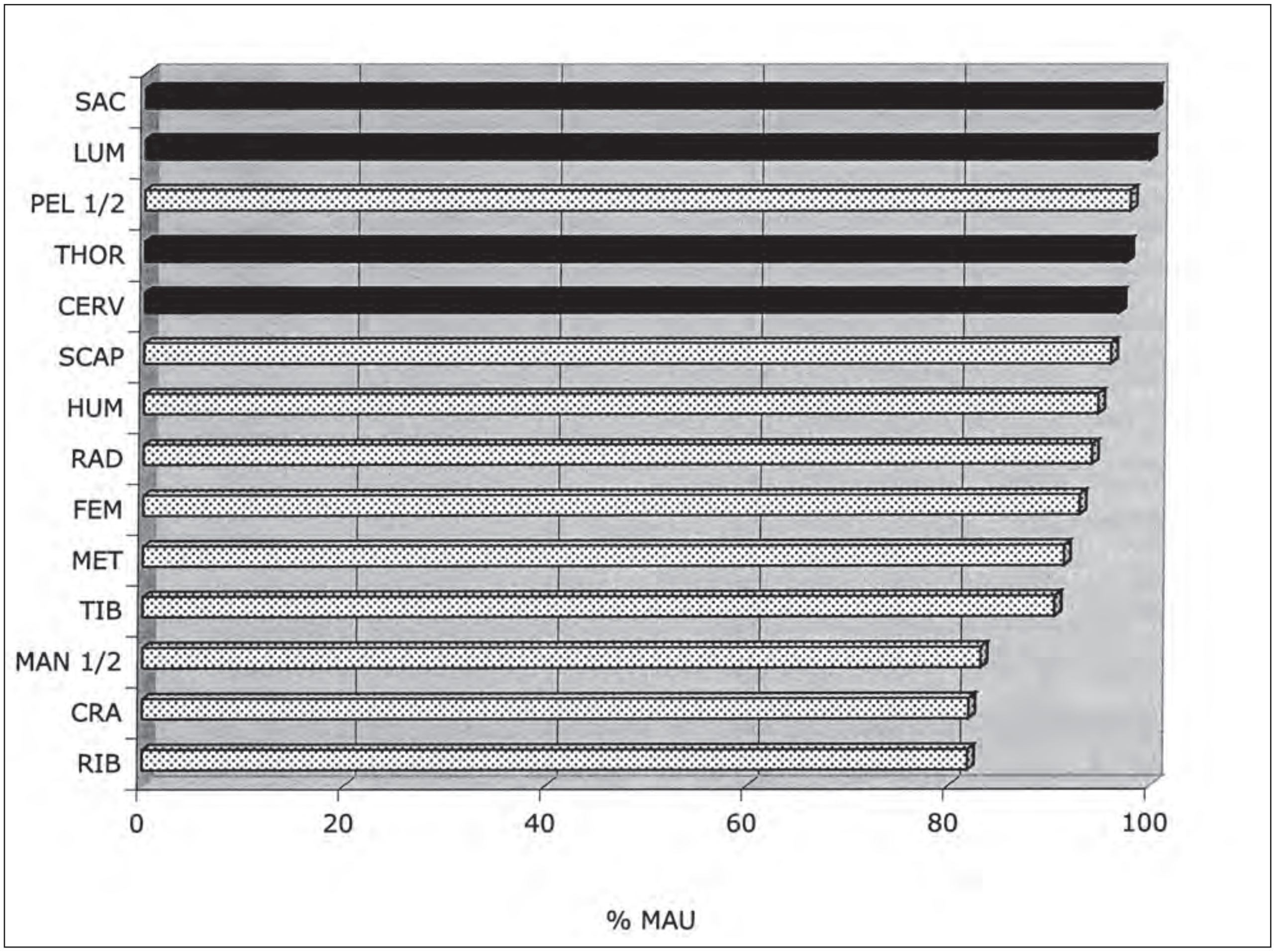
In addition to playing a pivotal role in reconstructions of site type relative to the transport dynamic, axial elements, and particularly backbones, provide the direct evidence of utilization of that meaty and fat-rich portion of carcasses. A proportional abundance of vertebrae provides evidence of access to backbones, and butchery damage on vertebrae provides evidence of how they were utilized for food.

The problem, of course, lies in the fragile structure of vertebrae relative to denser skeletal elements and in the fat content of cancellous portions. Many studies have shown that vertebrae, and other cancellous elements, are relatively vulnerable to destruction by a range of taphonomic and diagenetic processes (e.g., Klein, 1989; Marean et al., 1992; Lyman, 1994, and references therein; Lam et al., 1998). Prominent among these destructive processes are: human butchery and consumption; consumption by bone-crunching carnivores; differentially faster subaerial weathering of exposed cancellous portions; post-depositional crushing during sediment profile compaction; post-depositional chemical leaching of cancellous elements.

In short, the fossil and archaeological record has a high potential for bias against the preservation of backbones and other cancellous skeletal elements. Some researchers conclude pessimistically that these biasing effects are so pronounced and insurmountable that it may not be productive to use vertebrae (Marean and Cleghorn, 2003), or skeletal profiles in general (Klein, 1989; Klein et al., 1999), to reconstruct prehistoric human behavior from archaeological bone assemblages. If proven correct, that conclusion would mean that some of the following sorts of research questions may be unresolvable using archaeological skeletal profiles. Does a paucity of vertebrae in an assemblage mean that they were initially abundant but subsequently removed or destroyed *in situ*? Or, does a paucity of vertebrae mean an initial paucity at the site with behavioral significance? Does such a paucity necessarily become an analytical case of equifinality, or are there analytical approaches that enable a level of distinction between the alternatives? Similar questions could be posed for limb elements, which also have less dense, cancellous (epiphyses) and more dense (shafts) portions. For limbs, an optimistic resolution is well established: the use of denser limb shaft specimens to determine MNE values enables accurate reconstruction of initial limb proportions. Vertebrae in general may be less dense than limb shafts, but a similar analytical reliance on the densest vertebral portions might be productive. The most revealing experimental work on vertebral loss to hyenas has been conducted with fat-rich vertebrae of small to medium-sized domesticated bovids, yet, larger, size group 3 taxa predominate at Plio-Pleistocene archaeological sites. Larger vertebrae of size groups 3 and 4 taxa are more durable than small vertebrae, and they may have a significantly higher potential for preservation at a site. The reluctance of the Hadza to transport and boil Cape buffalo vertebrae illustrates this point; it also illustrates the obvious archaeological bias against transported and eaten backstraps, which may be archaeologically invisible from initial absence of transported backbones or from subsequent loss of them from a site.

For present purposes, my aim is simply to consider preliminarily how well vertebrae fare at Hadza sites and how butchery damage on vertebrae reflects the known intensive use of that carcass portion. Figure 3 shows the progressive loss of vertebrae as carcasses and bones are transported to base camps, processed for food and discarded, and abandoned to scavenging by hyenas. Based on a large sample of carcasses, it is evident, *contra* O'Connell et al., that essentially whole-carcass transport is the dominant Hadza pattern: axial, girdle, and limb elements are all very abundant in the transport data, (> 90 percent transported, except skulls and ribs, which are > 80 percent transported). Further processing by the Hadza, specifically chopping vertebrae, pelves, and ribs for boiling, followed by consumption of edible meat/fat and some gnawing and ingestion of fragmentary bones, decreases significantly the representation of those axial and girdle elements. Representation of vertebrae, for example, drops from the 96 to 100 percent range in the transport data, to values of 30 to 70 percent in the occupied camp sample (not vulnerable to scavenging carnivores). From an abandoned camp assemblage, which had additionally been scavenged by hyenas, the representation of vertebrae dropped further, to values in the 25-50 percent range. Notably, pelves and crania are quite abundant relative to other elements, because Hadza processing renders the denser portions of them unappealing to scavenging hyenas.

The timing of such skeletal changes helps to clarify Plio-Pleistocene site formation. Thus, at Plio-Pleistocene sites, crania, as the most likely skeletal markers of animal death sites, should have survived the effects of taphonomic biasing, if they were initially present. But at a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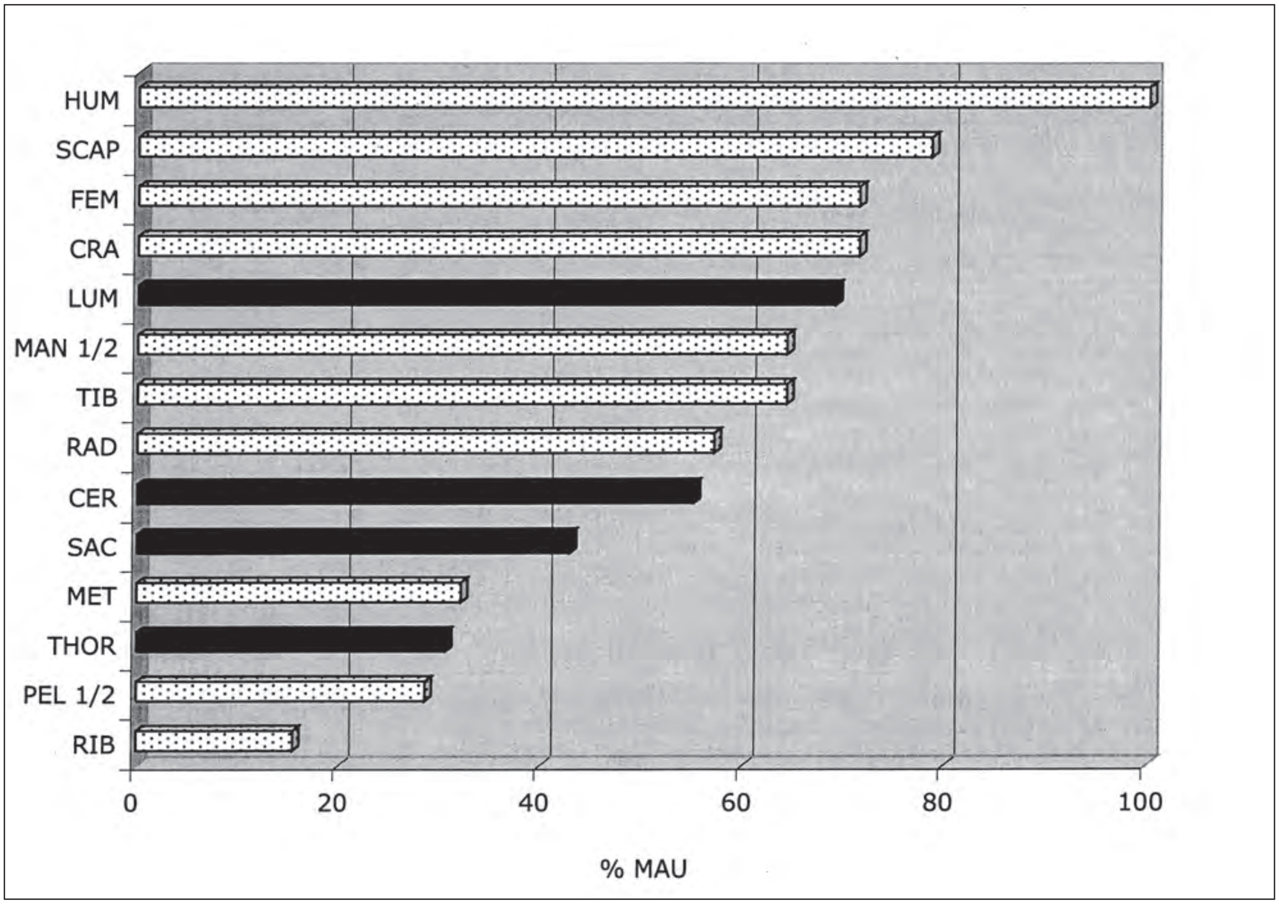
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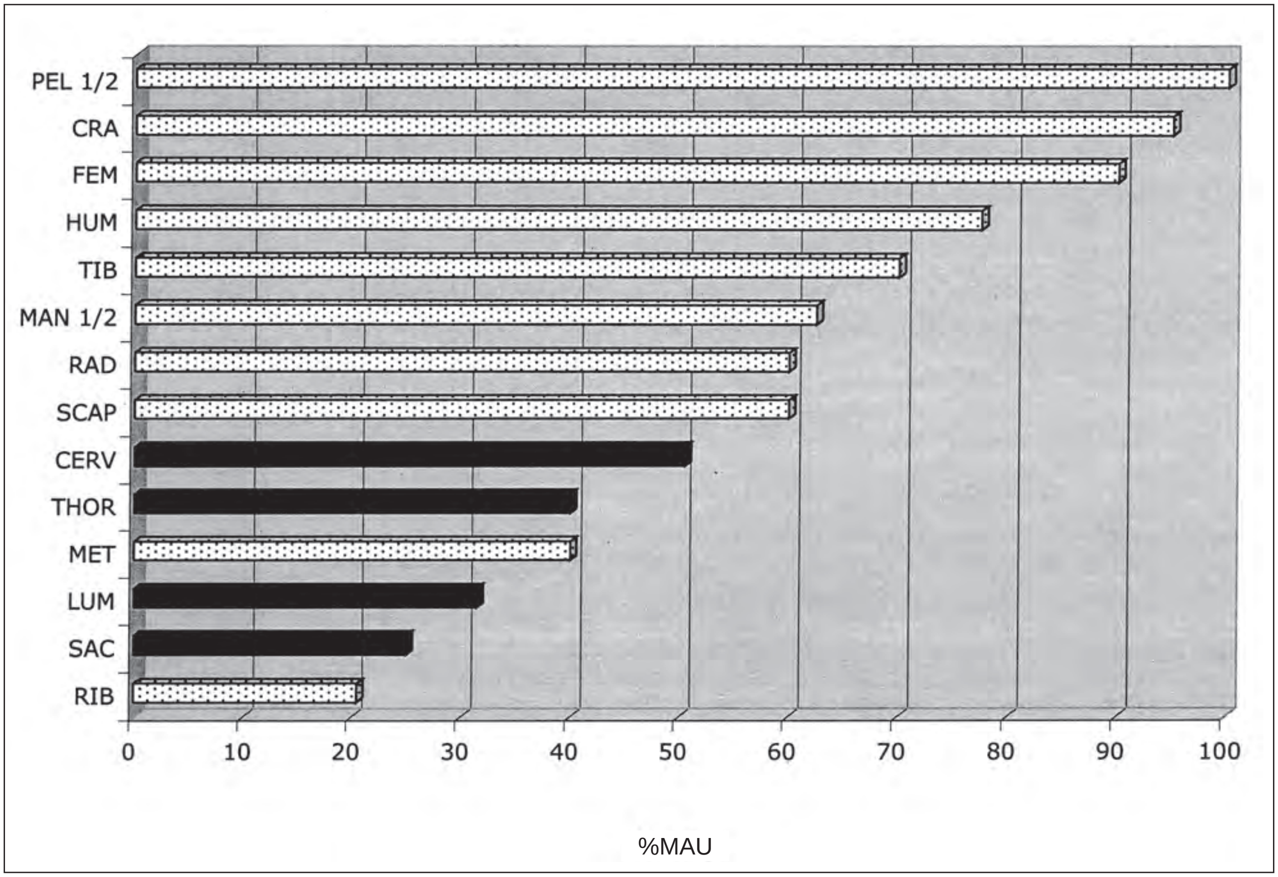

Figure 3. Skeletal profiles showing progressive loss of vertebrae (black shading) as carcasses and bones pass through several stages of utilization by Hadza foragers. Data from Bunn et al. (1988, 1991; Bunn, 1993) with all taxa combined; skeletal element abbreviations as in Figure 1. (a) Skeletal profile of carcass transport illustrates that vertebrae and all other skeletal elements are very well represented, as a result of Hadza objective to transport essentially entire carcasses to camp. If all bones survived taphonomic processes at Hadza camps, this same profile would be reflected in bone assemblages following further processing by Hadza. (b) Skeletal profile of actual bone assemblage collected from Hadza base camp immediately following further processing i.e., secondary butchery, cooking, consumption of meat and fat, by Hadza. There is a marked reduction in vertebral representation relative to the transport profile, attributable to Hadza destruction of cancellous and other less durable bone portions. Data from Bunn et al. (1991). (c) Skeletal profile of bone assemblage from Hadza base camp, collected two years after bones discarded and camp abandoned by Hadza. A further, more modest reduction in vertebral representation is evident, which is attributable in this case to gnawing and removal by hyenas and possibly other scavengers attracted to still-greasy vertebrae following boiling and discard by Hadza. Well-represented portions of crania and acetabular portions of pelves survive these taphonomic processes because they are reasonably durable and nutritionally unappealing to scavengers following Hadza processing. Data from Bunn (1993).

FLK *Zinj* and other Plio-Pleistocene assemblages, however, crania are poorly represented. Significant loss of vertebrae may readily result from differential destruction by human and carnivore processing for food and need not be attributed to post-depositional, density-mediated profile compaction or leaching in a buried context. As a pervasive geological force, profile compaction might be predicted to act uniformly across a buried site assemblage, thereby eliminating all, not just some, less dense portions. The presence of some undamaged and yet relatively fragile vertebrae at Plio-Pleistocene sites may indicate that it was more initial taphonomic processes, rather than much later diagenetic processes that shaped observed skeletal profiles in the bone assemblages.

Given the known intensive processing of vertebrae by the Hadza, what damage patterns result? From observations of Hadza butchery, cooking, and meat-eating, several types of damage to bones are predicted, including (1) defleshing cut marks oriented parallel to the backbone on neural spines and transverse processes from removal of the backstraps and tenderloins; (2) cut and chop marks from field butchery of vertebral portions and from pot-sizing of defleshed bones for boiling; (3) gnawing damage inflicted by the Hadza, and by scavenging hyenas. A sample of 100 vertebral specimens from an abandoned Hadza camp assemblage was examined to document how well these known taphonomic processes are reflected on the bones. Fifty specimens of each of the two commonest taxa used by the Hadza, zebra and impala, were examined for surface damage following standard procedures.

Several noteworthy patterns of bone damage were observed. For zebra vertebrae, the chopping of articulated portions into pot-sized pieces for boiling left deep gashes and sheared off, planar surfaces on most specimens. 80 percent of zebra vertebrae exhibited chop marks from the use of small steel axes by Hadza butchers. Cut marks from the use of steel knives to deflesh and disarticulate vertebrae were likewise abundant and occurred on 48 percent of the zebra vertebrae. Most of these were defleshing cuts oriented parallel to the backbone on neural spines, on the dorsal surfaces of transverse processes, and on the lateral surfaces of zygapophyses. A few were short, disarticulating cuts oriented transverse to the backbone on zygapophyses and near centrum epiphyses reflecting use of a knife to cut between bones rather than the overwhelming force of an ax to chop through them. 38 percent of zebra vertebrae exhibited both chop and cut marks, and 26 percent exhibited well-defined, large carnivore (hyena) tooth punctures (10 percent) or other gnawing damage. The gnawing damage illustrates that even after boiling by the Hadza, vertebrae retain sufficient grease and nutritional appeal to hyenas that some are gnawed and others probably removed from the site. For impala vertebrae, the results are similar qualitatively in the kinds of locations of damage, but the frequency of bone damage is lower (70 percent chopped; 43 percent cut; 33 percent both), and the relative completeness of individual vertebrae is higher. In other words, the Hadza are able to deflesh and boil the individually smaller impala vertebrae without inflicting as much damage to the bones as with larger zebra vertebrae. Although the frequencies of damage differ, both zebra and impala vertebrae provide strong evidence of Hadza defleshing of loins and chopping of vertebrae.

PLIO-PLEISTOCENE IMPLICATIONS

As discussed elsewhere (Bunn 2001), applying Hada butchery patterns to reconstructions of the Plio-Pleistocene has many constraints. Although the anatomical locations and clusters of defleshing cut marks on limb elements from Hadza butchery show strong similarities to the Plio-Pleistocene FLK Zinj pattern, there is a marked contrast in the pattern of butchery damage to vertebrae between the two contexts. Chop marks and cut marks are abundant on vertebrae from Hadza butchery but rare on vertebrae from FLK Zinj. Although the frequency of chop marks produced during preparation to boil bones is not relevant to the Plio-Pleistocene example, the contrast remains strong even if restricted to defleshing cut marks resulting from separation of the loins from the backbone. This is an interesting contrast, and it emphasizes the need for improving the interpretive framework for reconstructing behavior from cut-mark data. A more comprehensive analysis of Hadza bones by vertebral portion, and more experimental work on butcheries by stone tools would help.

Given the known sequence by which large carnivores consume carcasses (e.g., Blumenschine, 1987), access to meaty limbs and particularly to hindlimbs, as documented at FLK Zinj, implies the availability of loins and backbones. Were loins butchered, transported, and then eaten by hominins at FLK Zinj? That is difficult to answer conclusively, although several alternatives for formation of the FLK Zinj site should be considered. First, the very low number of vertebrae and vertebral fragments may reflect an initial rarity of vertebrae at FLK Zinj; in other words, hominins preferentially transported limbs not backbones to the location from death sites elsewhere. Recall that crania, the last element to leave death sites in analogue studies, are poorly represented at FLK Zinj. The small sample of vertebral specimens precludes finding much direct evidence of loin defleshing and consumption.

Second, the number of vertebral specimens may be a small, biased remnant that survived removal by hyenas and/or other carnivores of most vertebrae. In other words, hominins transported limbs and backbones to FLK Zinj for further processing, followed by selective removal by scavengers of most vertebrae and other greasy portions. From this discussion of Hadza transport dynamics, particularly the cause-effect relationship between boiling technology and transporting of backbones, it is difficult to view this alternative as being equal in probability to the first alternative. In the Plio-Pleistocene context without the technology for boiling, and thus lacking also the incentive for transport and the means for chopping and boiling vertebrae for fat, where is the equifinality? Why expend energy transporting backbones that could not have been utilized efficiently?

Third, no meaningful transport of carcasses or portions thereof was required, because the FLK Zinj site was a repeated carnivore kill site, providing intact carcasses on-site, which were then scavenged by hominins (Binford 1981; O'Connell et al., 2002). According to O'Connell et al. (2002), scavenging of vertebrae by hyenas then yielded an FLK Zinj bone assemblage dominated by limbs and heads. This death-site alternative is neither an objective nor a parsimonious reading of available evidence, and it, thus, lacks merit. Even Binford disavowed it many years ago (Binford, 1988; Bunn and Kroll, 1988). Factual evidence from the bone assemblage and a substantial database from modern taphonomic studies contradict the death-site model. As reported several times, heads are not abundant in the FLK Zinj assemblage. Mandibles are abundant, but crania are poorly represented. To depict FLK Zinj as a death site, it will be necessary to conjure up a taphonomic agent responsible for removal of so many crania from the death site. To accumulate the four dozen or more (MNI = 48) large mammal carcasses documented in the bone assemblage from *in situ*, natural deaths at the FLK location within a conceivable time frame of site formation, which is several years (Bunn and Kroll 1987), not decades, centuries, or millennia (O'Connell et al., 2002), it would be necessary to invoke, without supporting evidence, a Plio-Pleistocene accumulation rate *many* times higher than observed in modern analogue studies (Behrensmeyer, 1983; Bunn et al., 1991; Sept, 1994; Tappen, 1995).

By tracing some of the dynamics of carcass transport by Hadza foragers and how these insights may impact understanding of ancient hominin behavior, I hope that the present study contributes in a small way to a long tradition of taphonomic studies in African paleoanthropology that was initiated in the 1960s by the pioneering research of Bob Brain, whose ongoing research continues to the present day.

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References

Bartram, L.E. 1993. Perspectives on skeletal part profiles and utility curves from eastern Kalahari ethnoarchaeology. In: Hudson, J. (Ed.), From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains. Center for Archaeological Investigations, Southern Illinois University, Carbondale (IL), pp. 115-137.

Bartram, L.E., Kroll, E.M., Bunn, H.T. 1991. Variability in camp structure and bone food refuse patterning at Kua San camps. In: Kroll, E.M., Price, T.D. (Eds.), The Interpretation of Archaeological Spatial Patterning. Plenum Press, New York, pp. 77-148.

Behrensmeyer, A.K. 1983. Patterns of natural bone distribution on recent land surfaces: Implications for archaeological site formation. In: Clutton-Brock, J., Grigson, C. (Eds.), Animals and Archaeology, Volume 1: Hunters and Their Prey. British Archaeological Reports International Series, 163, Oxford, pp. 93-106.

Binford, L.R. 1981. Bones: Ancient Men and Modern Myths. Academic Press, New York.

Binford, L.R. 1983. Fact and fiction about the Zinjanthropus floor: Data, arguments, and interpretations. Current Anthropology 29, 123-135.

Blumenschine, R.J. 1987. Characteristics of an early hominid scavenging niche. Current Anthropology 28, 383-407.

Brain, C.K. 1981. The Hunters or the Hunted? An Introduction to African Cave Taphonomy. University of Chicago, Chicago.

Bunn, H.T. 1983. Comparative analysis of modern bone assemblages from a San hunter-gatherer camp in the Kalahari Desert, Botswana, and from a spotted hyena den near Nairobi, Kenya. In: Clutton-Brock, J., Grigson, C. (Eds.), Animals and Archaeology, Volume 1: Hunters and Their Prey. British Archaeological Reports International Series, 163, Oxford, pp. 143-148.

Bunn, H.T. 1993. Bone assemblages at base camps: A further consideration of carcass transport and bone destruction by the Hadza. In: Hudson, J. (Ed.), From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains. Center for Archaeological Investigations, Southern Illinois University, Carbondale (IL), pp. 156-168.

Bunn, H.T. 2001. Hunting, power scavenging, and butchering by Hadza foragers and by Plio-Pleistocene *Homo*. In: Stanford, C.B., Bunn, H.T. (Eds.), Meat Eating and Human Evolution. Oxford University, New York, pp. 199-218.

Bunn, H.T., Kroll, E.M. 1986. Systematic butchery by Plio/Pleistocene hominids at Olduvai Gorge, Tanzania. Current Anthropology 27, 431-452.

Bunn, H.T., Kroll, E.M. 1987. On butchery by Olduvai hominids (Reply to R.B. Potts). Current Anthropology 28, 96-98.

Bunn, H.T., Kroll, E.M. 1988. Fact and fiction about the Zinjanthropus floor: Data, arguments, and interpretations (Reply to L.R. Binford). Current Anthropology 29, 135-149.

Bunn, H.T., Bartram, L.E., Kroll, E.M. 1988. Variability in bone assemblage formation from Hadza hunting, scavenging, and carcass processing. Journal of Anthropological Archaeology 7, 412-457.

Bunn, H.T., Kroll, E.M., Bartram, L.E. 1991. Bone distribution on a modern East African landscape and its archaeological implications. In: Clark, J.D. (Ed.), Cultural Beginnings: Approaches to Understanding Early Hominid Life-ways in the African Savanna. Dr. Rudolf Habelt GMBH, Bonn.

Hudson, J. 1993. The impacts of domestic dogs on bone in forager camps; or, the dog-gone bones. In: Hudson, J. (Ed.), From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains. Center for Archaeological Investigations, Southern Illinois University, Carbondale (IL), pp. 301-323.

Klein, R.G. 1989. Why does skeletal part representation differ between smaller and larger bovids at Klasies River Mouth and other archaeological sites? Journal of Archaeological Science 16, 363-381.

Klein, R.G., Cruz-Uribe, K., Milo, R.G. 1999. Skeletal part representation in archaeofaunas: Comments on “Explaining the Klasies pattern: Kua ethnoarchaeology, the Die Kelders Middle Stone Age archaeofauna, long bone fragmentation and carnivore ravaging” by Bartram & Marean. Journal of Archaeological Science 26, 1225-1234.

Lam, Y.M., Chen, X., Marean, C.W., Frey, C.J. 1998. Bone density and long bone representation in archaeological faunas: Comparing results from CT and photon densitometry. Journal of Archaeological Science 25, 559-570.

Lartet, E., Christy, H. 1865-1875. Reliquiae Acquitanicae: Being Contributions to the Archaeology and Paleontology of Perigord and Adjoining Provinces of Southern France. Williams and Norgate, London.

Lyman, R.L. 1994. Vertebrate Taphonomy. Cambridge University, Cambridge.

Marean, C.W., Spencer, L.M., Blumenschine, R.J., Capaldo, S.D. 1992. Captive hyaena bone choice and destruction, the schlepp effect and Olduvai archaeofaunas. Journal of Archaeological Science 19, 101-121.

Marshall, F. 1994. Food sharing and body part representation in Okiek faunal assemblages. Journal of Archaeological Science 21, 65-77.

O’Connell, J.F., Hawkes, K., Blurton Jones, N. 1988. Hadza hunting, butchering, and bone transport and their archaeological implications. Journal of Anthropological Research 44, 113-161.

O’Connell, J.F., Hawkes, K., Blurton Jones, N. 1990. Reanalysis of large mammal body part transport among the Hadza. Journal of Archaeological Science 17, 301-316.

O’Connell, J.F., Hawkes, K., Lupo, K.D., Blurton Jones, N.G. 2002. Male strategies and Plio-Pleistocene archaeology. Journal of Human Evolution 43, 831-872.

Sept, J.M. 1994. Bone distribution in a semi-arid riverine habitat in eastern Zaire: Implications for the interpretation of faunal assemblages at early archaeological sites. Journal of Archaeological Science 21, 217-235.

Tappen, M. 1995. Savanna ecology and natural bone deposition. Current Anthropology 36, 223-260.

Yellen, J.E. 1977. Archaeological Approaches to the Present: Models for Reconstructing the Past. Academic Press, New York.

Yellen, J.E. 1991. Small mammals: !Kung San utilization and the production of faunal assemblages. Journal of Anthropological Archaeology 10, 1-26.