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## HADZA HUNTING, BUTCHERING, AND BONE TRANSPORT AND THEIR ARCHAEOLOGICAL IMPLICATIONS

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*A study of Hadza hunting and scavenging practices, patterns of medium/large mammal carcass dismemberment and transport from kill sites to base camps, and subsequent processing and disposal of bones reveals archaeological bone assemblage formation processes among these hunter-gatherers in northern Tanzania. Body part transport patterns are highly variable, but they probably are understandable in terms of the goal of maximizing net nutritional benefit relative to the costs of field processing and transport. The Hadza data have implications for some widely held views about patterns of bone transport among hunters, for particular reconstructions of past human or hominid behavior based on those views, for the problem of distinguishing hunting versus scavenging as contributors to assemblage composition, and for current thought about the suitability of modern hunters as a source of inference about the prehistoric past.*

SINCE THE MID-1970s, prehistorians have been increasingly concerned with explaining variation in the relative proportions of different skeletal elements found in archaeological faunal assemblages. Their underlying assumption is that such variation can provide important information about certain aspects of past human behavior, including the role of meat in the diet, the degree of reliance on food storage, and the relative importance of scavenging versus hunting. As this concern has grown, archaeologists have recognized that differences in skeletal element representation are typically the product of many factors, of which human activity is only one. This in turn has prompted research designed to identify the processes likely to affect bone assemblage composition. Examples of such research include studies of the bone-related activities of nonhuman

predators and other organisms (e.g., Brain 1981; Hill 1975; Binford 1981; Haynes 1981; Bunn 1982; Blumenschine 1986c); bone transport processes, both biological and geological (e.g., Behrensmeyer 1975; Behrensmeyer and Hill 1980; Schick 1986); and density-related bone attrition (e.g., Binford and Bertram 1977; Brain 1981; Lyman 1984; Grayson 1987). (See Gifford 1981 for a review of the paleontological literature on these and related topics.) Most of this research is "actualistic": it entails the observation of bone assemblage formation processes and their effects in the modern world. It is based on the proposition that past events are the product of processes which continue to operate. These processes can be observed and potentially understood in the present.

Given the ultimate goal of this work, it is interesting that relatively little attention has been given to the bone-accumulating activities of modern humans, particularly hunter-gatherers. Binford's (1978, 1981) comprehensive ethnoarchaeological reports on the Nunamiut are prominent exceptions. Most other projects, though important, have been smaller and far less ambitious (e.g., Gifford 1977; Yellen 1977; Brain 1981; Bunn 1982, 1983; Crader 1983; Jones 1984). Moreover, most archaeologists concerned with problems of prehistoric bone assemblage composition have ignored this literature (but see Speth 1983; Thomas and Mayer 1983; Lyman 1985; Todd 1987; Grayson 1987). Some have explicitly denied its relevance to their research (e.g., Shipman 1983; Shipman and Rose 1983), arguing that living hunters and the circumstances under which they exist have no parallel in the past, a position now often advocated among archaeologists in general (e.g., Wobst 1978; Schrire 1980, 1985). Since the archaeological record is largely unreadable in the absence of assumptions about the behavior which produced it, those who reject modern hunters as a source of inference have turned instead to the behavior of nonhuman predators or to "commonsense" arguments as a basis for their interpretations. Arguments like these are ubiquitous in the recent literature but are perhaps best developed with respect to the prehistory of Pleistocene Africa (e.g., Hill 1984; Potts 1984, 1987; Klein and Cruz-Uribe 1984, 1987; Klein and Scott 1986).

The relevance of modern human behavior to an understanding of the past is a complex issue. It is widely recognized that contemporary hunter-gatherers are not "living fossils." Obvious morphological, behavioral, and ecological differences distinguish them from our Pleistocene ancestors. Still, all humans confront the basic problems of survival and reproduction as large-bodied, bipedal, tool-using, social primates. No other living organism shares these characteristics. The fact that some modern humans exploit large-bodied mammalian prey as a basic part of their subsistence and create archaeologically observable bone assemblages as a consequence invites careful consideration of their potential utility as a source of information and inference about the past. It could well be that factors unique to the modern world, such as the influence of state societies, the presence of commercial markets, and the availability of mechanized transport, shape the way contemporary hunters treat carcasses. If so, then it might be difficult, perhaps even impossible, to use their behavior to

learn about the Pleistocene. On the other hand, the most important determinants of carcass treatment could include the nutritional benefits to the hunters and their dependents, the costs of butchering with simple blades and of transporting meat on foot from kill site to base camp, and the problems of defense against carnivorous competitors. If this is the case, then modern hunters might be a critical source of evidence about the behavior of large-bodied, bipedal, tool-using, social hunters in the past. The key questions are these: What factors shape contemporary hunter-gatherer behavior with respect to carcass treatment and the formation of archaeological bone assemblages? and Are those factors also likely to have been important prehistorically?

As a step toward answering these questions, we report here the results of recent research on bone assemblage formation processes among the Hadza of northern Tanzania.<sup>1</sup> We describe and analyze patterns of large mammal carcass acquisition, butchering, transport, consumption, and disposal and the archaeological consequences thereof. Although these features of Hadza behavior are often highly variable, they appear to be understandable in terms of costs and benefits which are likely to be quite general. In particular, we argue that the frequency with which different body parts are transported from butchering sites to base camps is determined, at least in part, by the nutritional utility of the parts in question relative to the costs of field processing and transport. These same factors should also affect, though not completely determine, the relative proportions of different skeletal elements in archaeological assemblages produced by the Hadza. We then review the implications of the Hadza data for several important issues in the recent literature on bone assemblage composition, including the validity of currently available models of hunter-gatherer bone transport, the reliability of recent reconstructions of early hominid foraging patterns, and the utility of criteria offered to distinguish hunting and scavenging archaeologically. In each case, we show that conventions now used to interpret assemblage composition are often poorly grounded and in many ways directly challenged by the Hadza data. These results contradict the idea that the behavior of modern hunter-gatherers is irrelevant to prehistory. On the contrary, they show that contemporary foragers provide an opportunity to test conventional archaeological assumptions and to develop theoretically and empirically better grounded expectations about the activities of ancient hunters.

## THE EASTERN HADZA

The Eastern Hadza are a group of 600–800 people who occupy a 2,500 km<sup>2</sup> area in the Eastern Rift Valley, south and east of Lake Eyasi, in northern Tanzania. The climate of this region is warm and dry. Annual average rainfall is in the 300–600 mm range, most of it falling in the six-month wet season (November–April) (Schultz 1971). Vegetation is primarily mixed savannah woodland; medium/large animals are locally abundant (Smith 1980).

At the beginning of this century, only the Hadza occupied this country (Baumann 1894; Obst 1912; Reche 1914). They apparently lived entirely by hunting

and gathering. Local incursions by non-Hadza pastoral and agricultural groups are recorded as early as the 1920s and have continued to the present (McDowell 1981; Woodburn 1986). Archaeological evidence suggests that farmers and pastoralists have been present for several millennia, hunter-gatherers far longer (Mehlman 1988).

During the past fifty years, various segments of the Hadza population have been subjected to a series of government- and mission-sponsored settlement schemes designed to encourage them to abandon the foraging life in favor of full-time farming (McDowell 1981; Ndagala 1986; Woodburn 1986). None of these schemes has been successful, and in every case most of the Hadza involved have returned to the bush, usually within a few months. In each instance, some Hadza have managed to avoid settlement and have continued to live as full-time hunter-gatherers.

Ethnographic data on the Eastern Hadza are available in a number of short reports dating from the late nineteenth century to the mid-1960s (references in Woodburn 1964). The first comprehensive account of Hadza life was provided by Kohl-Larson (1958), based on fieldwork in the 1930s. More recently, James Woodburn (e.g., 1964, 1968, 1972; see also Bennett et al. 1970, 1975) has presented the results of several periods of fieldwork between 1958 and 1970. Research within the last decade has been primarily concerned with ecological and ethnoarchaeological issues (Smith 1980; McDowell 1981; Vincent 1985; Bunn 1986).

During 1985–86, we spent 188 days over fourteen months living among 200–300 Hadza in the areas known locally as Tli'ika and Han!abi, collecting quantitative information on time allocation, foraging returns, and other topics. Data reported here are derived from this fieldwork (see also Blurton Jones, Hawkes, and O'Connell 1987; Hawkes, O'Connell, and Blurton Jones 1987; O'Connell, Hawkes, and Blurton Jones 1987, 1988). The Hadza we observed most closely (a variable population of 45–75 individuals in the dry season, 35–50 individuals in the wet) pursued a seasonally variable, central-based foraging strategy and were dependent on hunting and gathering for the bulk of their subsistence. They occasionally obtained agricultural products (mainly maize, millet, and tobacco) from the occupants of villages located five-to-six-hours' walk to the south and southwest, sometimes as gifts, sometimes in exchange for dried meat. Quantitative data on the amounts of meat given and domesticates received have yet to be tabulated, but both were relatively small.

### *Hadza Hunting and Scavenging*

The Hadza hunt a wide variety of animal prey (Woodburn 1964; McDowell 1981). Medium/large mammals (adult live weight >40 kg) taken include giraffe (*Giraffa camelopardalis*), buffalo (*Syncerus caffer*), zebra (*Equus burchelli*), eland (*Taurotragus oryx*), greater and lesser kudu (*Tragelaphus strepsiceros*, *T. imberbis*), wildebeest (*Connochaetes taurinus*), hartebeest (*Alcelaphus buse-laphus*), impala (*Aepyceros melampus*), and warthog (*Phacochoerus aethiopicus*), as well as lion (*Panthera leo*), leopard (*P. pardus*), and, rarely, hyena (*Crocuta*

*crocuta*). All these animals are hunted with the bow and arrow, the latter usually (but not always) poisoned (Fosbrooke 1956; Woodburn 1970). Firearms, snares, and traps are very seldom used. Elephant (*Loxodonta africana*) are not hunted, apparently because Hadza arrow poison is not strong enough to kill them (Woodburn 1968). However, the flesh of elephants dead of other causes is scavenged whenever possible (O'Connell, Hawkes, and Blurton Jones 1988).

Hadza hunting takes two forms, intercept and encounter. *Intercept hunting* is practiced only in the mid-to-late dry season, when animals are concentrated around a relatively small number of water sources. Hunters build blinds overlooking these waters and along game trails leading to them. Most intercept hunting is done at night, but hunters occasionally make use of blinds in the daytime as well. Tactics are fairly simple: the hunter sits quietly in the blind until an animal passes close by (i.e., within about 25–30 m), shoots, and, if he hits it, either waits for daylight or, if it is already light, for an hour or two until the poison takes effect; then he tracks the animal. A hunter who is confident that a large animal has been well hit often returns to camp and enlists others to help him in tracking. If he tracks alone and finds his prey, he will secure the carcass, usually by covering it with brush, and return to camp for help carrying it back. If two people are in the tracking party, one goes back for help, and the other stays with the carcass.

Since Hadza men are always armed, *encounter hunting* is effectively in progress most of the time they are away from camp. Prey may be seen on early morning or late afternoon walks, when hunters often leave camp for several hours specifically to look for it; in the course of foraging with their wives for other resources (especially honey); while acting as guards for parties of women collecting roots, berries, or baobab in areas where they are likely to meet non-Hadza; or simply when traveling between camps. In all of these cases, direct visual contact with potential prey leads to the same result. The hunter stalks to within 25–30 m, shoots, and, if he hits the animal, waits for the poison to work; he then pursues it. If the hunter misses and the animal runs, he seldom follows, probably because he is unlikely to get another good shot at the animal that day. Game is sufficiently abundant that potential prey are sighted frequently, and a hunter's chance for a successful shot may be better with another animal.

The Hadza also obtain the meat of medium/large mammals by scavenging kills made by other predators (O'Connell, Hawkes, and Blurton Jones 1988). Toward this end, they routinely monitor the flight of vultures, listen carefully to the calls of lion and hyena, and visit areas where lions have been active, especially during the dry season when Hadza and lions are likely to be near the same water sources. Having observed a possible scavenging opportunity, the Hadza move quickly to the spot and, on arrival, attempt to drive off any predators that are present and to appropriate the kill. Under some circumstances, particularly if lions are involved and the carcass has been largely consumed, the Hadza may shoot at one or more of the predators. If the predators defend the carcass, they may be killed.



Table 1 is a list of medium/large mammals taken by residents of camps in which we lived from September 1985 through October 1986. The list includes fifty-seven individuals representing eleven species, mainly impala, zebra, and medium-sized antelope. Most were taken in the late dry season (one every one-to-two days on average versus one every seven-to-eight days in the wet and early dry). Intercept hunting produced most of the carcasses acquired in the late dry season (ca. 60 percent), encounter hunting most of those taken in the wet and early dry (ca. 75 percent). Scavenging yielded 15–25 percent of carcasses taken in all seasons. No significant differences were evident in the range of species taken seasonally, although the apparent restriction of zebra, wildebeest, and warthog to the dry-season bag is interesting, especially since these animals were present throughout the year. Apart from elephant, which is only scavenged, there were no significant differences in the means by which various species in the sample were acquired.

### *Carcass Disarticulation, Transport, and Consumption*

Once taken, most medium/large mammal carcasses are divided into manageable segments and carried back to the residential base. Quantitative data on this process are available for thirty-nine butchering incidents involving animals ranging in size from impala to giraffe (see Appendix).

Most carcasses are treated in essentially the same way. First, a fire is kindled under the nearest shade, usually within 10–15 m of the kill, but sometimes up to 70–80 m distant. As the butchering proceeds, small bits of flesh will be roasted here, and marrow bones will be warmed and cracked. Branches and brush are piled alongside the carcass to form a small pallet on which pieces can be placed as they are detached or onto which the carcass can be rolled if necessary. Except as noted, butchering is accomplished entirely with double-edged, soft-steel knives, 12–15 cm in length. The carcass is completely or partly skinned. Rear limbs are separated from the pelvis as complete units by cutting to the proximal head of the femur (either from the dorsal or ventral surface of the limb) and separating it from the acetabulum. Front limbs are also removed as complete units with the scapulae attached, generally by cutting between the inside surface of the scapula and the outer surface of the ribs.

The sheet of flesh covering the outer surface of the ribs is stripped off and set aside. The skull is chopped from the top of the vertebral column with an axe. Long rolls of flesh (loin strips) are cut from both sides of the vertebral column along the top of the ribs (from the sacrum to the base of the neck or, less often, to the atlas). Where the cut is not extended along the neck, the neck meat is cut loose as a sleeve or sheet by slicing around the vertebral column. The belly sheet is removed by cutting or chopping along the distal ends of the ribs. Often these cuts are extended along both sides of the sternum, detaching it as an extension of the belly sheet. This step may involve the use of an axe. Cuts are made from immediately behind the mental symphysis down the ventral surface of the neck, freeing the tongue and esophagus as a single unit. Internal organs and intestines are also removed at this time. Intestines

TABLE 1  
Medium/Large Mammals Taken by Hadza Hunters, September 1985–October 1986

	Season											
	Late Dry, 1985				Wet, 1985–86				Early Dry, 1986			
	Int	Enc	Sca		Int	Enc	Sca		Int	Enc	Sca	
Number of days observed	47			61		36		44				
Type of hunt												
Species taken												
Elephant	—	—	—	—	—	—	1 <sup>+</sup>	—	—	—	—	—
Zebra	5	1	2	—	—	2	—	—	2	—	—	—
Warthog	1	3	—	—	—	—	—	—	—	—	1	—
Giraffe	1	—	—	—	—	1	1	—	—	—	—	—
Eland	—	—	—	1	—	—	—	—	—	—	—	—
Greater kudu	—	—	—	—	—	—	—	—	2*	—	—	—
Hartebeest	1	1	—	1	—	—	—	—	—	—	—	—
Wildebeest	2	—	2	—	—	—	—	—	1	—	—	—
Impala	8 <sup>+</sup>	1	2 <sup>+</sup>	4	—	1	1	—	5*	—	1 <sup>+</sup>	—
Lion	—	1	—	—	—	—	—	—	—	—	—	—
Hyena	—	—	—	—	—	—	—	—	—	1	—	—
Totals	18	7	6	0	6	4	2	0	10*	1	1	2

Data pertain to animals taken by hunters in the eight sequentially occupied camps in which the ethnographers resided. Seasons: Wet = Nov.–Apr.; Early Dry = May–July; Late Dry = Aug.–Oct. Types of hunt: Int = intercept; Enc = encounter; Sca = scavenge. All animals listed were mature adults, except one each in the four cells marked (+); these individuals were immature. Animals marked (\*) may not all have been taken by intercept, though two impala and both kudu probably were.



are freed of their contents and rolled in small bundles for transport. Ribs are separated into sets of three to six and detached from the vertebrae by simply snapping them loose or by chopping them off with an axe. Either way, the proximal ends of some ribs may remain attached to the vertebral column. The vertebral column itself is cut or, more often, chopped into segments, the number of which varies with the size of the animal.

Certain patterns of treatment vary consistently by species or size class. Alcelaphine antelope and impala are carefully skinned, and the hides are saved for later use in the manufacture of clothing, carrying bags, and ground coverings. Zebra, giraffe, warthog, and, in our sample at least, eland are only partly skinned in the initial butchering process, and even then only as necessary to facilitate disarticulation of body parts or removal of flesh from bones or to provide clean working surfaces on which to cut, stack, or bundle butchered meat. Sizeable patches of hide from these animals are often brought back to camp, either as separate parcels or still attached to the meat. There they are pounded with rocks, lightly roasted, and eaten, usually after all other edible tissue (meat and marrow) has been consumed. Smaller animals (e.g., impala, warthog) may be broken into fewer segments prior to transport. In particular, one or both rear limbs may be left attached to the pelvis, and the head and neck, ribs and thoracic vertebrae, or ribs, thoracic vertebrae, and neck may remain connected. Conversely, larger animals (e.g., eland, giraffe) are routinely and medium-sized animals (in our sample, zebra and impala) are occasionally disarticulated even more completely. Long bones are stripped of flesh and separated one from another. Meat is cut from scapulae in long filets or sheets. Pelves are stripped or, less often, split sagittally through the sacral vertebrae and pubis.

Meat consumption at butchering stations is generally limited to the relatively small bits adhering to bones which have been stripped of meat for transport (mainly ribs, skulls, mandibles, and long bones). These bits may be plucked or sliced off raw, or they may be lightly roasted on the bone and then scraped, cut, or bitten off. Once defleshed, marrow-bearing bones (mandibles, humeri, radiocubiti, femora, tibiae, and metapodials) are almost always cracked at mid-shaft, usually with a rock or wooden knife handle, and the contents are consumed on the spot. In no case did we see long bone shafts scraped to remove the periosteum before being cracked (cf. Binford 1981:287, 1988; Bunn 1982:43; Bunn and Kroll 1988:142). On some long bones, the cancellous tissue in articular ends may be partly gouged out with a knife and eaten. Ribs are sometimes cracked in half, and the broken ends are gnawed and sucked. If skulls are stripped of meat, that meat is always eaten on the spot, the skull and mandible are thoroughly shattered, and all edible contents are consumed. Skulls are broken with axes, rocks, or the dense articular ends of long bones. Sometimes the skull itself is grasped by the muzzle and swung against a tree or an outcrop of rock. (We have observed this only with zebra skulls.) Hooves are split with a knife, and the fatty tissue around the phalanges is dug out and eaten.

Once the animal has been disarticulated and the consumption of meat and

marrow from skeletal elements to be discarded is complete, the remaining meat and bones are packed for transport, and the party leaves for camp. Large articulated sets of bone and meat (e.g., complete heads, sections of the vertebral column, pelves, and limbs) are simply borne across the carrier's shoulder or atop his or her head. Loose pieces of meat are bundled in the long cloth cloaks routinely used by women as items of dress and as carrying bags. Alternatively, such pieces may be tied to a long pole carried by one or two porters or simply draped over a carrier's body to form a kind of "meat shirt."

On arrival at camp, carriers take meat to the household area to which it was assigned when the carcass was butchered. There, household members process the meat further, either for immediate consumption or for drying for later consumption or trade. Bones are stripped of meat as described above, cracked for marrow, and discarded. Meat intended for immediate consumption is cut into small chunks and boiled. Vertebrae with large amounts of meat still adhering are cut into shorter sections, severed laterally with an axe to expose the cancellous tissue, and boiled as well. Later they are plucked from the pot, methodically shattered with rocks, picked clean of all edible tissue, and discarded. All meat is generally eaten as soon as it is cooked, although small quantities may be set aside for absent household members or for a later meal. Meat to be dried is cut into flat sheets or long thin strips and set in the sun on rocks, the roof of the hut, or a specially constructed rack or pallet of dry branches. The drying process usually takes no more than a few hours if begun early in the day. Meat to be traded usually leaves camp the next day. Whether destined for local consumption or trade, meat seldom remains in camp more than three days.

### ANALYSIS OF MEAT, MARROW, AND BONE TRANSPORT

As we have indicated, almost all meat from hunted or scavenged carcasses is routinely transported from butchering sites to residential bases. The only exceptions involve very large animals (giraffe and eland), where the amount of meat available may be more than the largest recruitable carrying party can move or consume. Bones, however, are often stripped of edible tissue and discarded during the butchering process. The number and type of bones discarded versus the number transported to the base camps vary greatly between species. To illustrate, Figure 1 shows the average transport frequency of various skeletal elements of giraffe, zebra, and alcelaphines. For giraffe, no more than 20 percent of all elements in any given category were moved in a sample of five cases.<sup>2</sup> Elements most frequently taken were vertebrae and upper limb bones. Skulls, mandibles, and lower limb bones were never moved. Element transport frequencies were much higher for zebra and alcelaphines, averaging about 70 percent across all elements. Differences in element transport frequencies between these latter two taxa are striking. In a sample of eleven zebra carcasses, less than 40 percent of mandibles and ribs, but more than 80 percent of all vertebrae and pelves and more than 65 percent of all

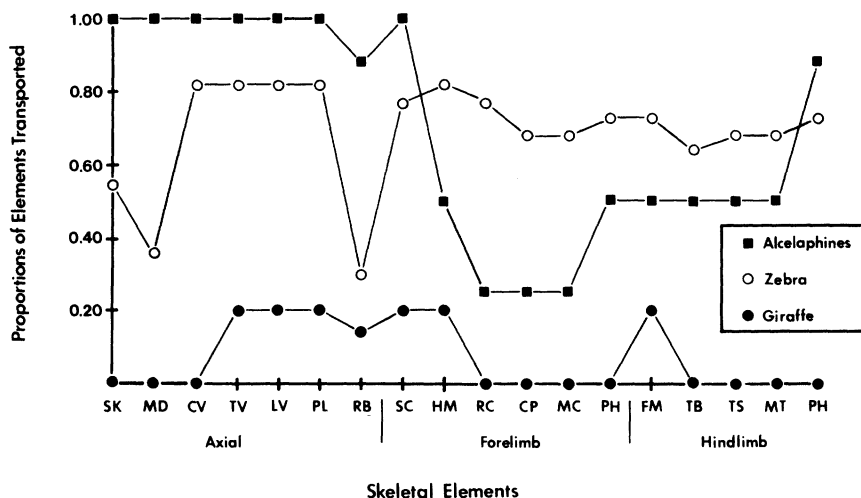


Figure 1. Proportions of Skeletal Elements Transported from Giraffe, Zebra, and Alcelaphine Antelope Kill Sites to Residential Base Camps, September 1985–October 1986

Number of giraffe=5, zebra=11, alcelaphine antelope=4. Value indicated for each element is the total number of elements of that type transported from all kills of a given taxon divided by the total number of elements of that type originally in all kills of that taxon. Thus, if a total of seven humeri are transported from eight zebra kills, leaving nine humeri in the field, the proportion transported is 7/16, or 0.44. Element abbreviations: SK=skull, MD=mandible, CV=cervical vertebrae, TV=thoracic vertebrae, LV=lumbar vertebrae, PL=pelvis, RB=ribs, SC=scapulae, HM=humeri, RC=radius/cubiti, CP=carpals, MC=metacarpals, PH=phalanges, FM=femora, TB=tibiae, TS=tarsals, MT=metatarsals.

appendicular elements, were taken to base camps. In contrast, among four alcelaphines, all axial elements except ribs, but only 25–50 percent of most appendicular elements, were taken to base. Differences in transport frequency within taxa are equally striking (e.g., Appendix, cases 14 vs. 15, 20 vs. 21).

### *Order of Selection for Transport*

In attempting to account for these and other patterns in the bone transport data, we are concerned with two dimensions of variation: the order in which elements are selected for transport across all carcasses and the number of elements selected from individual carcasses. We consider the order of selection first. The problem here is essentially the same as that confronted by a forager deciding to select some subset of resources from among an available array. Foraging models developed by evolutionary ecologists (e.g., Stephens and Krebs 1986) lead us to expect that if resources vary in terms of net benefit gained from consumption relative to associated costs, the subset selected will

often be that which maximizes net nutritional benefit. This suggests that, all else being equal, the array of parts transported from a kill should be those which maximize net nutritional benefits relative to costs associated with consumption, including transport and processing.

Binford (1978) developed precisely this line of argument in his analysis of body part transport among the Nunamiut. Like the Hadza, the Nunamiut differentially transport the body parts of large mammals (primarily caribou) from kill sites to residential base camps. To explain this pattern, Binford constructed a quantitative ranking of caribou body parts, called the general utility index, based on several measures related to nutritional value. He then showed that Nunamiut transport decisions were predictable in terms of that ranking or its various derivatives. In general, high-utility parts were more likely to be moved from kill site to base camp, low-utility parts less likely. Metcalfe and Jones (1988) have subsequently shown that Binford's body part ranking reflects a simple underlying relationship: rank varies directly, and very closely, with the weight of attached edible tissue (meat, marrow, and bone grease). They have also shown that, in the Nunamiut case, the weight of attached edible tissue predicts the relative probability of skeletal element transport. In general, bones with more meat, marrow, and grease attached are more likely to be taken from the kill, and conversely.

Satisfying as these results may be, precisely the same explanation cannot apply in the Hadza case, simply because the Hadza almost always strip some bones of meat prior to transport. In other words, unlike the Nunamiut, Hadza decisions about bone transport are at least partly independent of the amount of edible tissue originally attached to each bone. It could be, however, that the same *general* consideration—maximizing net nutritional benefit relative to costs—underlies Hadza bone transport patterns. One purpose of field butchering is to produce a set of readily transportable packages of meat and marrow. Since bones are largely inedible and since transport has a cost, we might expect the Hadza to reduce that cost by stripping bones of edible tissue (meat and marrow) and discarding them in the field. All else being equal, the probability of discard at the kill site should vary directly with bone weight, with heavier elements more like discarded and lighter elements less so. On the other hand, the cost of removing edible tissue from bone varies greatly across elements. Some elements, like long bones, can be completely stripped of flesh and cracked for marrow in a very short time, while others, like vertebrae, require much more effort. Moreover, butchering often takes place under time constraints imposed by such factors as impending darkness or the absence of water within reasonable walking distance of the carcass. This suggests that element rank or transport potential might also vary as a function of the amount of usable tissue attached and the cost in time of removing it in the field. Elements with substantial amounts of attached tissue which cannot be completely stripped in a short time might be more likely to be carried back to camp, and conversely. In principle, it should be possible to construct a unimodal scale which measures the net benefit of transporting any element which has been quickly stripped

and to compare predictions about transport probability derived from it with actual Hadza practice.

Another purpose of field butchering is to provide access to certain parts of the carcass for immediate consumption. Although meat and marrow are highly valued among the Hadza, they are not equally available to all members of any local group. Access varies depending on one's presence in situations where meat is eaten and on one's ability to extract or retain shares. Under these circumstances, we might expect some individuals, given early access to a carcass either as hunters or as members of a carrying party, to take advantage of the temporary reduction in competition (relative to levels they are likely to encounter at camp) by eating certain parts at the kill. All else being equal, we might expect such parts to be those which give high benefits from consumption relative to the costs of processing, *independent* of the costs of transport. Parts selected in any particular case should vary with the economic anatomy of the animal, its condition, and the set (or subset) of parts actually available to the potential consumer(s) in question. In general, we might expect marrow-bearing limb bones and skulls to be frequent targets of such feeding because of the high caloric value of their contents relative to processing costs (Jones and Metcalfe 1988). Kill site consumption of this kind might or might not be consistent with the alternate goal of reducing carcass transport weight as much as possible within a limited time. Different actors operating on the same carcass might also give different weight to these goals and might incur different costs and benefits relative to each depending on a variety of situational factors, including whether they arrive early or late in the butchering sequence, whether they are especially hungry, and whether they have children at camp.

We lack the data on element weights, caloric (or other nutritional) values, and processing times to construct the scales needed to test these propositions (see Blumenshine and Caro 1987 for some of the necessary information). However, we can determine whether evidence exists for an element scale in the transport data and, if so, whether the rankings indicated are likely to reflect nutritional utility relative to field-processing and transport costs. To do this, we used Guttman scaling, or scalogram analysis, a technique widely employed in the social sciences to investigate ordinally ranked phenomena (for comprehensive discussion, see Torgerson 1958; Kronenfeld 1971; Edwards 1983).

If any set of items can be ranked on a single dimension, they can be arrayed as a scale. Such a scale would underlie the transport of carcass elements *if* they could be ranked in terms of net nutritional utility *and if* rank determines the order in which parts are selected for transport. This implies that (1) if any parts are to be moved, those of highest rank will always be among those selected; (2) if some part of intermediate rank is moved, then all those of higher rank will be moved as well; and (3) if some part of intermediate rank is *not* moved, then those of lower rank will not be moved either. If such a pattern exists, one can arrange the order of cases and elements in a matrix in a way that reflects these relationships, thereby revealing the ranking of elements.



There is no theory of error in Guttman scale analysis and thus no statistical test for goodness of fit which would determine whether any data so arrayed reflect the presence of a cumulative scale. The intuitive criterion customarily used to address this question is called the coefficient of reproducibility (REP), which is calculated:  $REP = 1 - [\text{number of errors} \div (\text{number of cases} \times \text{number of variables})]$ , where the number of errors is the number of cells which lack the value necessary to produce a perfect scale. REP scores greater than .90 are generally thought to indicate the presence of a scale.

Some additional considerations are important to our use of Guttman scaling. One is a commonly observed analytic convention: variables in which a single value is represented in more than 80 percent of the cases are generally eliminated in calculating REP because their inclusion tends to produce spuriously high REP scores. We observe this convention here. Second, to simplify analysis and discussion, we scored body part transport patterns as follows: 80 percent or more of all elements in the category (e.g., vertebrae, humeri) moved = transported (T), 21–79 percent moved = partly transported (t), 20 percent or less moved = not transported (–).<sup>3</sup> Cases and variables were then rearranged in matrices in such a way as to produce the the smoothest possible gradient, (T) through (t) to (–). Errors were identified by the method outlined in Edwards (1983:184–91).

Finally, decisions about which elements to move and which to leave behind are not always made by a single operator but, rather, by several individuals acting independently, especially after the carcass has been divided. Thus, one person, making decisions about his or her own allocation only, may elect to transport several elements, including some of relatively low rank, while another individual, acting with respect to his or her own allocation only, may decide to strip, consume, and discard several elements of equal or higher rank. These factors may produce transport patterns for the entire carcass which are inconsistent with expectations based on the notion of scale-related transport decisions, even though such a scale is actually involved in each individual decision. We cannot readily adjust for this behavior but simply note its potentially complicating effect.

Figure 2 presents the results of Guttman scale analyses of bone transport data for zebra, impala, and alcelaphines recovered completely intact. (Carcasses recovered partly intact are discussed later in this section.) REP values for zebra and impala are both equal to 0.90, suggesting that skeletal elements in these taxa are indeed cumulatively scaled. These results are especially interesting in view of the small number of cases involved and the problem of multiple operators. The value for alcelaphines is 0.83, which does not support the presence of a scale by the standards normally applied in scalogram analysis. Nevertheless, inspection of the matrix suggests a scale might well be evident in a larger sample. For the sake of this discussion, we assume that a scale *may* be indicated.

Comparison of the scales across taxa (Figure 3) reveals some interesting similarities and differences. For zebra, the data suggest a five-step scale, with



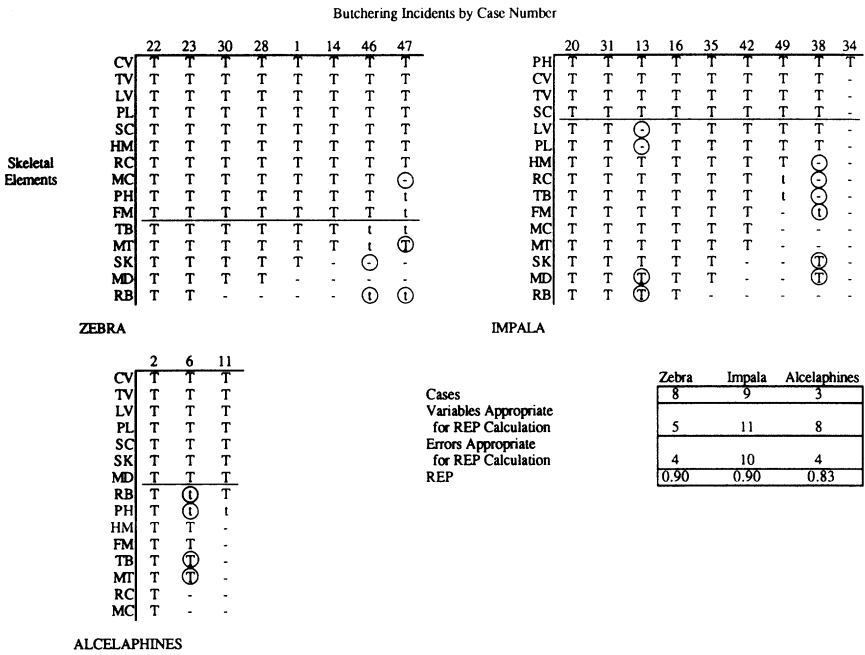


Figure 2. Scalogram Analysis of Skeletal Element Transport for Zebra, Impala, and Alcelaphine Antelope

Carcasses not completely intact when encountered are excluded from analysis. Abbreviations as in Figure 1. Carpals and tarsals are not considered in this analysis because they are generally treated as part of the associated metapodials. (T)= 80 percent or more of elements in category transported; (t)= 21–79 percent transported; (–)= less than 20 percent transported. Circled cells are errors. Variables and errors below horizontal line in each matrix are appropriate for REP calculation. (See text for additional discussion.)

vertebrae, pelvis, and upper forelimb elements ranked highest for transport, followed in descending order by other limb elements, skull, mandible, and ribs. For impala, the pattern is broadly similar, except that phalanges are consistently high-ranked, probably because they are removed and transported with the hide rather than because of their relative food value. Also, scapulae are ranked more closely with vertebrae and pelvis than with other elements of the forelimb. For alcelaphines, the sensitivity of scale discriminations is probably limited by the small sample of carcasses. Note, however, that while vertebrae, pelvis, and scapulae are again relatively high-ranked for transport, skulls, mandibles, and ribs may also fall in this range, whereas most limb elements move to the bottom of the scale.

Data on giraffe, eland, and warthog are too limited to permit scalogram analysis, but comparison of transport patterns is still possible. For giraffe (see

Zebra	Impala	Alcelaphine
Cervical Vertebrae	Phalanges	Cervical Vertebrae
Thoracic Vertebrae	Cervical Vertebrae	Thoracic Vertebrae
Lumbar Vertebrae	Thoracic Vertebrae	Lumbar Vertebrae
Pelvis	Scapula	Pelvis
Scapula	Lumbar Vertebrae	Scapula
Humerus	Pelvis	Skull
Radiocubitus	Humerus	Mandible
Femur	Radiocubitus	Ribs
Tibia	Tibia	Phalanges
Metapodials	Femur	Humerus
Phalanges	Metapodials	Femur
Skull	Skull	Tibia
Mandible	Mandible	Radiocubitus
Ribs	Ribs	Metapodials

Figure 3. Comparison of Scalogram Analysis Results for Zebra, Impala, and Alcelaphines

Elements are ranked in terms of probability of transport for each prey taxon as indicated by scalogram analysis; highest ranked are at top of each column. Elements grouped together and separated by horizontal lines (e.g., all vertebrae, pelvis, and upper forelimb elements under zebra) appear to have similar transport potential.

Appendix, cases 25, 39, 41, 43, 44), the only elements moved are thoracic and lumbar vertebrae, pelvis, scapulae, humerus, femur, and ribs, all in at least partly defleshed condition. The lone eland in the sample (case 37) displays a similar, but not identical, pattern. Elements moved include thoracic and lumbar vertebrae, pelvis, humeri, one radiocubitus, and a few ribs. The warthog data present an interesting contrast: in one case (18), the few elements left at the kill included the cervical and thoracic vertebrae, which are among the *least* frequently abandoned across all other taxa.

Two general observations emerge from this discussion. First, although Guttman scale analysis is not a particularly robust technique, our results indicate that skeletal elements can be ranked on a cumulative, unidimensional scale in terms of their probability of transport from butchering stations to residential base camps. Second, while the rank order of elements apparently varies across species, thoracic and lumbar vertebrae, pelvis, and scapulae are almost always high-ranked for transport. Limb elements, skulls, mandibles, and ribs are generally of intermediate or low rank for transport, depending on the species. A larger sample of butchering and transport cases might well refine and further discriminate element rankings, especially for alcelaphines. Data on other taxa might produce different rankings.

We suggested above that transport probability might vary as a function of nutritional utility relative to field-processing and transport costs. If we are correct, bones which are easily stripped of meat and marrow should often be processed and left in the field, and conversely. Bones taken back to camp should have large amounts of edible tissue still attached. The results of our

scalogram analysis are at least partly consistent with these expectations. Vertebrae and upper limb bones in all species in the sample are associated with large amounts of edible tissue (Blumenschine and Caro 1987), but because of their complex shape, vertebrae are more difficult to strip. The standard Hadza practice of removing the loin strips from vertebrae takes about as much time as stripping a limb, but it leaves a large amount of meat still attached. If the goal of field processing is to reduce carcass weight for transport, while taking as much edible tissue as possible back to base, all within a limited period of time, then one might well expect vertebrae to be carried home more often than limb bones.

Other elements are more problematic. Scapulae and pelves are transported more often than limb bones, yet their surfaces are relatively smooth, which suggests similar processing costs. However, our impression is that field stripping leaves more tissue on scapulae and pelves than on limbs; if this is so, more frequent transport would be anticipated. Quantitative data are needed to test our impressions. Also problematic is the apparent contrast in the relative frequencies of skulls, mandibles, ribs, and limb bones transported from zebra and alcelaphine antelope kills. Zebra skulls, mandibles, and ribs are left in the field more often than limbs, while for alcelaphines the pattern is just the reverse. If our data accurately reflect transport probabilities and if our hypothesis about their determinants is correct, then the costs of processing alcelaphine limbs must be less than those of heads and ribs relative to transport costs, and conversely for zebra. Again, quantitative data are needed to resolve this problem.

We also suggested that transport probability might vary as a function of food value versus processing costs, *independent* of the costs of transport. If we are correct, then marrow-bearing skulls and long bones, especially distal long bones, might often be processed for immediate consumption and discarded at the kill, while other elements are taken back to camp. Hadza transport patterns appear to be at least partly consistent with this proposition. Processing for immediate consumption might also explain the differential treatment of limbs versus scapulae and pelves. The costs of stripping these elements might be similar, but the returns could be quite different. Long bones contain marrow; scapulae and pelves do not. This hypothesis could also account for variation in the treatment of zebra and alcelaphine skulls and limbs. Zebra skulls may provide a greater nutritional return for effort than limbs, while for alcelaphines it might be the reverse. Yet again, the need for quantitative data on nutritional benefits and processing costs is clear.

### *Number of Bones Transported*

The second major question about bone transport concerns the number of bones per carcass moved from butchering site to residential base. As we have indicated, the range of variation here is very high. All bones from some carcasses were transported to base camps, but none were from others. In the majority of cases, only a subset was moved. If, as we suggested above, one

goal of field processing is to increase the net benefit of transport, we might expect this variation to be the product of three factors: carcass size, size of the carrying party, and distance from butchering site to residential base. All else being equal, the larger the carcass, the smaller the carrying party, and/or the greater the distance, the more bones should be left in the field, and conversely. In our sample, these variables are not completely independent. Size of carrying party and distance from butchering site to base are both at least partly related to carcass size. The first of these relationships was not unanticipated. Hunters routinely enlist help in moving a large carcass, and the number of people who respond varies in part with the amount of meat available, either to be consumed on the spot or transported and, in the process, claimed as a share. Figure 4 shows the relationship between average carcass weight and average number of adults per carrying party. The ratio is roughly constant at about 10–20 kg per carrier across the lower half of the carcass weight range, but it increases sharply across the upper half. For giraffe, which are more than double the weight of the next largest prey species, the ratio is about 45 kg per carrier, a much larger load than individual Hadza normally carry away from a kill. This high ratio reflects the upper limit on the number of adult carriers that can normally be recruited from Hadza camps, especially in the wet season when four of the five giraffe in the sample were taken. Also, it almost certainly explains why meat as well as bone was abandoned at several giraffe and eland kills.<sup>4</sup>

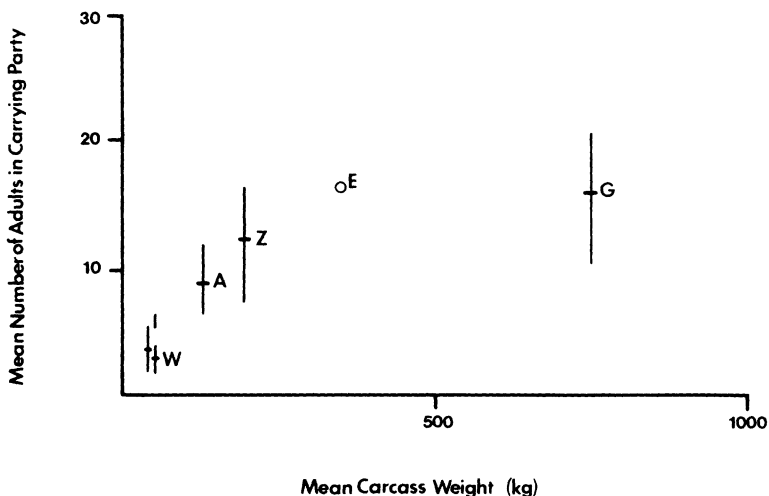


Figure 4. Relationship between Mean Carcass Weight (kg) of Prey and Mean Number of Adults in Carrying Party

Vertical bars indicate mean and standard deviation in carrying party size associated with various taxa. Abbreviations: I = impala, W = warthog, A = acelaphine antelope, Z = zebra, E = eland, G = giraffe. Weight estimates for prey are from Coe, Cummings, and Philipson (1976).

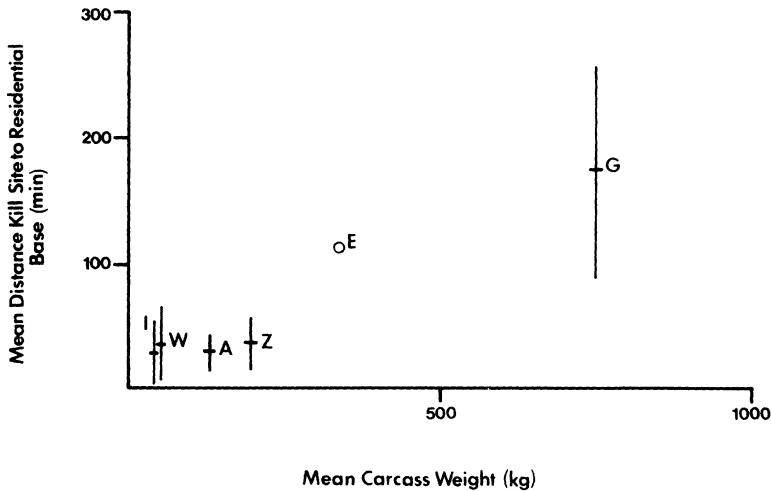


Figure 5. Relationship between Mean Carcass Weight (kg) of Prey and Mean Distance (in minutes) from Butchering Site to Residential Base

Vertical bars indicate mean and standard deviation in butchering site–base camp distances for each taxon. Abbreviations as in Figure 4.

The relationship between carcass size and distance from kill site to camp was unexpected (Figure 5).<sup>5</sup> There is in fact no correlation between carcass size and distance among the smaller species (impala through zebra), all of which were taken at an average twenty-to-forty-five minutes' walk from base. However, the larger species, eland and giraffe, were taken at much greater distances, roughly two-and-a-half hours away on average. This pattern could imply that larger animals were encountered at greater distances from Hadza camps, although our observations on encounter rates, when tabulated, will probably not support this. A more plausible (but presently untested) explanation is that larger animals shot at relatively great distances are more likely to be pursued and that larger animals wherever shot are likely to be pursued further, simply because the potential returns from doing so are much greater. Larger animals may also travel further before they succumb to the arrow poison.

Figure 6 shows the relationship between the distance from kill site to base camp and the size of carrying party. Apart from the fact that a few very distant kills are associated with large party sizes, which is certainly a function of prey size, these variables are uncorrelated.

From the preceding, we can expect the relative proportion of elements transported to vary inversely with prey size only at the higher end of the prey size range, since party size scales to prey size across the lower end of the range. The proportion of elements transported should also vary with distance only at the upper end of the distance range, since larger animals are killed at greater distances. Both these expectations are met. Figure 7 shows the relationship between carcass weight and percentage of elements transported; Figure 8 shows the relationship between kill site–base camp distance and proportion

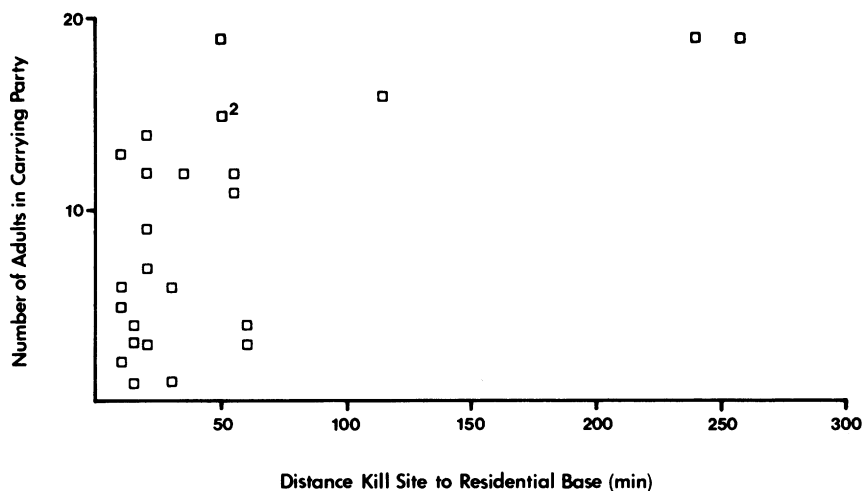


Figure 6. Relationship between Distance (in minutes) from Butchering Site to Residential Base and Number of Adults in Carrying Party

Number of cases = 25.

of elements transported. In both cases, large animals killed at relatively great distances account for most, though not all, of the low values for element transport. This leaves a surprising amount of variance in bone transport frequency among animals with average adult weights in the 40–200 kg range, killed within an hour's walk of camp.

Some of this variance might reflect minor differences in party size relative

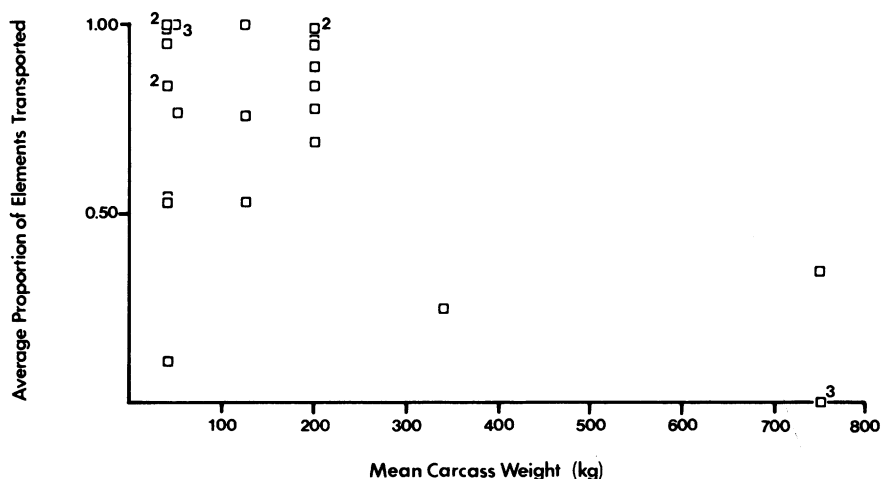


Figure 7. Relationship between Mean Carcass Weight (kg) of Prey and Average Proportion of Skeletal Elements Transported

Number of cases = 29.



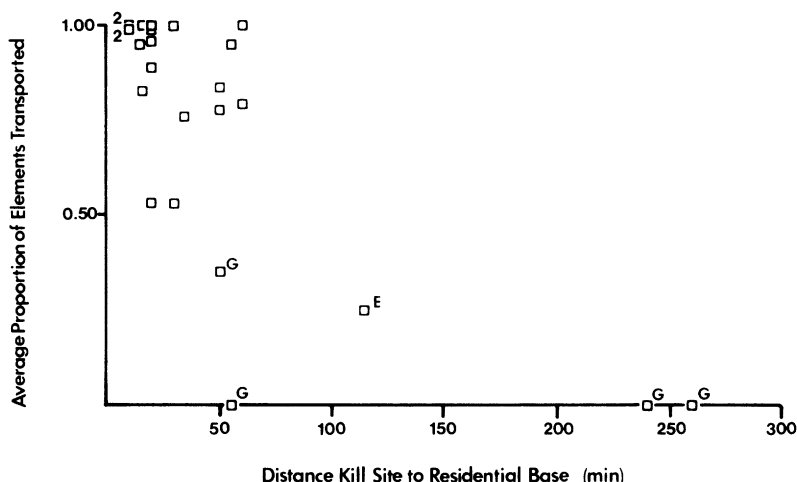


Figure 8. Relationship between Distance (in minutes) from Butchering Site to Residential Base and Average Proportion of Skeletal Elements Transported

G = giraffe, E = eland. Number of cases = 25.

to carcass weight. We investigated this possibility by examining the relationship between estimated average carcass weight per adult carrier and the percentage of skeletal elements transported for animals in the 40–200 kg range (Figure 9). No correlation is apparent. Alternatively, some of this variance might reflect the combined effects of variation in carcass weight relative to party size and distance. We assessed this possibility by looking at the relationship between combined transport costs, measured as the average carcass weight per carrier times the distance from kill to camp, and proportion of elements transported for animals the size of zebra and smaller (Figure 10). Again, no correlation is apparent.

One further possibility is also worth mentioning. The relative proportion of bones transported from carcass to base may vary in a curvilinear manner, rather than in a linear manner as suggested above. Although larger parties have the capacity to move more elements, they can also consume more marginal bits of meat and more marrow than smaller parties. Every pair of carrier's legs has a stomach attached. As party size increases, so does its appetite. Larger parties might mean that more bones are likely to be stripped of meat and smashed for their contents in the field. If so, then bone transport should increase with party size, but only up to the point that carrying party appetite plus bone transport capability equal the total number of elements in the carcass. Further increases in party size would then cause the average number of elements transported to decline. A critical implication of this argument is that in no case should all bone be transported, simply because consumption should always lead to bone discard, even at relatively small party sizes. As the capacity

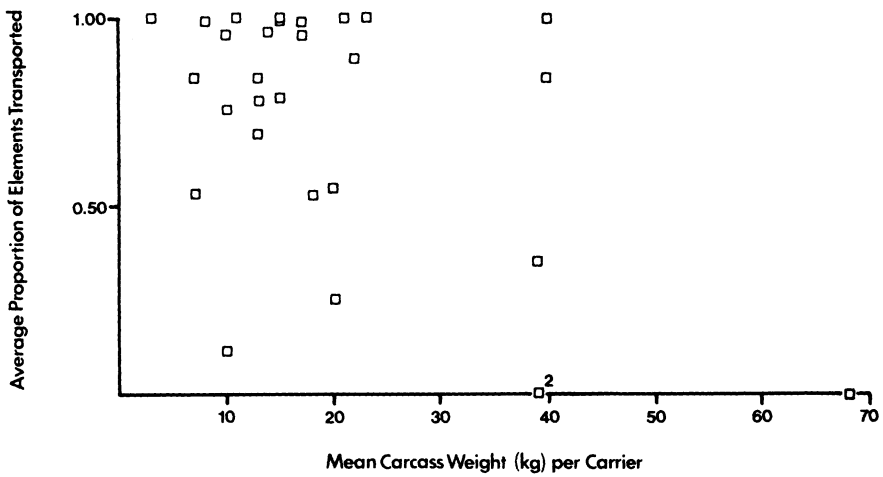


Figure 9. Relationship between Mean Carcass Weight (kg) of Prey per Adult Carrier and Average Proportion of Skeletal Elements Transported

Number of cases = 29.

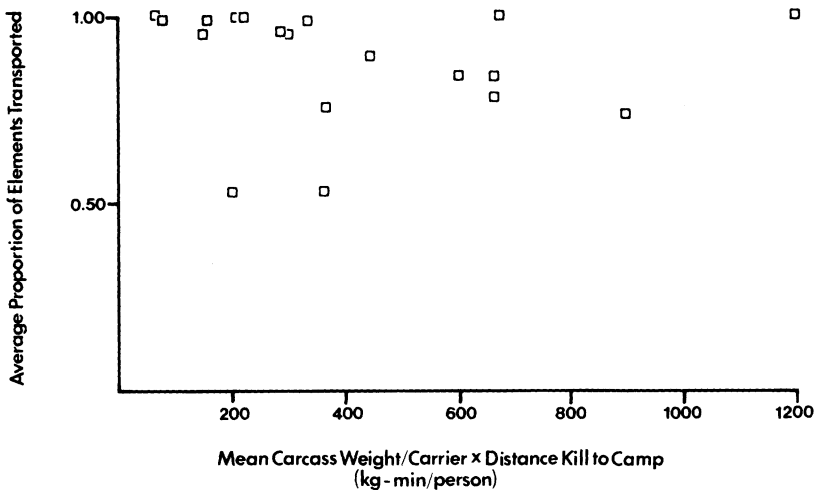


Figure 10. Relationship between Combined Transport Costs and Average Proportion of Skeletal Elements Transported

Combined transport costs are measured as the mean weight (kg) of prey per adult carrier  $\times$  distance (in minutes) from butchering site to residential base. Data are included for zebra, alcelaphine antelope, impala, and warthog only. Number of cases = 20.

to transport bone increases, the percentage available to be transported should decrease. Intriguing as this argument may be, the data fail to match its predictions. Our sample contains many cases in which all or nearly all bone was transported to base.

We are left with quite substantial unexplained variance in the relative amount of bone transported per carcass, particularly in the 40–200 kg body size range. Some of this variance could be the product of differences between the *average* weights for various taxa used in this analysis and the *actual* weights of the carcasses considered. Decisions to transport, rather than to butcher and dispose of bone in the field, may also reflect other circumstances surrounding each butchering incident, in addition to those already mentioned, such as the time of day (carcasses encountered later being less likely to be the object of feeding in the field, and perhaps conversely) or the appetites of those who encounter the kill or comprise the carrying party. The possible effects of these factors have yet to be examined.

### *Hunted versus Scavenged Carcasses*

The preceding analysis has considered only those carcasses which the Hadza acquired completely intact. Our sample also includes ten carcasses which were obtained after they had been partly consumed by other predators or scavengers. Their condition on encounter is described in Table 2. Eight were kills made by nonhuman predators; two were kills made by Hadza but attacked by scavengers before the Hadza could locate them. Five were more than 75 percent intact at the time they were taken, with tissue loss mainly confined to the intestines and upper hindquarters; the other five had been heavily ravaged.

Carcass condition clearly affects the pattern of skeletal element transport. Figure 11 compares the proportions of elements transported from zebra, warthog, alcelaphine antelope, and impala kills recovered completely intact, moderately damaged (>75 percent intact), and heavily ravaged (<50 percent intact). Carcasses taken completely intact display the pattern described in the preceding analysis, with high percentages of most axial and upper limb elements plus phalanges, but fewer skulls and ribs, transported. The average proportion of all elements moved is high:  $84 \pm 29$  percent. Moderately damaged carcasses show about half of all available axial elements and phalanges moved, but far fewer long bones. The average proportion of elements transported is  $34 \pm 29$  percent, significantly less than the average for intact carcasses (difference of means test,  $p < 0.005$ ). Heavily ravaged carcasses display a third pattern, with many forelimb elements, but fewer hindlimb and axial elements (especially lumbar vertebrae, pelves, and ribs), transported. The average percentage of all elements taken away is  $54 \pm 41$  percent, probably different from the averages for intact and moderately damaged carcasses ( $p < 0.05$  and  $< 0.025$ , respectively).

Any attempt at explaining these differences must be speculative, especially in view of the small sample sizes involved and because carcass condition on

**TABLE 2**  
**Notes on Condition and Treatment of Carcasses Recovered Partly Intact, September 1985–October 1986**

Carcasses Encountered in Moderately Damaged Condition (>75% Intact)	Carcasses Encountered in Heavily Ravaged Condition (<50% Intact)
<p>+ 26 Sept. 85/case 12: Adult man and teenaged boy encountered 2 adult female lions feeding on adult wildebeest killed previous night at small swamp, 20 min. from residential base; shot arrows to drive lions from kill. Carcass recovered with viscera completely, upper hindquarter partly, consumed. Field processing: all appendicular elements except scapulae and phalanges stripped of flesh, cracked for marrow, and discarded at butchering site. All other elements plus meat transported to base.</p> <p>+ 11 Oct. 85/case 15: Adult man found adult zebra killed previous night by 2 lions in dry watercourse, 30 min. from residential base. Lions apparently fled at his approach. Carcass recovered with viscera completely, upper hindquarter partly, consumed. No damage to other parts. Field processing: all skeletal elements stripped of flesh; mandible, long bones (except 1 humerus, 1 femur), and metapodials cracked for marrow; skull shattered for braincase and sinus cavity contents; vertebrae stripped, boiled, shattered, and picked clean. All but 2 bones (humerus and femur) discarded at kill site; meat transported to base.</p> <p>* 13 Oct. 85/case 17: Party of 5 adult women and 1 man foraging for baobab encountered adult female impala freshly killed by leopard, 1.3 hr. from residential base. Leopard fled at their</p>	<p>20 Oct. 85/case 21: Hunter encountered, shot impala; later tracked it, found carcass largely consumed by hyena. Head only recovered intact; stripped of meat, smashed for contents; completely consumed by hunter, wife, and son in field.</p> <p>20 Apr. 86/case 40: 2 young men, 1 boy found impala apparently killed by leopard, later scavenged by hyena, then vultures, 1–2 hr. from residential base. Pelvis, rear limbs, lumbar vertebrae missing; head, front limbs (including scapulae), some vertebrae (cervical and thoracic), and ribs recovered. No data on field processing or consumption. All elements indicated as present transported to base.</p> <p>28 May 86/case 44: Distant hyena calls attracted attention. 2 adult men, 2 women, 4 adolescent boys, 1 girl left at first light to investigate; walked 3 hr., guided last hour by sight of vultures circling. Encountered 3 adult lions resting on partly consumed adult giraffe, with about 20 hyenas waiting at a distance. Hyenas left as Hadza arrived; lions driven from kill with arrows. Carcass recovered with viscera completely consumed; most meat gone from hindquarter, ribs, and forequarter on upper side of carcass. Lower side intact. Field processing: all bones (except cervical vertebrae) stripped of meat, cracked for marrow, and discarded at kill. All meat transported to base.</p>

*Continued on next page*

Table 2.—Continued

approach. Carcass recovered with viscera and upper hindquarter partly consumed. Field processing: carcass divided into several pieces, carried some distance, then a small fire kindled; long bones and metapodials stripped of flesh, cracked for marrow, and discarded. All axial elements, scapulae, phalanges (attached to hide), plus meat transported to base.	+ 22 Sept. 86/case 52: Hyena calls attracted attention; adult man left camp to investigate; found warthog carcass within 20 min. Animal killed previous night by lion; later scavenged by hyenas which fled at man's approach. Carcass recovered with viscera completely consumed, most meat gone from limbs and axial skeleton, head near fully fleshed, and limb bones intact. Little or no field consumption; all skeletal elements returned to base.
18 Oct. 85/case 19: Adult man and wife encountered 3 adult lions feeding on adult zebra killed previous night in small dry watercourse, about 1 hr. from residential base. Man shot arrow to drive lions off kill. Carcass recovered with viscera completely, upper hindquarter partly, consumed. Field processing: most limb elements, mandible, some ribs stripped of flesh; long bones, metapodials, and mandible cracked for marrow; all these elements discarded in field. All axial elements (except mandible and stripped ribs), parts of one upper limb, and all meat transported to base.	24 Oct. 86/case 59: 2 young adult men returned to residential base with 4 complete, but defleshed, articulated limbs from immature impala scavenged by hyenas. Carcass probably encountered less than 1 hr. from camp. No data on carcass condition on encounter, but probably was heavily ravaged. Head may have been intact, consumed in field by Hadza.
10 July 86/case 45: Adult man located carcass of adult zebra he shot 2 days earlier, about 1 hr. from residential base. Carcass partly consumed by single hyena, but no details available on condition. Field processing: hunter stripped off as much meat as he could carry, returned to camp late in day. Parts removed (including loin strips and part of belly sheet) suggest carcass was largely intact on encounter. Hunter reckoned carcass would be gone by following day.	

(\*) indicates cases in which ethnographers observed acquisition and subsequent field processing and transport.  
(+) indicates cases in which ethnographers saw only field processing or its immediate results.  
All other cases are known only from informant reports.

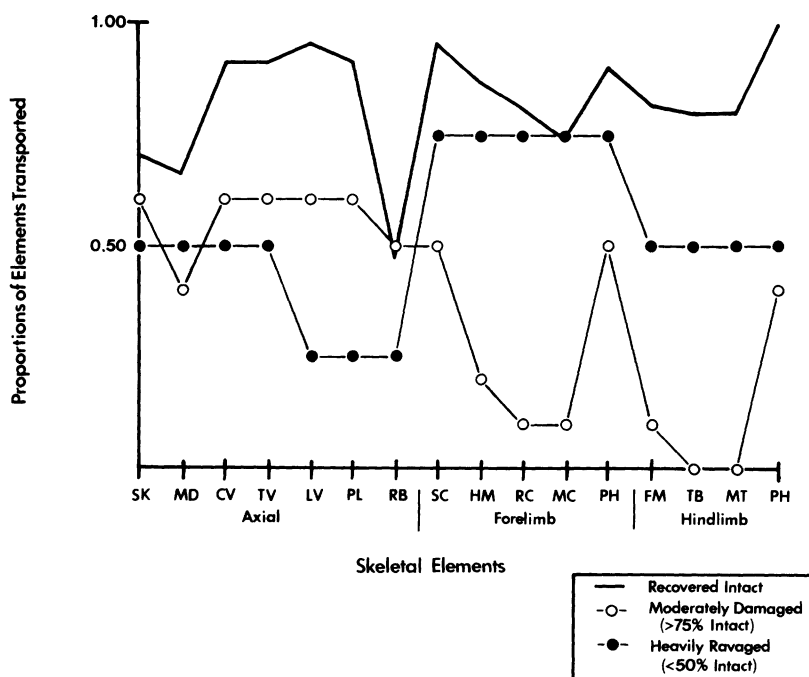


Figure 11. Relationship between Carcass Condition on Encounter and Proportion of Skeletal Elements Transported from Kill Site to Residential Base

Data are included for alcelaphine antelope, impala, warthog, and zebra only. Number of intact cases = 24, moderately damaged = 5, heavily ravaged = 4.

encounter and subsequent processing were not always observed directly (see Table 2). We can begin by suggesting that partial consumption by carnivores is likely to change the net benefits available from various elements through Hadza field processing, either for transport or immediate consumption. Specifically, elements from which significant amounts of tissue have already been removed might more likely be completely stripped and discarded in the field than intact elements would be. This may account for the relatively high rates of bone discard from rear limbs on some moderately damaged carcasses. However, it probably cannot explain all such discard (e.g., case 17, wherein one hindlimb was still intact on encounter, but both were abandoned), nor can it account for the abandonment of forelimb elements in cases where the limbs were undamaged on encounter (e.g., cases 12, 15, and 19). Field consumption of elements as a means of avoiding competition at camp may also have been a consideration. With regard to the more heavily ravaged carcasses, we would expect that elements removed were those which yielded the greatest net benefit from transport, given the array of elements available. Forelimbs may have been favored because other, higher-ranked elements had already been consumed. Better data on the availability and condition of elements encountered



at partially consumed carcasses, as well as on potential net benefits from transport and immediate consumption, are required to resolve this problem.

### *Summary of Hadza Transport Patterns*

Four important points emerge from our analysis of Hadza carcass transport patterns:

1. Scalogram analysis suggests that medium/large mammal bone transport and discard patterns reflect the ranking of body parts on a unidimensional scale.
2. The positions of parts on the scale may vary between species; but certain elements, notably vertebrae, scapulae, pelves, and upper limb bones, are more likely to be transported from kill sites to base camps than others. This pattern may reflect behavior directed at the goal of reducing transport costs as much as possible within a limited period of time by stripping some elements of meat and marrow and discarding them in the field. It may also reflect an attempt to avoid competition for nutritionally high-ranked elements by consuming their contents at the kill. Additional data on element weights, nutritional values, and processing times are needed to test these propositions.
3. The number of parts moved from kill site to base camp varies with carcass size and distance relative to the number of carriers. This is consistent with the suggestion that field processing and associated skeletal element discard are directed at increasing the net benefit of carcass transport by reducing transport costs. However, a substantial amount of variance remains unexplained by this consideration.
4. The kind and number of parts removed also varies with carcass condition on encounter. In general, fewer bones are transported from both moderately and heavily damaged carcasses than from those recovered intact. Those most commonly taken from moderately damaged carcasses include axial elements of all types, scapulae, and phalanges. Other limb elements are more often left in the field. In contrast, limb elements (especially forelimb elements) are the parts most often moved from heavily damaged carcasses, followed by skulls, mandibles, and upper vertebral elements. Ribs, pelves, and lower vertebral elements are occasionally unavailable for transport, apparently having been consumed by hyenas or other scavengers. We suspect that the same factors affecting skeletal element transport from carcasses recovered intact also influence the movement of body parts in these cases, but the condition of parts on encounter significantly affects relative transport and processing costs and benefits.

## ARCHAEOLOGICAL CONSEQUENCES

We are now in a position to make a series of observations about the archaeological record produced by Hadza butchering and bone transport practices. The Hadza create three kinds of sites in which bones are deposited: residential

base camps, ambush sites, and butchering sites. These are distinguished by features of location, pattern of occupation or use, and composition of associated bone assemblages. *Residential base camps* are places where people carry out most of their regular domestic activities, including eating, sleeping, preparing food, and maintaining weapons and other gear. They are always located within walking distance (usually within fifteen minutes, but not less than ten; sometimes up to sixty minutes) of a seasonally reliable source of water. Base camps are often situated on locally high ground and are commonly associated with rocky outcrops, which the Hadza favor (they say) because they provide refuge from elephants. Regardless of any potential advantages in terms of shade, softness of substrate, or access to water, we know of no case in which the Hadza camped in sandy stream channels, although they had many opportunities to do so during the study period. We suspect that the presence of predators in and along these channels, especially at night, inhibits or precludes such a practice. Mosquitos may also be a consideration.

Base camps are used repeatedly over long periods of time. The Hadza with whom we lived occupied eight camps over 188 days of observation. All had signs of previous occupation, such as collapsed or standing huts, hearths, or refuse middens resulting from occupations during the preceding three-to-five years. These features were generally located within 100 m of the spot on which the Hadza were camped. In at least two cases, they camped directly atop features deposited during the previous year's occupation. In a third instance, they reoccupied huts built and abandoned the month before. (See O'Connell, Hawkes, and Blurton Jones 1987 for additional information on site structure.)

*Ambush sites* are used in the course of dry-season intercept hunting. They are located overlooking perennial water sources or on nearby game trails. As indicated above, they are marked by the presence of blinds. These structures are often built on or around small rocky outcrops. Animals shot at these locations sometimes die within a short distance (<200 m) and may be brought back to the blind area for butchering and partial consumption. Lions and other predators may also hunt nearby, especially if the site is near water; and where they do, a recurrent scavenging opportunity may be created. As in the case of animals obtained by hunting, carcasses scavenged by the Hadza may be brought to the blind area for processing. This happened with four animals in our butchering sample, two of which were taken near the same blind (one by hunting, one by scavenging). At least two other animals not included in the sample (one impala, one zebra) were also killed and dismembered near this blind in the same dry season.

The blind in question overlooks a small swampy patch, about 250 m long and 100 m wide, located in an intermittent stream channel. A rock sill across the channel impedes drainage, so that water spreads out over relatively level ground upstream, creating the swamp. Rocky outcrops at various points along the sides of the swamp are used as foundations for at least three blinds, including the one mentioned above. Blinds are also occasionally constructed on small patches of slightly raised ground within the swamp. Bone concentrations which

appear on the basis of damage morphology to be the products of Hadza field butchering were noted at all three blind locations associated with rocky outcrops. Each concentration contained the remains of several species of ungulates, including impala, mid-sized antelope, and zebra, among others. Although we have made no formal survey, we know of several other dry-season ambush site complexes like this (each of which also contains the remains of more than one prey species) and reckon they are not uncommon in the Tli'ika/Han!abi district. Like base camps, these sites are probably used repeatedly by the Hadza over long periods of time. (Brooks and Yellen 1987 report a similar pattern for the !Kung.)

*Butchering sites* are places where animals killed or scavenged are disarticulated for transport to a residential base. They are likely to be used only once and are therefore more common, but probably less visible archaeologically, than either residential bases or ambush sites. Most are within an hour's walk from an occupied base camp at the time they are created, but they otherwise display no clear pattern in location. During the period covered by our observations, carcasses were found and butchered in stream channels, on rocky hillsides, in grassy swales, and along ridges—in short, wherever the animal in question finally succumbed.

The bone assemblages deposited at butchering sites and residential base camps are, by definition, mirror images of one another.<sup>6</sup> Figure 12 compares the body part composition of assemblages deposited at all butchering sites combined with that of assemblages deposited at all residential base camps. Note that the order in which elements are arrayed on the plot differs from that in all previous figures: elements are ranked in descending order of frequency, left to right, for base camps and in ascending order, left to right, for butchering sites. Also note that the element most frequently deposited across all sites in each category is given the value 1.00, as it would be if these assemblages were encountered archaeologically. The representation of all other elements at sites in that category is scaled as a percentage of that value.

The distinctions are obvious. Element categories most frequently deposited at residential base camps are vertebrae, scapulae, pelves, and humeri. Those least often deposited are ribs, skulls, mandibles, metapodials, and tibiae. Of the sixteen element categories ranked, seven of the eight most often deposited at base camps are vertebrae, pelves, and proximal limb elements; seven of the eight least deposited are ribs, heads, and distal limb elements. The situation at butchering sites is precisely the reverse. Note that certain details of this contrast are subject to variation depending on the taxonomic mix of species taken. If our sample included more alcelaphines and fewer zebra, for example, the relative positions of skulls, mandibles, ribs, and limb elements would be somewhat different (see Figures 1–2). Nevertheless, vertebrae, scapulae, and pelves would still be the most common elements at base camps and the least common at butchering stations. Our data suggest that this aspect of the pattern would persist regardless of the relative frequencies of taxa included in our sample. Note also that the pattern would probably be different if the sample included a greater proportion of carcasses encountered in less than complete

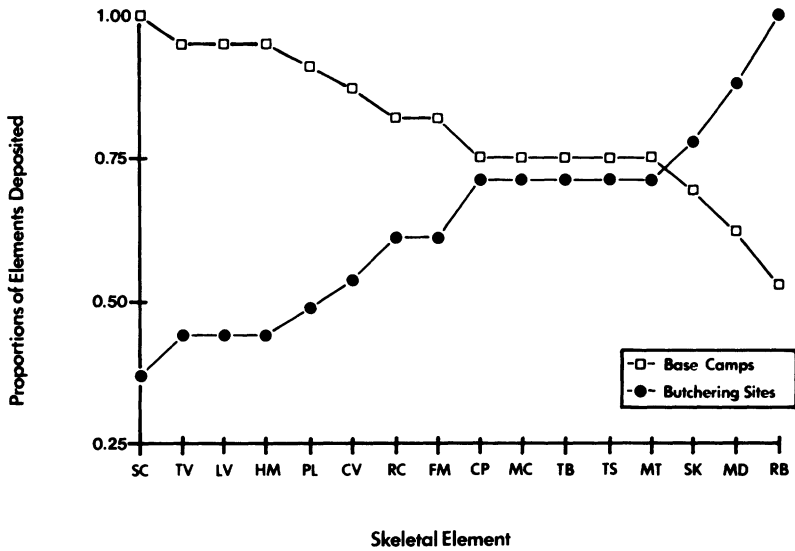


Figure 12. Comparison of Bone Assemblages Deposited at Ordinary Butchering Sites and Residential Base Camps

Data are from all sites in each category combined; ambush sites (Appendix, cases 11, 12, 15, 28) are not included. The element most often deposited at sites in each category is scaled at 1.00; relative values of other elements are ranked accordingly. Abbreviations as in Figure 1.

condition (i.e., partly consumed by other predators and/or scavengers). Its precise form would depend somewhat upon the array of species involved and even more so on the degree of damage the carcasses had suffered by the time the Hadza acquired them.

Comparison of assemblages deposited at ambush sites with those left at butchering and at residential sites is hampered by the small number of ambush site butchering events in our sample. As indicated above, bone transport was recorded in only four cases, two involving alcelaphine antelope (Appendix, cases 11, 12) and two involving zebra (cases 15, 28). Two of these carcasses were moderately damaged on encounter; two were intact. In these four cases, 75 percent of all scapulae and of all axial elements (except ribs), but no more than 35 percent of other appendicular elements, were taken back to the residential base. From these data, we tentatively conclude that bone assemblages deposited at ambush sites are similar to those left at ordinary butchering stations and are, correspondingly, quite different from those deposited at residential base camps.

## DISCUSSION

The Hadza data have important implications (1) for some widely held views about patterns of bone transport among hunters, (2) for particular reconstructions of past human or hominid behavior based on those views, (3) for the

problem of distinguishing hunting versus scavenging as contributors to assemblage composition, and (4) for current thought about the suitability of modern hunters as a source of inference about the prehistoric past.

### *Patterns of Bone Transport among Hunters*

Archaeologists have long attributed variation in the relative frequency of different body parts in archaeological faunal assemblages to differential transport by hunters. Two different, but related, models of transport are cited in the current literature. One is based primarily on a series of influential papers by White (e.g., 1952, 1953, 1954) and Perkins and Daly (1968). Working with assemblages from the North American Great Plains, White found that skeletal element representation often varied inversely with the animal body size: larger species were represented by fewer elements, and conversely. He also found that limb elements were more commonly represented across all species than axial parts. He inferred that these differences reflected the transport practices of hunters. All else being equal, he suggested, the bones of larger prey carcasses were more likely to be stripped of meat and abandoned at the kill, primarily as a means of reducing transport costs. Similarly, limb elements were more likely to be removed from kills than axial parts because they bore greater amounts of edible tissue relative to total element weight including bone. Perkins and Daly made a similar argument based on their analysis of faunal remains from an early Neolithic site in Turkey and coined the term "schlepp effect" to describe the pattern.

Although these ideas are deeply imbedded in the recent literature (for recent general statements, see Rathje and Schiffer 1982:117–18; Butzer 1982:194; Grayson 1984:20–21; Schiffer 1987:69–70; for substantive applications, see Bunn 1986; Bunn and Kroll 1986, 1988; Klein 1976; Klein and Scott 1986; Klein and Cruz-Uribe 1987; Redman 1978:164), they lack much support apart from the archaeological data which originally provoked them. White (1954) cites only two ethnographic sources; Perkins and Daly cite White. Neither develops a theoretical argument beyond suggesting that cost/benefit considerations involving weight will affect body part transport. Neither presents any quantitative data on the distribution of meat and marrow on the relevant animals or on the total weight of body parts including bone. Neither makes any attempt to test the argument or to consider alternative explanations (cf. Binford 1981:184–85; Klein and Cruz-Uribe 1984; Lyman 1984, 1985). In short, these are plausible hypotheses, grounded in commonsense notions of efficiency, about possible causes of archaeologically observed patterns in bone assemblage composition. Nevertheless, through frequent citation and reiteration over a period of years, archaeologists have come to accept it as an established fact that hunters move a greater proportion of bones from smaller carcasses than from larger ones and that they transport limbs more often than axial parts.

The Hadza data directly contradict one of these propositions and provide only limited support for the other. The Hadza routinely move meat and bone from kills to base camps and often abandon bones in the field as part of the



butchering process. Their selection of elements for transport is situationally variable, but it displays evidence of a scale. Those bones most likely to be moved in most cases are vertebrae, pelves, and upper forelimbs; those least likely include distal limb elements. This is precisely the reverse of one major element of the "schlepp effect" model (Perkins and Daly 1968). This pattern is not unique to the Hadza; it has also been documented among other hunter-gatherers, including some from very different environments (e.g., Yellen 1977; Binford 1978:76–78, figs. 2.8–2.9; Lee 1979; Bunn 1983). Regarding the second proposition concerning the proportion of elements transported, the Hadza data show that this varies inversely with carcass size, but only in rather broad terms. A substantial amount of variance in this domain may not be explicable by transport costs.

The second model has been developed by Binford (1978) for the Nunamiut. As we indicated above, Binford saw that the Nunamiut often abandoned large mammal body parts at or near kill sites and inferred that the practice reflected considerations of efficiency. To test this idea, he developed a series of economic utility indices which he used to rank caribou body parts. He then evaluated Nunamiut bone transport in terms of these indices and found that they did indeed predict transport patterns. In general, high-ranked parts were more likely to be taken away from kills than were low-ranked parts. Metcalfe and Jones's (1988) reanalysis showed that element rank was a function of the weight of associated edible tissue. In general, the more meat, marrow, and grease attached to a bone, the more likely it was to be taken away, and conversely. Binford's results, especially as rephrased by Metcalfe and Jones, suggested that utility indices based on the anatomical distribution of edible tissue could be used to explain archaeologically observed differences in skeletal element representation, given appropriate adjustments for variation in the economic anatomy of the species represented and the effects of postdepositional processes. Much of Binford's subsequent research has been directed at exploring this possibility (Binford 1981, 1984; see also Speth 1983; Thomas and Mayer 1983; Todd 1987; Grayson 1987).

Despite the merits of Binford's model for the Nunamiut case, the Hadza data indicate that it cannot be applied universally. The Hadza almost always strip meat from some bones, sometimes from all bones, prior to transport. Thus, unlike the Nunamiut, their decisions about bone transport are at least partly independent of the amount of edible tissue originally associated with each bone. Utility indices based on these amounts cannot be used to predict or explain Hadza transport patterns or, by extension, the archaeological record they produce.

Having highlighted these differences in carcass treatment patterns, we suggest that they reflect the same underlying consideration: maximizing net nutritional benefit relative to processing and transport costs. Comprehensive comparison of the Nunamiut and Hadza patterns from this perspective is beyond the scope of this paper, but we suspect that the differences which distinguish them mainly reflect the conditions of carcass acquisition. Most carcasses taken



by the Hadza are acquired one at a time and are targeted for immediate use, either local consumption or (less often) drying for trade. Transport capacity is roughly matched with carcass size, except in the case of the largest animals. Bones can be, and often are, stripped and discarded at the kill as a means of reducing transport costs. Even where transport of the entire carcass is possible, field consumption by the carrying party may result in the discard of many, occasionally all, skeletal elements. In contrast, most carcasses acquired by the Nunamiut are taken in groups of up to about sixty individuals, the majority of which are destined for storage. Total carcass weight typically exceeds immediate transport capacity by a substantial margin, so at least some carcasses must be left in the field partially butchered for days or even months. These carcasses are almost always frozen by the time they are transported to base, which means that deboning or partial consumption in the field is not a realistic option. This difference in the conditions surrounding transport also accounts for the Nunamiut practice of splitting limbs in midshaft during butchering, a practice we never observed among the Hadza. Disarticulation at the joints is likely to be much more time-consuming when dealing with a frozen carcass, much less when the carcass is fresh (see Binford 1978:47–60 for additional discussion).

### *Reconstructions of Past Hominid Behavior*

The Hadza data not only challenge current models of bone transport by hunters but also undercut reconstructions of past human or hominid behavior based on those models. The recent literature on Plio-Pleistocene East Africa provides an example.<sup>7</sup> Pertinent archaeological data come primarily from two localities in the Eastern Rift—Olduvai Gorge (Leakey 1971) and East Turkana (Coppens et al. 1976). (See Isaac 1984; Toth and Schick 1986 for comprehensive summaries and discussions of recent work.) Sites in both areas are found in sediments marking former stream channels or the shorelines of ancient lakes and are often defined by the presence of stone artifacts and animal bones, notably (but not only) those of medium/large mammals (Jones 1984). When initially reported, these sites were generally interpreted as the remains of residential base camps, much like those used by modern hunter-gatherers. A sexual division of labor was inferred, and, again by analogy with modern hunters, the bone accumulations were seen, at least in some cases, as the remains of prey taken elsewhere and brought to the sites for sharing and consumption (Isaac 1978; Leakey and Lewin 1977). This interpretation was challenged on several grounds, including the alleged integrity of the sites themselves (e.g., Binford 1977), and as a result was partly discredited. Current interpretations are less far-reaching and, with some exceptions, explicitly avoid analogies with modern hunters, except to emphasize points of contrast. It is now generally agreed that, in at least some sites, the bones and stones are in primary context, that is, their association is not the product of geological redeposition. It is also agreed that, in at least some cases, the bones and stones are connected through hominid activity: some bones bear cut marks which could have been caused

by the stone tools; some stone tools display edge damage which could have been caused by cutting meat (Bunn et al. 1980; Bunn 1982; Potts 1982). Whether the bones have been transported from kills to central places and, if so, whether by hominids or other animals remain matters of vigorous dispute.

The current conventional wisdom, best represented in the work of Bunn (1982, 1983, 1986; Bunn and Kroll 1986, 1988), Potts (1982, 1983, 1984), and Isaac (1983, 1984), sees the bones as having been transported, primarily by hominids, from kill or death sites to central places (though not necessarily camp sites). Three characteristics of the bone assemblages are crucial to this argument. First, bones are spatially concentrated in these sites at densities at least an order of magnitude greater than those normally encountered in comparable East African environments today (e.g., Behrensmeyer and Dechant Boaz 1980). Second, the taxonomic composition of the bone assemblages is highly diverse: they often include more than one individual of more than one species of more than one body size class. This is also unusual by modern East African standards (Behrensmeyer and Dechant Boaz 1980). Third, the assemblages are said to display disproportionate percentages of appendicular versus axial skeletal elements: they contain too many limb bones relative to the number of vertebrae and pelves. In modern East African environments, appendicular elements are often dispersed from large mammal kill/death sites, while axial elements are left behind (Hill 1975). These three features of the early sites are taken to suggest the operation of some selective agent(s) of accumulation. Geological processes are eliminated on various grounds, leaving biological actors, most likely hyenas and/or hominids, as potentially responsible. Hyenas are ruled out for two reasons. First, since the bone damage morphology at the early sites is unlike that found in modern hyena dens, a nonhyenid pattern of consumption is apparently indicated. Second, bones in modern hyena dens rarely have much meat or marrow attached. If this were also true of Plio-Pleistocene dens and if the early sites were indeed dens, then it becomes difficult to account for the hominid presence, as indicated by the stone tools and the cut marks on the bones. For these reasons, Bunn and Potts both conclude that at least some of these early sites contain hominid-transported bone assemblages. Isaac agrees, largely on the basis of Bunn's and Potts's work.

This conclusion is directly challenged by the data on bone transport among the Hadza. The modern Hadza deposit some bone assemblages which display all the critical characteristics mentioned above: the bones are concentrated in space, represent a wide array of species and size classes, and include disproportionate numbers of appendicular relative to axial skeletal elements. These bones almost certainly show damage patterns produced by meat stripping and marrow cracking (though this has not yet been demonstrated). They are often found in sites on or near ephemeral stream channels. These sites are not base camps, however, nor have the assemblages they contain been transported in the sense meant by Potts, Bunn, and Isaac. They are ambush sites, places where the Hadza regularly take game from blinds, scavenge kills from other

predators, and butcher carcasses for transport, consuming small quantities of meat and marrow and discarding some bones in the process. *If these sites were evaluated by the criteria now used by many archaeologists to identify bone assemblages as transported, they would be misclassified* (see also Brooks and Yellen 1987:89).

This observation causes us to reevaluate Potts's and Bunn's arguments in more detail. In concluding that the early bone assemblages have been transported, both rely heavily on the high ratios of appendicular to axial skeletal elements said to be found at the early sites. Potts (1982, 1984) cites the observation made by Hill (1975) and others, mentioned above, that, in modern East African environments, limb bones are often dispersed or removed from kill sites, presumably by predators and scavengers, while axial elements are left behind. Assemblages dominated by limb elements are thus seen as likely to have been transported. Hyenas are eliminated on the grounds of bone damage patterns, which leaves hominids as the only plausible alternative, an interpretation consistent with the associated stone tools and the cut marks on bones. The implicit assumption is that all predator-scavengers, or in this case hyenas and hominids, move the same bones from kills. The ethnographic data on hominid bone transport available at the time (e.g., Binford 1978, 1981; Yellen 1977) were not consistent with this but were not cited. This means Potts's argument rests on a theoretically and empirically unsupported behavioral analogy between modern nonhominid predator-scavengers and early hominids (see also Blumenschine 1986a).

Bunn (1982) takes a slightly different approach, calling attention to two bone data sets, one collected from a San base camp, the other from a modern hyena den. Both contain high proportions of limb elements. Bunn infers that some of the same factors are conditioning element transport in both cases. One of these factors, perhaps the most important, is economic utility: Bunn says that "meaty" limbs tend to be taken away from kills, while "less meaty" axial parts are often left behind.<sup>8</sup> High proportions of limb elements in Plio-Pleistocene archaeological sites therefore indicate that the bones, and probably the tissue once attached, have been transported. Hyenas are ruled out on the same grounds used by Potts, which means hominids are implicated, a conclusion consistent with the stone tool associations and the damage patterns on the bones.

However, Bunn's ethnographic data do not support this argument: vertebrae and ribs make up half the sample (30 percent and 20 percent, respectively) from the San site (Bunn 1982, 1983). Bunn apparently expected that the San would transport limbs more often than axial parts and that the pattern of element representation would be more like that at the hyena den, where vertebrae and ribs are uncommon (5 percent and 10 percent of the sample, respectively). He attributes the mismatch between data and expectations to the circumstances of this particular case, specifically to the large number of people present and available to transport meat and to the short distance(s) from kill(s) to camp. "Under different circumstances," Bunn (1982:177) argues, "a decision to abandon less transportable and less useful axial bones at the animal's death site

might well have been reached." This expectation is based primarily on Perkins and Daly's (1968) "schlepp effect" argument, which is unsupported, as we have shown.

All of this does not necessarily mean that Potts, Bunn, and Isaac are wrong about the behavioral implications of bone assemblage composition at these early sites, *only that they cannot be right for the reasons they give. Neither does it imply that the sites should necessarily be reinterpreted, by analogy with the modern Hadza, as kill-butcherer or ambush sites.* We return to this point below.

### *Hunting, Scavenging, and Bone Assemblage Composition*

The recent literature on Pleistocene hominid foraging emphasizes the potential importance of scavenging as a major, perhaps even the principal, contributor to archaeological bone assemblages dating from this period (e.g., Bunn et al. 1980; Binford 1981, 1984; Potts 1984; Bunn and Kroll 1986; Blumenshine 1986c; Shipman 1986). As a result, many archaeologists are now concerned with identifying criteria which can be used to distinguish scavenging from hunting archaeologically. The Hadza data are relevant to several propositions about such criteria. Specifically, Vrba (1975) and Klein (1982) suggest that assemblages produced by hunting will contain a relatively high percentage of the remains of juvenile animals, while those produced by scavenging will consist mainly of adults. Vrba also proposes that hunting will produce assemblages marked by a narrow range of prey sizes, scavenging by a broad range. Neither of these propositions is supported by the Hadza data. The Hadza take essentially the same range of medium and large mammals in about the same proportions by hunting and by scavenging (O'Connell, Hawkes, and Blurton Jones 1988). Elephant is the only exception: these animals are scavenged but not hunted. Also, nearly all animals in our sample (fifty-three of fifty-seven individuals) were adults, apparently in prime condition. Of the four immatures, three were scavenged and one hunted.

More recently, Potts (1983), Binford (1984), and Blumenshine (1986a) have suggested that hunted and scavenged assemblages may be distinguished by differences in the relative proportions of body parts they contain (see Blumenshine 1986a for a useful comparative discussion). Working primarily from Hill's (1975) data on carcass disarticulation sequences, Potts suggests that "early" scavenging may be marked by preferential removal of forelimbs, especially if the scavenger is attempting to minimize time spent at the carcass as a means of avoiding potentially dangerous encounters with competitors. Forelimbs were among the first parts separated from the carcasses in Hill's data set. Hindlimbs, according to Potts, are likely to be left to "late" scavengers. Binford suggests that because early scavengers may have access to essentially the same body parts as hunters, they will likely treat carcasses in essentially the same way with respect to transport and discard. Late scavengers, on the other hand, will be confronted with heavily ravaged carcasses, in which heads and feet are the only remaining parts available for consumption and/or transport. Blumenshine uses data on nonhominid carnivore predation and scavenging in Serengeti National Park to show that parts available to scavengers will vary

depending on carcass size and initial consumer type. He further demonstrates that, in this habitat at least, midsized adult herbivores killed by lions represent the most common scavenging opportunity and that parts available from these carcasses include not only heads and feet, but also marrow-bearing long bones.

The Hadza data are inconsistent with most of these suggestions. As we indicated above, transported assemblages produced by "early" Hadza scavenging are marked by very low proportions of limb elements in general, while those derived from "late" scavenging are dominated by forelimbs. Potts's arguments about the preferential removal of forelimbs in early scavenging situations and of hindlimbs in late ones are thus both directly contradicted. We note that Potts's argument again entails an unsupported analogy between the behavior of hominid and nonhominid predator-scavengers. It also confuses the effects of those biological and physical processes operating long after carcasses have ceased to be attractive to scavengers with those occurring during the scavenging process itself (Blumenschine 1986a). The Hadza data are also inconsistent with Binford's suggestion that moderately ravaged carcasses will be treated like those recovered completely intact. Even minor damage to a scavenged carcass may change the relative value of various body parts. The Hadza data are more consistent with the "heads and feet and/or legs" pattern predicted by both Binford and Blumenschine for "late" scavenging. We expect that the differences between the Hadza data and other data are related to field-processing and transport costs, but this remains to be demonstrated. It could be that they reflect nothing more than the small size of the Hadza sample.

### *Modern Hunters as a Source of Inference about the Prehistoric Past*

During the past ten years, a strong reaction has developed against the use of modern hunters as a source of inference about prehistory (e.g., Wobst 1978; Schrire 1980, 1985; Shipman 1983; Shipman and Rose 1983; Hill 1984; Potts 1987; Klein and Cruz-Urbe 1984). This can be seen as part of a larger reaction against the use of analogy in archaeology, a reaction that has periodically swept the discipline more than once since the beginning of this century (see Wylie 1985 for a general review). Objections to analogies based on modern hunters frequently cite their fully modern anatomy, relative technological sophistication, marginal environmental situation, and close contact with (if not complete encapsulation by) state societies. Because all these factors have emerged in the last 100,000 years, some much more recently, modern hunters are seen to be irrelevant to the exploration of the past, especially the remote Pleistocene past. To extrapolate from their behavior, so the argument goes, is to presume the existence of similarities between ancient and modern hominids which should themselves be the object of inquiry.

Those who adopt this position are rightly cautionary about inappropriate comparisons, but they also beg an important question. Because the archaeological record cannot be read directly, one must approach it with some knowledge of the processes likely to affect it and the patterns they are likely to



create. Recent research on such topics as nonhominid bone modification and density-dependent attrition reflects widespread recognition of this requirement. The same requirement also applies to hominid behavior as reflected archaeologically. The data do not speak for themselves; they are only informative insofar as they match or fail to match expectations. The question is, from where do those expectations come? If modern hunters are not the source, what is? In recent work on the Pleistocene, expectations have been based on "commonsense" models of past hunter-gatherer behavior, like the White-Perkins/Daly model of transport. As we have seen, this model not only fails to predict modern Hadza behavior, but it also lacks any other independent theoretical or empirical support. Expectations have also been based on the behavior of nonhuman predator-scavengers. Morphological contrasts between these organisms and hominids which affect the economics of dismemberment and transport make this a misleading choice. In short, these approaches are simply not adequate.

Calls to reject modern hunters as a source of information and analogy are based on the assumption that features unique to the modern world shape their behavior. This is an empirical question. Whether or not the assumption is correct depends on which aspects of hunter-gatherer behavior are at issue, how that behavior is shaped in the modern world, and whether the same factors might also have affected the behavior of hominids in the past. In this paper, we have described patterns of bone assemblage formation among the modern Hadza. Among other things, we have shown that the Hadza routinely butcher medium/large mammal carcasses and transport parts from kill sites to residential base camps. In the process, they create various archaeological bone assemblages which differ in the relative proportions of body parts they contain. We have argued that these differences reflect the relative costs and benefits of field processing and consumption versus transport to and consumption at the residential base. Specific factors which appear to be pertinent to calculating these costs and benefits include the size of the carcass, its distance from the residential base, the number of carriers available to transport it, the time available for field butchering and consumption, the time required to process various body parts in the field, and nutritional and other benefits available to individual consumers from immediate field consumption relative to those to be derived from transport and consumption and/or sharing with others at the base. Our argument about the importance of these factors cannot be taken as conclusive in the absence of better quantitative data, but it is at least strongly suggestive. None of these factors appears to reflect circumstances peculiar to modern Hadza life, such as the presence of pastoralists or the history of state-sponsored settlement schemes.

The Hadza pattern as described here cannot be used as a model to reconstruct past behavior from archaeological data. It does, however, have immediate relevance. Among other things, it shows that archaeologists should not continue to assume that hunters will transport more appendicular than axial



parts from kills to base camps, that hyenas and hominids will remove the same parts from kills, that bone assemblages containing the remains of many species represent base camps, or that stream channels represent ideal residential sites. Moving beyond these cautionary points will require an explanation of the Hadza pattern. Our hypotheses about causality represent initial steps in this direction; further work will be required to sharpen and test them. This project and others like it provide essential elements in the construction of archaeological models. The question is not whether to use information from the modern world, but how to use it best.

## Appendix

### Data on Hadza Butchering and Bone Transport, September 1985–October 1986

Data on skeletal element transport and disposal are available from thirty-nine incidents involving medium/large mammals, defined as species with average adult body weights equal to or greater than 40 kg. These data are summarized in the accompanying Table A, with additional descriptive notes. *Case numbers* have been assigned in chronological order to *all* medium/large carcasses acquired, whether data on bone transport are available or not. Since carcasses for which such data are unavailable are not included in this table, case numbers are discontinuous. Note also that the list includes two animals (both giraffe, cases 39 and 41) not listed in text Table 1. Both were taken by hunters from camps other than those occupied by the ethnographers. All animals listed are adults except as noted by an asterisk (\*) after the case number. *Date* is the date on which the carcass was recovered by the Hadza. *Methods of acquisition* are described as encounter hunting (ENC), intercept hunting (INT), and scavenging (SCA). Encounter hunting means the animal was shot while the shooter was actively foraging; intercept hunting means it was shot while the shooter was sitting in a blind or hide. Scavenging means it was acquired after it had died or been killed by another animal or by a non-Hadza. *Recovered intact* means the carcass had not been damaged by other predators or scavengers when found by the Hadza. Additional information on carcasses recovered partly intact is presented in text Table 2. *Distance to camp* is the walking time, measured in minutes, from the spot where the carcass was dismembered to the residential base camp from which the carrying party originated. *Adult members of the carrying party* include all individuals of both sexes aged about fourteen or older. Children are those aged about eight to fourteen. Younger children very seldom accompany carrying parties except as infants in arms. *Meat left at the kill* refers to those cases in which a substantial portion (more than about 5 kg) of edible tissue (meat or marrow) was left behind after the departure of the carrying party. *Elements transported* is an index calculated by dividing the number of complete bones of a particular type transported from the butchering site to the residential base by the number of bones of that type in the complete carcass. Thus, if one femur is discarded at the butchering site and the other carried back to camp, the value for femora is 0.50. Except as noted, all skeletal elements discarded were completely stripped of meat. All long bones and metapodials, skulls, mandibles, and vertebrae were cracked and/or shattered, and their edible contents removed and consumed. The notation *DK* (don't know) indicates that data are lacking.

**TABLE A**  
**Hadza Butchering and Bone Transport**

Case no.	1	2	6	11	12	13	14	15	16	17
Date	7 Sept.	8 Sept.	19 Sept.	24 Sept.	26 Sept.	27 Sept.	27 Sept.	11 Oct.	13 Oct.	13 Oct.
Species	Zebra	Hartebeest	Wildebeest	Hartebeest	Wildebeest	Impala	Zebra	Zebra	Impala	Impala
Method of acquisition	INT	ENC	INT	INT	SCA	INT	ENC	SCA	INT	SCA
Recovered intact	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No
Dist. to camp (min.)	20	10	35	20	20	15	50	30	10	80
No. of carriers										
Adult	9	6	12	7	10	1	15	15	5	6
Child	4	4	1	0	8	0	0	1	0	0
Meat left at kill	No	No	No	No	No	No	No	No	No	No
Elements transported										
Skull	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00
Mandible	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00
Atlas/axis	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Cervical vertebrae	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Thoracic vertebrae	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Lumbar vertebrae	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Pelvis	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	1.00	1.00
Ribs	0.00	1.00	0.50	1.00	1.00	1.00	0.00	0.00	0.90	1.00
Scapulae	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Humeri	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.50	1.00	0.00
Radius/ulna	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00
Carpals	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00
Metacarpals	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00
Phalanges	1.00	1.00	0.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Femora	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.50	1.00	0.00
Tibiae	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00
Tarsals	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00
Metatarsals	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00
Phalanges	1.00	1.00	1.00	1.00	0.50	1.00	1.00	0.00	1.00	1.00

*Continued on next page*

Table A—Continued

Case no.	18	19	20	21	22	23	24	25	27	28
Date	17 Oct.	18 Oct.	18 Oct.	20 Oct.	21 Oct.	21 Oct.	22 Oct.	23 Oct.	26 Oct.	29 Oct.
Species	Warthog	Zebra	Impala	Impala	Zebra	Zebra	Warthog	Giraffe	Warthog	Zebra
Method of acquisition	INT	SCA	INT	ENC	INT	INT	ENC	INT	ENC	INT
Recovered intact	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Dist. to camp (min.)	60	60	30	DK	20	10	15	50	10	20
No. of carriers										
Adult	3	DK	1	3	12	13	3	19	2	14
Child	1	DK	0	0	3	2	0	1	1	0
Meat left at kill	No	No	No	No	No	No	No	Yes	No	No
Elements transported										
Skull	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Mandible	1.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Atlas/axis	0.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Cervical vertebrae	0.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Thoracic vertebrae	0.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Lumbar vertebrae	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Pelvis	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Ribs	0.00	0.50	1.00	0.00	0.80	0.80	1.00	0.70	1.00	0.20
Scapulae	1.00	0.50	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Humeri	1.00	0.50	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Radiocubiti	1.00	0.50	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Carpals	1.00	0.50	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Metacarpals	1.00	0.50	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Phalanges	1.00	0.50	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Femora	1.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Tibiae	1.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Tarsals	1.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Metatarsals	1.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00
Phalanges	1.00	0.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00

Table A—Continued

Case no.	29	30	31*	34	35	37	38	39	40	41
Date	29 Oct.	31 Oct.	31 Oct.	5 Dec.	11 Dec.	29 Dec.	25 Mar.	26 Mar.	20 Apr.	24 Apr.
Species	Warthog	Zebra	Impala	Impala	Impala	Eland	Impala	Giraffe	Impala	Giraffe
Method of acquisition	ENC	INT	SCA	ENC	ENC	ENC	ENC	ENC	SCA	ENC
Recovered intact	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Dist. to camp (min.)	60	55	20	DK	15	115	DK	50	90	240
No. of carriers										
Adult	4	12	3	4	4	16	2	11	3	19
Child	0	0	0	0	3	2	0	2	0	0
Meat left at kill	No	No	No	No	No	Yes	No	Yes	No	Yes
Elements transported										
Skull	1.00	1.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
Mandible	1.00	1.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
Atlas/axis	1.00	1.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
Cervical vertebrae	1.00	1.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
Thoracic vertebrae	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00
Lumbar vertebrae	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00
Pelvis	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	0.00
Ribs	1.00	0.00	1.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Scapulae	1.00	1.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
Humeri	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	1.00	0.00
Radiocubiti	1.00	1.00	1.00	0.00	1.00	0.50	0.00	0.00	1.00	0.00
Carpals	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
Metacarpals	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
Phalanges	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	1.00	0.00
Femora	1.00	1.00	1.00	0.00	1.00	0.00	0.50	0.00	0.00	0.00
Tibiae	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Tarsals	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Metatarsals	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Phalanges	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00

Continued on next page

Table A—Continued

Case no.	42	43	44	45	46	47	49	52	59*
Date	19 May	26 May	28 May	10 July	13 July	1 Aug.	7 Aug.	22 Sept.	24 Oct.
Species	Impala	Giraffe	Giraffe	Zebra	Zebra	Zebra	Impala	Warhog	Impala
Method of acquisition	ENC	ENC	SCA	ENC	ENC	ENC	INT	SCA	SCA
Recovered intact	Yes	Yes	No	No	Yes	Yes	Yes	No	No
Dist. to camp (min.)	DK	240	180	60	50	DK	30	20	DK
No. of carriers									
Adult	6	19	9	1	15	15	6	1	2
Child	0	1	0	0	6	1	0	0	0
Meat left at kill	No	DK	Yes	Yes	No	No	No	No	No
Elements transported									
Skull	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Mandible	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Atlas/axis	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
Cervical vertebrae	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
Thoracic vertebrae	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
Lumbar vertebrae	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
Pelvis	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
Ribs	0.00	0.00	0.00	0.00	0.40	0.60	0.00	1.00	0.00
Scapulae	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00
Humeri	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00
Radiocubiti	1.00	0.00	0.00	0.00	1.00	1.00	0.50	1.00	1.00
Carpals	1.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00
Metacarpals	1.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00
Phalanges	1.00	0.00	0.00	0.00	1.00	0.50	1.00	1.00	1.00
Femora	1.00	0.00	0.00	0.00	1.00	0.50	0.00	1.00	1.00
Tibiae	1.00	0.00	0.00	0.00	0.50	0.50	0.50	1.00	1.00
Tarsals	1.00	0.00	0.00	0.00	0.50	1.00	0.00	1.00	1.00
Metatarsals	1.00	0.00	0.00	0.00	0.50	1.00	0.00	1.00	1.00
Phalanges	1.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00

*Additional Notes on Individual Cases*

11. This animal was butchered near the blind from which it was shot. Some skeletal elements were discarded in the stream channel nearby.
12. This animal was found and butchered at a site used for intercept hunting. Some skeletal elements were discarded in the stream channel nearby.
15. Same as 12.
25. Head, neck, four ribs, and all four feet (phalanges) were left at the kill in partly defleshed condition, apparently because the carrying party was too small to transport them to residential base. They were placed in a tree, out of reach of lions and hyenas. The following day, a party of at least five to six young teenaged boys returned to the kill, where they completely stripped all bones, consumed some of the meat, and returned to camp with the rest, leaving the bones behind. They probably cracked the foot bones for marrow before abandoning them, but this is not certain.
28. Same as 11.
37. Head was abandoned at the kill fully fleshed, except for a small bit of fatty tissue removed from behind each orbit. Neck was left partly fleshed, with some meat still adhering to the vertebral processes.
39. Carcass was abandoned with the vertebral column and pelvis fully articulated. Meat had been largely stripped off, but some was still attached to the vertebral processes.
41. Carcass was abandoned with the head, vertebral column, pelvis, and ten ribs fully articulated. Pelvis, ribs, and lumbar and thoracic vertebrae were stripped of meat, but cervical vertebrae were not. Eyes, fatty tissues behind the orbits, and tongue had been removed from the head, which was otherwise left intact.
44. Informants report the neck meat was left untouched.



## NOTES

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2. Our "proportion of elements transported" is the numerical equivalent of Binford's "minimum animal unit" (MAU). For further information on the latter, see Binford 1978, 1984.

3. Adjusting the boundaries for "t" anywhere in the ranges 1–39 percent and 61–99 percent has no effect on the results of this analysis.

4. Meat was abandoned at butchering sites on at least six, possibly seven, occasions, all but one involving giraffe and eland. In every case, this appeared to reflect a limitation on transport capacity.

5. Minor differences in the number of cases shown in Figures 5–6 and 7–10 reflect missing data on number of carriers or distance from kill site to base camp for some cases.

6. These assemblages need not necessarily be mirror images of one another. If, for example, the Hadza routinely moved bones to some other location, neither butchering site nor residential base (as do the Nunamiut, see Binford 1978), the complementary relationship between assemblages at the latter two site categories would be weakened.

7. See Klein 1976; Klein and Cruz-Urbe 1984, 1987; Klein and Scott 1986 for additional examples.

8. Blumenschine (1986b) observes that, in at least some species of African ungulates, certain elements (notably lumbar vertebrae and pelves) may bear more meat than upper limb elements (see also Blumenschine and Caro 1987).

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