Hadza Scavenging: Implications for Plio/Pleistocene Hominid Subsistence[1]

JAMES F. O'CONNELL, KRISTEN HAWKES, AND NICHOLAS BLURTON JONES
Department of Anthropology, University of Utah, Salt Lake City, Utah 84112 (O'Connell and Hawkes)/ *Graduate School of Education, University of California, Los Angeles, Calif. 90024* (Blurton Jones), *U.S.A.* 3 VIII 87

The frequent association of stone tools and large animal bones in African Plio/Pleistocene archaeological sites has long been taken as evidence of the importance of hunting in early hominid diets (Dart 1953, Isaac and Crader 1981). Many now argue that it reflects hominid scavenging, not hunting (Binford 1981, Shipman 1986; see also Clark 1959). Some maintain that scavenging was a significant part of hominid subsistence and the principal source of animal tissue in the diet (Shipman 1986, Szalay 1975, Sinclair, Leakey, and North-Griffiths 1986). Evaluation of this argument requires an estimate of the costs and benefits of hominid scavenging in African savannah environments (Shipman 1986, Sinclair et al. 1986, Schaller and Lowther 1969, Blumenschine 1986). Observations of modern hunter-gatherers who actively exploit all scavenging opportunities they encounter provide a basis for such estimates. Here we report scavenging practices among Hadza hunter-gatherers in northern Tanzania. During 1985–86, scavenging yielded 20% of all medium/large-mammal carcasses acquired by the Hadza. Scavenging returns were highly variable, depending on carcass encounter rates, carcass size and completeness on encounter, and success at displacing the original predators. We infer that scavenging could have been an important source of animal tissue for early hominids in comparable environments only intermittently and only if they could displace large carnivores in competitive encounters.

The Eastern Hadza are a population of 600–800 occupying a 2,500-km^2 area in the Eastern Rift Valley, southeast of Lake Eyasi (Woodburn 1968*a*). This region has a warm, dry climate with a marked six-month rainy

 This work was supported financially by the National Science Foundation, the Swan Fund, B. Bancroft, the University of Utah, and the University of California, Los Angeles. We thank Utafiti (Tanzanian National Research Council) for permission to pursue fieldwork, L. C. Smith for introducing us to the Hadza and for access to unpublished data, and D. Bygott and J. Hanby for vital assistance in the field. We thank the Hadza themselves for their tolerance, advice, and support. R. Blumenschine, T. Cerling, J. D. Clark, C. Gamble, D. Gifford-Gonzalez, K. Hill, F. C. Howell, B. Isaac, H. McHenry, D. Metcalfe, M. Norton-Griffiths, V. Sarich, P. Shipman, C. Schrire, I. Sinclair, R. Wrangham, and A. Zihlman offered useful comments. D. Gillett provided technical support.

season (mean annual rainfall 300–600 mm). Vegetation is primarily mixed savannah woodland; medium/large mammals are locally abundant (Smith 1980). At the beginning of this century, only the Hadza occupied this country. They lived entirely by hunting and gathering (Obst 1912). Since then, they have suffered gradual encroachment by pastoral and agricultural groups and have also been subjected to a series of government- and mission-sponsored settlement schemes (McDowell 1981). Most Hadza now support themselves by a combination of hunting and gathering, farming, and farm labor, the precise mix of strategies pursued varying locally. Some 200 Hadza are essentially full-time subsistence foragers. During 1985–86, we spent 188 days over 14 months living among the latter, collecting quantitative data on time allocation, foraging returns, and other topics. The data reported here are derived from this fieldwork, which forms part of a larger study of human ecology in this region.

The Hadza we observed (a variable population of 45–75 in the dry season, 35–50 in the wet) pursued a seasonally variable, central-based foraging strategy (Woodburn 1968*a*, Vincent 1985, Hawkes, O'Connell, and Blurton Jones 1987, Blurton Jones, Hawkes, and O'Connell 1987). During the dry season, when medium/large mammals were concentrated near water sources, adult men practiced both encounter and intercept hunting (*sensu* Binford 1978), the latter from blinds near water sources or along heavily used game trails, usually within an hour's walk from the residential base. Weapons were limited to the bow and arrow (often poisoned); traps and snares were not employed except rarely for small birds. Men did not often take small game, although they frequently shot arrows at ground-nesting birds. Women foraged daily for roots and baobab fruit, also within about an hour's walk from camp. Women and boys took tortoises and small mammals whenever they were found. In the wet, when game animals were dispersed, intercept hunting was abandoned. Men continued encounter hunting, again mainly for medium/large mammals, often in the context of honey-collecting trips with their wives. Women also foraged separately for berries and roots. The daily foraging radius for men and women was greater in this season, often up to two hours or more from camp.

Scavenging is a standard part of Hadza foraging (Woodburn 1986*b*). All Hadza monitor the flight of vultures and listen carefully to the nighttime calls of lions and hyenas. While hunting, adult men often visit areas where lions have been active, especially during the dry season, when they are likely to be operating near the same water sources. If they suspect a possible scavenging opportunity, Hadza abandon other activities and move quickly to the spot, often at a run. On arrival, they attempt to drive off any predators that are present and appropriate the kill. Leopards and hyenas usually leave kills as soon as the Hadza appear, but lions do not always retreat immediately and so become hunting targets themselves.

During the study period, Hadza with whom we lived took 54 medium/large mammals (adult live weight > 40 kg) representing 11 species, almost all adults (table 1).

TABLE 1
Medium/Large Mammals (Adult Live Wt. > 40 kg) Acquired by Hadza September 1985–October 1986

	Hunted	Scavenged
Elephant *(Loxodonta africana)*	–	1
Zebra *(Equus burchelli)*	10	2
Warthog *(Phacochoerus aethiopicus)*	3	1
Giraffe *(Giraffa camelopardalis)*	2	1
Eland *(Taurotragus oryx)*	1	–
Greater kudu *(Tragelaphus strepsiceros)*	2	–
Hartebeest *(Alcelaphus buselaphus)*	3	–
Wildebeest *(Connochaetes taurinus)*	3	2
Impala *(Aepyceros melampus)*	17	4
Lion *(Panthera leo)*	1	–
Hyena *(Crocuta crocuta)*	1	–

Eleven carcasses (20% of the total and about 14% of total carcass weight) were obtained by scavenging, the rest by hunting. Apart from elephant, which are never hunted (Woodburn 1968*a*), there were no significant differences in the arrays of species taken by the two methods.

The appendix provides details on each scavenging incident. Six carcasses were acquired over a period of 47 days in the 1985 late dry season (September–October), an average of one every eight days. All were found within 1.3 hour's walk from camp. One was encountered intact less than two minutes after the predator had made the kill; four of the other five were missing only viscera and portions of the upper hind leg. In each instance, predators (lions in four cases, leopards in two) were still on the kill when the Hadza arrived but left immediately or were driven off or killed. In one situation involving a leopard, the Hadza who appropriated the kill were adult women armed only with digging sticks. Average income from scavenging in this season was about 9.5 kg (live weight) per camp per day or about 180 g per camp resident per day (table 2).

Two carcasses were obtained by scavenging during 61 days of observation in the 1985–86 wet season (November–April), an average of one every 31 days. One was found about 30 minutes' walk from camp; the other was about 1.5 hours away. One had been largely consumed by predators and other scavengers; the other was badly decomposed. Mean income from scavenging was about 1.0 kg per camp per day or about 25 g per camp resident per day.

Only one scavengeable carcass was taken during 36 days of observation in the early dry, a giraffe found about 50% intact, three hours' walk from camp, with lions still feeding on it when the Hadza arrived. Because of the size of this animal, average scavenging income for this period was high: 10 kg per day and about 245 g per camp resident per day.

Two carcasses were taken by scavenging in the succeeding late dry, an average for the latter period of one every 22 days. Both were found less than one hour from

TABLE 2
Seasonal Variation in Medium/Large Carcasses Acquired by Hadza Hunting and Scavenging September 1985–October 1986

	Season			
	Late Dry 1985 (Sept.–Oct.)	Wet 1985–86 (Nov.–Apr.)	Early Dry 1986 (May–July)	Late Dry 1986 (Aug.–Oct.)
Number of days observed	47	61	36	44
Number of carcasses acquired by hunting	22	6	4	11
Number of carcasses acquired by scavenging	6	2	1	2
Percentage of total scavenged	21	25	20	15
Estimated weight (kg) of carcasses acquired by hunting	2,930	625	1,190	1,065
Estimated weight (kg) of carcasses acquired by scavenging	435	60	375	10
Percentage of total scavenged	13	9	24	1
Estimated mean carcass weight (kg) available from scavenging per camp per day	9.3	1.0	10.1	0.2
Estimated mean carcass weight (g) available from scavenging per camp resident per day	155–210	20–30	200–290	<5
Average number of days per scavenging encounter	7.8	30.5	36.0	22.0
Average distance (min.) base camp–carcass	45	60	180	<40
Carcass condition				
≥ 75% intact	5	0	–	0
≤ 50% intact	1	2	1	2

NOTE: Carcass weight estimates derived from Coe et al. (1976). Some carcasses (including hunted) acquired incomplete.

camp, one less than 20 minutes away. Both had been heavily ravaged by carnivores. Average income from scavenging in the 1986 late dry season was very low: about 0.2 kg per camp per day and less than 5 kg per camp resident per day.

Our sample of scavenging incidents is small, but it represents the entire suite of medium/large-mammal scavenging events for members of a Hadza camp on 45% of all days over a 14-month period. These data permit some general observations:

1. Scavenging has sometimes been treated as if it were a foraging strategy distinct from and conflicting with other subsistence activities (Shipman 1986). This is not true for the Hadza. For them, as for large mammalian carnivores (Houston 1979) and some nonhuman primates (Butynski 1982, McGrew 1979, Goodall 1986), scavenged resources are simply a subset of a much broader range of potential prey types, in the Hadza case both plant and animal. Scavenging opportunities are recognized and acted on in the course of other activities, mainly routine foraging trips. Eight of the eleven incidents listed in the appendix fit this pattern. In the other three cases (21 Sept. 85, 28 May 86, 22 Sept. 86), Hadza left camp specifically to scavenge but only when prompted by direct evidence of scavenging opportunities. That the Hadza quickly abandon other activities to pursue scavenging opportunities suggests that the mean nutritional return rate from scavenging, where opportunities occur, is comparatively high. Further quantitative analysis should enable us to specify return rates relative to other foraging activities.

2. Hadza scavenging success reflects the ability of armed men to appropriate kills from large carnivores. Five of eleven carcasses, representing about 85% of total scavenged carcass weight, were seized from lions that were still feeding when the Hadza arrived. In three instances the lions had to be driven from the kill; in one a lion itself was killed. Other predator species (in our sample, leopards and hyenas) are less persistent in defense (Houston 1979) but according to our data produce fewer scavengeable kills.

3. Hadza scavenging success seems to vary directly with hunting success, measured either as the number of carcasses acquired by season ($r = 0.97$) or as estimated weight of carcasses acquired by season ($r = 0.75$). Our sample is too small to eliminate the possibility that these relationships are fortuitous, but the data are nonetheless suggestive.

4. Hadza scavenging success varies seasonally with respect to carcass encounter rate and distance from residential base (table 2). This variation probably reflects seasonal differences in medium/large-mammal biomass. Aerial surveys by Smith (1980) and others in 1977–78 showed that medium/large-mammal biomass reached a peak in the late dry season (October 1977: 1,980 kg/km^2). At this time, prey species, predators, and the Hadza themselves were concentrated around a relatively small number of permanent water sources. The situation was apparently similar during our 1985–86 fieldwork; scavengeable carcass encounter rates were relatively high then and distances between base camps and carcasses comparatively short. During the 1977–78 wet

season, Smith and his associates found that prey species, predators, and the Hadza were more dispersed and that many large mammals had left the study area entirely (January 1978 medium/large-mammal biomass: 818 kg/km^2). Again, the pattern was much the same in 1985–86; carcass encounter rates were correspondingly lower and camp-carcass distances greater at this time.

5. This seasonal pattern does not extend to average weight of animal tissue available for consumption, particularly from scavenging (table 2). Mean weights per camp resident per day were relatively high in late dry 1985 and early dry 1986 but much lower in the intervening wet and in late dry 1986. This highlights an important point: the amount of edible tissue available from scavenged carcasses depends not only on the number of encounters and success in interference competition but also on carcass size and completeness on encounter (Blumenschine 1986). The combined effect of these factors makes scavenged animal tissue a highly variable resource for the Hadza regardless of season.

The point is emphasized by considering day-to-day availability rather than seasonal averages. Scavenged meat and marrow were consumed in quantity on as many as 20–25% of all sample days in the late dry season of 1985 and on up to 40% of all days during the last three weeks of that time. Eight months later, in the early dry 1986, *average* income from scavenging was higher (245 vs 180 g per camp resident per day), but all of this tissue came from a single large animal and was gone in three to four days. Scavenged meat was available on only 10% of all sample days in this season. In the succeeding late dry, the situation was still worse. Scavenged meat was available on only 3% of all sample days and even then only in very small quantities.

The Hadza data indicate that scavenging success depends primarily on rate of encounter with scavengeable carcasses, carcass size and completeness on encounter, and ability at interference competition, especially against large felids. Early hominid scavenging success was probably also shaped by these factors. In attempting to assess their effect in Plio/Pleistocene times, four questions seem especially pertinent:

1. Do the Hadza locate all scavengeable carcasses, or would a different search strategy produce a higher encounter rate? Since we lack data on carcass encounters except in the context of Hadza foraging, answers to this question are inevitably speculative. The Hadza forage both singly (men) and in groups (women) over distances generally less than an hour's walk from their residential base in the dry season and up to three hours' walk in the wet. They locate carcasses in the course of foraging for other resources and by monitoring birds and animal calls. The latter indications may be apparent at distances of up to several miles.

Under these circumstances, and especially given the importance of birds and animal calls as markers, it is difficult to see how carcass encounter rates could be much improved. For example, the daily foraging radius could be increased, especially in the dry season; but since the Hadza, other predators, and their prey are already concentrated around the limited number of available water sources, the net result might well be a *decline* in carcass encounters, at least insofar as foraging takes the Hadza away from the stream channels where carcasses are often found. Foraging more widely in the wet would be prohibitively expensive in terms of time taken from searching for and handling other resources and would also entail reduced likelihood of finding carcasses in areas closer to camp.

Alternatively, the average size of women's foraging groups could be reduced, thereby increasing the number of foraging parties. This *might* yield a marginal increase in the number of carcasses encountered, especially those not marked by birds, but would also very likely reduce the probability of success at interference competition (see below) as well as increase the risk of inter- and conspecific predation. Dispersing the Hadza into smaller, more widely separated camps or even as individuals might also increase the total number of carcasses encountered by all Hadza combined but would probably reduce the frequency of individual access to scavenged tissue as a function of reduced opportunities for sharing. Probability of success at interference competition would also be negatively affected.

Following local herbivores in anticipation of scavenging opportunities is probably not a viable option, since herbivore groups are small and difficult to monitor in close cover (cf. Sinclair et al. 1986). Moreover, the foraging opportunity costs associated with such a strategy would be very high.

Since scavenging opportunities are recognizable at distances of up to several miles, and since the Hadza watch for and eagerly seize every opportunity they see, we think that they are about as successful at scavenging as they can be in this habitat. Some alternative foraging strategies might produce marginally better results, but not without incurring additional costs such as increased risk of predation, reduced access to other resources, and lower probability of success at interference competition.

2. How might carcass encounter rates vary in modern East African environments for hunter-gatherers like the Hadza? Potential carcass encounter rates appear to be a function of local medium/large-animal biomass, including the number of predators (Blumenschine 1986). Coe, Cummings, and Phillipson (1976) and East (1984) have shown that in 15 East African wildlife areas medium/large-herbivore and large-carnivore biomass vary closely with each other and with annual rainfall. Medium/large-herbivore biomass figures for the Hadza area (Smith 1980) are within but toward the low end of the range reported by Coe et al. and are correlated with annual rainfall in a similar manner (fig. 1), which means that Hadza country is not depauperate with respect to prey populations, given the local precipitation regime. Data on large-carnivore numbers in Hadza territory are unavailable, but they may be low relative to ungulate biomass and local rainfall because of hunting pressure by pastoralists and the Hadza themselves. Hadza carcass encounter rates might be higher, but probably not much higher, if more carnivores were present. They are proba-

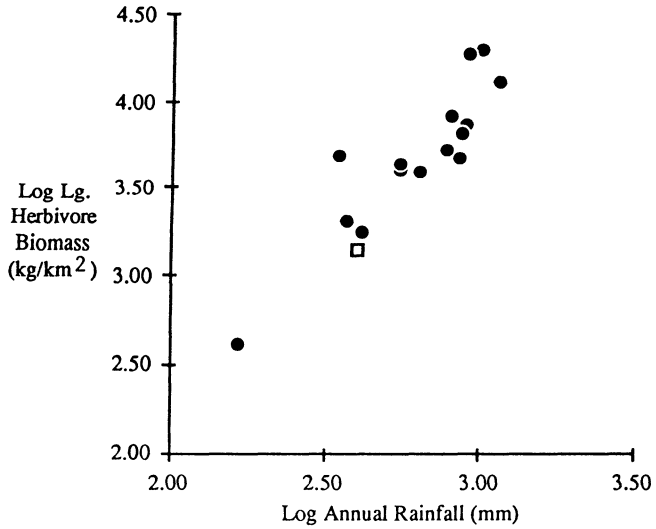

FIG. 1. *Relationship between annual rainfall and large-herbivore biomass from 15 East African wildlife areas (Coe et al. 1976) and Hadza area (Smith 1980).* Open square, *Hadza area.*

bly below the average potentially available in the 15 wildlife areas reported by Coe et al. and East.

3. How would Plio/Pleistocene carcass encounter rates have compared with those experienced by the Hadza? Savannah woodland environments marked by highly seasonal rainfall have been typical of East Africa for at least the last three million years (Coppens et al. 1976, Bonnefille 1979). Medium/large-mammal faunas have also been broadly similar throughout this time (van Couvering 1980, Vrba 1980, Kappelman 1984). Data on paleosol carbonate isotopes from Olduvai Gorge lead Cerling and Hay (1986) to infer that temperatures at the Plio/Pleistocene boundary were about 5–7° C lower and average precipitation about 40% higher than at present. If the modern relationship between rainfall and biomass described by Coe et al. and East prevailed in the past, then in at least some parts of Plio/Pleistocene East Africa medium/large-herbivore and carnivore numbers may have been significantly higher than they are now. Indications of increased taxonomic diversity in the paleontological records from Olduvai and East Turkana (Blumenschine 1986 and references therein), especially in the larger body-size classes, are consistent with this expectation.

More precise if highly speculative estimates of biomass and carcass encounter rates are possible. Cerling and Hay (1986) estimate the average annual rainfall at Olduvai in Bed I times at 800–1,000 mm. Using Coe et al.'s regression equation, this suggests a local medium/large-mammal biomass of roughly 8,000–11,000 kg/km^2 (cf. Shipman 1986), about five to eight times the figure for modern Hadza country. If these estimates are correct, and if carcass encounter rate varies directly with biomass, then carcass encounter rates might have been about five to eight times what they are in Hadza country today. A 40% increase in annual rainfall at East Turkana in the Plio/Pleistocene suggests a medium/large-mammal biomass of about 1,000 kg/km,^{2} roughly the same as the wet-season figure for modern Hadza territory. Carcass encounter rates might have varied accordingly. In other words, carcass encounter rates documented for the Hadza might be within and not more than an order of magnitude below the top end of the range of rates experienced by Plio/Pleistocene hominids in the two areas from which we have the most archaeological data. The presence of more large-bodied herbivores, whose carcasses persist for longer periods than those of smaller creatures (Blumenschine 1986), may have improved the average returns available to early hominid scavengers but are also likely to have increased their variance. These estimates are necessarily highly speculative. The opportunities for nomadic scavengers following ungulate migrations may have been greater, with less seasonal variability (Sinclair et al. 1986), but this pattern seems unlikely to have characterized the hominids associated with Plio/Pleistocene archaeological sites (Potts 1984).

4. Could early hominids have displaced large carnivores in competitive encounters? Bunn and Kroll (1986) and Potts (1984) rely on features of the relevant archaeological assemblages in suggesting that early hominids had this ability. Other commentators (Shipman 1986, Blumenschine 1986, Binford 1985) calculate scavenging opportunities as though they did not and estimate potential scavenging income for hominids as a function of amounts of edible tissue abandoned or unused by initial predators and other scavengers. Morse (1974) and Eaton (1979) show that success in interference competition depends partly on the relative body sizes of the individuals involved: larger individuals typically exclude or displace smaller ones. Shipman (1986) reckons that because Plio/Pleistocene hominids were smaller than most large East African carnivores (i.e., machairodont felids, lions, leopards, spotted hyenas), they must have been relegated to a subordinate role in the scavenging hierarchy. However, as she notes, Eaton (1979) also shows that relative group size can be an important determinant of competitive success. His summary of data on interference competition among large East African carnivores includes many instances in which groups of wild dogs and hyenas, sometimes including only two or three members, dominated individual lions in contests over food. The fact that chimpanzees are known to display with sticks and stones against carnivores (Goodall 1986) and in at least one instance apparently to have seized a kill from a leopard (Hasegawa et al. 1983) suggests that early hominids may indeed have been able to displace larger carnivores from kills, given a sufficient numerical advantage (Kortlandt 1963, Albrecht and Dunnett 1971). Stone throwing may have been especially important in such situations (Isaac 1987). Upright posture may have conferred the additional advantage of greater apparent size.

Because the Hadza pursue every scavenging opportunity they recognize, their success suggests the upper limits of this resource for a terrestrial home-range forager in comparable environments. If early hominids

could arrive quickly at kills and take carcasses from primary predators, the income potentially available from this activity might have equaled that of the modern Hadza where ungulate and predator densities were similar. They might have done better, perhaps much better, in higher-biomass localities, especially in some late dry seasons (see Speth 1987 for an important qualification about the value of meat in the dry season). On the other hand, because scavenging returns vary greatly over the short run, primarily as a result of random variation in carcass size and completeness on encounter, scavenging was probably not the "primary" food source sometimes suggested, even if early hominids were successful interference competitors. Scavenged animal tissue was more likely a windfall resource: briefly, sometimes seasonally abundant but generally unavailable on a day-to-day basis. Schaller and Lowther (1969) drew a similar conclusion in the Serengeti.

We note that success at interference competition need not imply significant hunting ability, especially the ability to take medium/large-mammalian prey (and conversely). A creature that could effectively threaten large carnivores by waving sticks or throwing stones might have been unable to capture healthy ungulates. A hominid that could run ungulates to exhaustion (Carrier 1984) might have been unable to threaten large carnivores. However, if early hominids were effective scavengers without also being effective and dangerous hunters, they would be unusual in comparison with modern large terrestrial East African predator-scavengers, including the Hadza, for whom hunting and scavenging are closely linked (Houston 1979, Schaller 1972, Kruuk 1972). Finally, if early hominids could *not* displace large carnivores, then their potential income from scavenging within home ranges is suggested by the two cases in which Hadza acquired carcasses without interference competition (26 Dec. 85, 20 Apr. 86). Given these and comparable returns from the other nine carcasses once the original predators had abandoned them, the total amount of scavenged animal tissue available to the Hadza would have been small indeed. The amount available to an early hominid unable to displace large carnivores would probably also have been small, even in the most favorable habitats.

APPENDIX: CARCASSES SCAVENGED BY HADZA SEPTEMBER 1985–OCTOBER 1986[2]

Late dry season 1985 (47 days observed)

21 Sept./mid-morning: Four to six adult men learn of lion kill (probably marked by vultures) about 1 hr. from residential base, leave immediately for the spot. On arrival, find "many" lions resting near heavily ravaged wildebeest carcass. One lion is shot and killed with bow and arrow; others run off. Lion carcass recovered intact, counted as hunted. Wildebeest said to have been "completely consumed" by lions, but some meat (probably small quantity) and marrow may have been obtained. Wildebeest carcass counted as scavenged but not included in weight estimates.

26 Sept./early morning: Adult man and teenaged boy encounter two adult female lions feeding on adult wildebeest killed previous night at small swamp 20 min. from residential base, shoot arrows to drive lions from kill. Carcass recovered with viscera completely, upper hind quarter partly consumed.

11 Oct./early morning: Adult man finds adult zebra killed previous night by two lions in dry watercourse 30 min. from residential base. Lions apparently flee at his approach. Carcass recovered with viscera completely, upper hind quarter partly consumed.

13 Oct./mid-morning: Five women and one man foraging for baobab encounter adult female impala freshly killed by leopard 1.3 hr. from residential base. Leopard flees at their approach. Carcass recovered with viscera and upper hind quarter partly consumed.

18 Oct./mid-morning: Adult man and wife encounter three adult lions feeding on adult zebra killed previous night in small dry watercourse about 1 hr. from residential base. Man shoots arrows to drive lions off kill. Carcass recovered with viscera completely, upper hind quarter partly consumed.

31 Oct./late afternoon: Three adult women foraging for roots about 30 min. from residential base hear leopard kill immature impala. Leopard flees at their approach. Carcass recovered intact.

Wet season 1985–86 (61 days observed)

26 Dec: Over a period of several days, young boys scavenge small quantities of meat (< 50 kg total) from largely intact but decomposing elephant carcass found in stream channel about 30 min. from residential base.

20 Apr./mid-afternoon: Two young men and a boy find impala apparently killed by leopard, later scavenged by one hyena, then by vultures, 1–2 hrs. from residential base. Pelvis, rear limbs, lower vertebrae gone; head, front limbs (including scapulae), some vertebrae and ribs recovered.

Early dry season, 1986 (36 days observed)

28 May/early morning: Distant hyena calls attract attention. Two adult men, two women, four adolescent boys, and one girl leave at first light to investigate, walk 3 hrs., guided during last by sight of vultures circling. Encounter three adult lions (two male, one female) resting on partly consumed adult giraffe, about 20 hyenas waiting at a distance. Hyenas leave as they arrive; lions driven from kill with arrows. Carcass recovered with viscera completely consumed, most meat gone from hindquarter, ribs, forequarters on upper side of carcass, lower side intact.

2. Total days observed 188. Scavenging incidents 13 and 31 Oct. 1985 witnessed by K. Hawkes; all others described by Hadza involved, usually within two to three hours and in no case more than six to eight hours after the incident in question took place. Included here are only those incidents in which Hadza recovered at least some edible tissue; several cases in which Hadza investigated apparent scavenging opportunities and procured nothing were recorded, but our records probably do not provide a reliable estimate of their frequency.

Late dry season 1986 (44 days observed)

22 Sept./first light: Hyena calls attract attention. Single adult man leaves camp to investigate, finds warthog carcass within 20 min. Animal killed previous night by lion, later scavenged by hyenas that flee at his approach. Carcass recovered with viscera completely consumed, most meat gone from limbs, axial skeleton, head near fully fleshed, limb bones intact.

24 Oct./mid-morning: Two young adult men return to residential base with four complete but defleshed articulated limbs from immature impala scavenged from hyenas. Carcass probably encountered less than 1 hr. away. No data on carcass condition on encounter but suspect it was heavily ravaged. Head may have been intact, consumed by Hadza in field.

References Cited

ALBRECHT, H., AND S. C. DUNNETT. 1971. *Chimpanzees in West Africa.* Munich: Piper-Verlag.

BINFORD, L. R. 1978. *Nunamiut ethnoarchaeology.* New York: Academic Press.

———. 1981. *Bones: Ancient man and modern myths.* New York: Academic Press.

———. 1985. Human ancestors: Changing views of their behavior. *Journal of Anthropological Archaeology* 4:292–327.

BLUMENSCHINE, R. 1986. *Early hominid scavenging opportunities: Implications of carcass availability in the Serengeti and Ngorongoro ecosystems.* British Archaeological Reports International Series 238.

BLURTON JONES, N., K. HAWKES, AND J. O'CONNELL. 1987. Studying costs of children in two foraging societies: Implications for schedules of reproduction. Paper presented at the conference "Comparative Socioecology of Mammals and Man," Durham, U.K., April 13–16.

BONNEFILLE, R. 1979. Méthode palynologique et reconstitutions paléoclimatiques au Cenozoique dans le Rift Est Africain. *Bulletin de la Société Géologique Française* 7, 21:331–42.

BUNN, H., AND E. KROLL. 1986. Systematic butchery by Plio/Pleistocene hominids at Olduvai Gorge, Tanzania. CURRENT ANTHROPOLOGY 27:431–52.

BUTYNSKI, T. M. 1982. Vertebrate predation by primates: A review of hunting patterns and prey. *Journal of Human Evolution* 11:421–30.

CARRIER, D. 1984. The energetic paradox of human running and hominid evolution. CURRENT ANTHROPOLOGY 25:483–93.

CERLING, T., AND R. HAY. 1986. An isotopic study of paleosol carbonates from Olduvai Gorge. *Quaternary Research* 25:63–78.

CLARK, J. D. 1959. *The prehistory of southern Africa.* Baltimore: Penguin.

COE, M. J., D. H. CUMMINGS, AND J. PHILLIPSON. 1976. Biomass and production of large African herbivores in relation to rainfall and primary production. *Oecologia* 22:341–54.

COPPENS, Y., F. C. HOWELL, G. LL. ISAAC, AND R. LEAKEY. 1976. *Earliest man and environments in the Lake Rudolf Basin: Stratigraphy, paleoecology, and evolution.* Chicago: University of Chicago Press.

DART, R. A. 1953. Predatory transition from ape to man. *International Anthropological and Linguistic Review* 1:201–17.

EAST, R. 1984. Rainfall, soil nutrient status, and biomass of large African savannah animals. *African Journal of Ecology* 22:245–70.

EATON, R. L. 1979. Interference competition among carnivores: A model for the evolution of social behavior. *Carnivore* 2:9–16.

GOODALL, J. 1986. *The chimpanzees of Gombe: Patterns of behavior.* Cambridge: Belknap Press of Harvard University Press.

HASEGAWA, T., M. HIRAIWA, T. NISHIDA, AND H. TAKASAKI. 1983. New evidence on scavenging behavior in wild chimpanzees. CURRENT ANTHROPOLOGY 24:231–32.

HAWKES, K., J. O'CONNELL, AND N. BLURTON JONES 1987. Hardworking Hadza grandmothers. Paper presented at the conference "Comparative Socioecology of Mammals and Man," Durham, U.K., April 13–16.

HOUSTON, D. C. 1979. "The adaptations of scavengers," in *Serengeti: Dynamics of an ecosystem.* Edited by A. R. E. Sinclair and M. Norton-Griffiths, pp. 263–86. Chicago: University of Chicago Press.

ISAAC, B. 1987. Stone throwing and human evolution. *African Archaeological Review.* In press.

ISAAC, G. LL., AND D. CRADER. 1981. "To what extent were early hominids carnivorous? An archaeological perspective," in *Omnivorous primates: Gathering and hunting in human evolution.* Edited by R. S. O. Harding and G. Teleki, pp. 37–103. New York: Columbia University Press.

KAPPELMAN, J. 1984. Plio-Pleistocene environments of Bed I and lower Bed II, Olduvai Gorge, Tanzania. *Palaeogeography, Palaeoclimatology, Palaeoecology* 48:171–96.

KORTLANDT, A. 1963. Bipedal armed fighting in chimpanzees. *Proceedings of the 16th International Congress of Zoology* 3:64.

KRUUK, H. 1972. *The spotted hyena: A study of predation and social behavior.* Chicago: University of Chicago Press.

MCDOWELL, W. 1981. A brief history of the Mangola Hadza. MS, Rift Valley Project, Ministry of Information and Culture, Division of Research, Dar es Salaam, Tanzania.

MCGREW, W. 1979. "Evolutionary implications of chimpanzee predation and tool use," in *The great apes.* Edited by D. A. Hamburg and E. R. McCown, pp. 441–64. Menlo Park: Benjamin/Cummings.

MORSE, D. H. 1974. Niche breadth as a function of social dominance. *American Naturalist* 108:818–30.

OBST, E. 1912. Von Mkalama ins Land der Wakindiga. *Mitteilungen der Geographischen Gesellschaft in Hamburg* 26:2–27.

POTTS, R. 1984. "Hominid hunters? Problems of identifying the earliest hunter-gatherers," in *Hominid*

evolution and community ecology: Prehistoric human adaptation in biological perspective. Edited by R. Foley, pp. 129–66. New York: Academic Press.

SCHALLER, G. 1972. *The Serengeti lion: A study of predator-prey relations.* Chicago: University of Chicago Press.

SCHALLER, G., AND G. LOWTHER. 1969. The relevance of carnivore behavior to the study of early hominids. *Southwestern Journal of Anthropology* 25:307–41.

SHIPMAN, P. 1986. Scavenging or hunting in early hominids: Theoretical framework and tests. *American Anthropologist* 88:27–43.

SINCLAIR, A. R. E., M. D. LEAKEY, AND M. NORTON-GRIFFITHS. 1986. Migration and hominid bipedalism. *Nature* 324:307–8.

SMITH, L. 1980. The distribution of Hadza hunter-gatherers in relation to their resources. MS, Department of Anthropology, University of Utah.

SPETH, J. 1987. Early hominid subsistence strategies in seasonal habitats. *Journal of Archaeological Science* 14:13–29.

SZALAY, F. S. 1975. Hunting-scavenging protohominids: A model for hominid origins. *Man* 10:420–29.

VAN COUVERING, J. 1980. "Community evolution in East Africa during the Late Cenozoic," in *Fossils in the making.* Edited by A. Behrensmeyer and A. Hill, pp. 272–98. Chicago: University of Chicago Press.

VINCENT, A. S. 1985. Wild tubers as a harvestable resource in the East African savannas: Ecological and ethnographic studies. Ph.D. diss., University of California, Berkeley, Calif.

VRBA, E. 1980. "The significance of bovid remains as indicators of environment and predation patterns," in *Fossils in the making.* Edited by A. Behrensmeyer and A. Hill, pp. 247–71. Chicago: University of Chicago Press.

WOODBURN, J. C. 1968*a*. "An introduction to Hadza ecology," in *Man the hunter.* Edited by R. Lee and I. DeVore, pp. 49–55. Chicago: Aldine.

———. 1968*b*. "Discussions, part VII," in *Man the hunter.* Edited by R. Lee and I. DeVore, p. 342. Chicago: Aldine.