Hadza meat sharing

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Abstract

In most human foraging societies, the meat of large animals is widely shared. Many assume that people follow this practice because it helps to reduce the risk inherent in big game hunting. In principle, a hunter can offset the chance of many hungry days by exchanging some of the meat earned from a successful strike for shares in future kills made by other hunters. If hunting and its associated risks of failure have great antiquity, then meat sharing might have been the evolutionary foundation for many other distinctively human patterns of social exchange. Here we use previously unpublished data from the Tanzanian Hadza to test hypotheses drawn from a simple version of this argument. Results indicate that Hadza meat sharing does *not* fit the expectations of risk-reduction reciprocity. We comment on some variations of the ''sharing as exchange'' argument; then elaborate an alternative based partly on the observation that a successful hunter does not control the distribution of his kill. Instead of family provisioning, his goal may be to enhance his status as a desirable neighbor. If correct, this alternative argument has implications for the evolution of men's work. © 2001 Elsevier Science Inc. All rights reserved.

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1. Introduction

Among behavioral ecologists and evolutionary psychologists, an exchange model, based on Trivers' (1971) ''reciprocal altruism,'' is commonly used to explain the wide sharing of certain foods, especially the meat of large animals, among ethnographically known hunter–

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gatherers. Sharers are seen as altruistic because they incur a cost in relinquishing some of the meat from their kills. But the shares are given up in exchange for the recipients' obligation to return shares of meat in the future; so the short run cost is repaid after a delay. Where the prey involved are large, the cost of such give-aways may seem relatively small because the hunter and his family can only eat so much meat at one time; and the benefits of repayment are especially high because of the hunter's risk of failure. Thus, the meat a man receives when he is not successful is worth more to him and his family than the meat he gives away. Over time, the net gains mount: those who share reciprocally do better than those who do not (Cashdan, 1985; Kaplan & Hill, 1985a, 1985b; Smith, 1988; Winterhalder, 1986, 1997).

Risk-reduction reciprocity is still risky. The delay between transfers raises the possibility that a recipient will fail to repay, leaving sharers uncompensated for their costs. Relating the problem to the famous prisoner's dilemma in game theory, Trivers (1971) saw this "cheating" as the main hurdle to the evolution of reciprocal altruism. Unless cheating is penalized, those who take without repaying will do better than reciprocators. Subsequent modeling, relying especially on iterated prisoner's dilemmas, confirmed that unconditional cooperation is vulnerable to free-riders. It also showed that reciprocators could do well if they clustered together and excluded cheaters (e.g., Axelrod & Hamilton, 1981).

Trivers (1971, 1985) applied reciprocal altruism to a wide array of interactions, from the interspecific symbioses of cleaner fish to alarm calling in birds and to human cooperation. He offered examples of human reciprocal altruism and speculated about aspects of human emotional and cognitive architecture that might have evolved to serve this kind of cooperation. The more encompassing the reciprocal interdependence, he argued, the more selection should favor capacities to take advantage of reciprocal exchanges. This includes not only initiating exchange relationships, but practicing subtle forms of cheating unlikely to be detected, and also detecting subtle forms of cheating by others. He showed how this model might help explain various features of human social behavior, emotion and cognition, including friendship, dislike, moralistic aggression, gratitude, sympathy, trust, suspicion, guilt, hypocrisy, and even altruistic behavior toward strangers.

Trivers' model, especially as represented by tit-for-tat in iterated prisoner's dilemmas, provides the "pathway to the evolution of cooperation," that has received the most attention from behavioral biologists, where "theoretical work on the evolution of cooperation is *heavily* skewed toward models of reciprocity" [original italics] (Dugatkin, 1997, p. 167). Diagnostics include: (1) an initial cost to cooperation — so there is short-term altruism, (2) a cost to repaying — so there is a temptation to default, and (3) score-keeping — so that cooperators do not continue to supply benefits to those who do not repay.

Axelrod and Hamilton's (1981) treatment showed that reciprocal altruism as captured by a tit-for-tat strategy in iterated two-person prisoner's dilemmas could not spread when rare, but could resist invasion by defectors when it was frequent, as long as consistent defection and tit-for-tat were the only two strategies allowed in the game. Models that alter aspects of this classic treatment have since proliferated. Dugatkin (1997, p. 24) summarized the results of about 70 of them that include "variations in population structure, number of players, number of strategies, readiness of players, stochasticity of strategies, stochasticity of environment, amount of memory, possibility of individual recognition, norms, ostracism, mobility of players and mistakes by players." This work shows that, in spite of the intuitive appeal of

reciprocal altruism, the conditions governing its emergence and/or resistance to invasion by alternative strategies are quite restrictive. Both theoretical and empirical work have dampened initial expectations that this was the main path to the evolution of cooperation in nonhuman animals.

The same skepticism about reciprocal altruism as the pathway to cooperation has not been applied to the human case. Dugatkin (1997, p. 167) assumes that "because humans are quite good 'score keepers,' reciprocity is the most salient form of human cooperation." Meat sharing among hunter–gatherers continues to be a commonly used concrete illustration of reciprocal altruism and its importance in human evolution (Cosmides & Tooby, 1992; Pinker, 1997; Ridley, 1996).

1.1. Conditional sharing

If meat sharing were organized to reduce the risk of hungry days, and if some hunters were more successful than others, then successful ones could pay off their debts to poorer hunters more quickly while the poorer hunters would accumulate debts they cannot pay. The better hunters would gain no insurance benefit by continuing to share as much with poor hunters as with good ones (Winterhalder, 1986).

But exchanges need not be balanced to be the result of reciprocal deals, worthwhile to each party. Boyd (1992) developed a set of models that illustrates this point, a useful reminder that cooperation need not imply equal costs or benefits for all (Hawkes, 1992a). If individuals differ in the benefits they can offer or the costs they incur, there may be gains from trade for both parties, even though one gives small benefits often, while the other repays with large benefits only intermittently. Of course, it could be the other way around — one providing large benefits often while the other gives only small benefits intermittently. In the case of meat sharing, better hunters may continue to give shares more often, even though they are not repaid in larger shares because the occasional shares they get from recipients are better than nothing. That would put all the bargaining leverage on the side of the poorer hunters, implying that they could refuse to repay past debts (should the chance come to do so) if the flow of shares to them stopped. If receipt of a share *does* obligate the receiver to repay, then hunters gain no more chance of repayment by putting anyone who already owes them meat any deeper in debt. If the incentive to give a share is the expected meat repayment, then the simplest expectation is that men should share less with those less likely to repay, and share less — or not at all — with others already in debt to them.

The unpredictability of big game hunting among ethnographically known low-latitude hunter–gatherers could have another effect on score keeping. Since even the best hunters face a high risk of failure, they may view success as partly a matter of chance. Someone who happens to be unsuccessful for a long stretch of time may have a change of fortune. If this were the case, then men who spent more effort hunting might be better credit risks. If all have about the same luck when they hunt, then those who allocate little effort would be free-riding on the work of others. Under these circumstances, men might repay meat with hunting effort. If so, those who allocate little effort would receive fewer and smaller shares than those who work harder.

This reasoning leads to a series of predictions from the simple risk-reduction reciprocity model about relationships among hunters' acquisition rates, foraging effort, and meat sharing. We use data collected among the East African Hadza to test them.

2. Overview of Hadza settlement and subsistence

The Hadza are a population of about 750 hunter–gatherers living in the arid savanna woodlands of the Eastern Rift, southeast of Lake Eyasi, northern Tanzania (Blurton Jones, Smith, O'Connell, Hawkes, & Kamazura, 1992; Woodburn, 1968). Data reported here were obtained in the course of several periods of fieldwork, beginning in the mid-1980s, among the 200–300 Hadza then living in the 600–800 km^2 district known locally as Tli'ika.

Throughout the study period, most Hadza in Tli'ika were likely to be found in one of five to seven camps, each with about 35–50 inhabitants (O'Connell, Hawkes, & Blurton Jones, 1991). Camps were generally larger in size and fewer in number in the dry season (June–November), smaller and more numerous in the wet. Occupation times varied from a week to more than 2 months. Each camp was divided into about 8–12 household areas, about half occupied by nuclear families, most of the rest by unmarried women, their unmarried adolescent daughters or granddaughters, and their preadolescent children or grandchildren. Most camps also included at least one household composed of teenagers and young adults of the same sex, usually males. Nuclear family households generally had about four to six occupants and were stable in composition; other households were smaller and more labile.

During 1985–1986, Hawkes and O'Connell followed a single group of roughly constant size, but intermittently changing composition, through a series of five such camps, collecting data on time allocation and foraging. For purposes of analysis, this part of the study period is divided into seven "seasons," defined on the basis of camp location and foraging patterns (see Hawkes, O'Connell, & Blurton Jones, 1997 for further details). Additional data were also collected by Hawkes, O'Connell and Blurton Jones among similar groups from late 1986 through mid-1989 (e.g., Blurton Jones, Hawkes, & O'Connell, 1997; Hawkes, O'Connell, & Blurton Jones, 1995), and more recently by Marlowe (1999).

Patterns in women and children's foraging have been reported in detail elsewhere (Blurton Jones, Hawkes, & Draper, 1994; Blurton Jones, Hawkes, & O'Connell, 1989; Blurton Jones et al., 1997; Hawkes et al., 1989, 1995, 1997). Women usually traveled in groups of five to seven adults, typically accompanied by one man or an older boy who provided protection, especially from local Datoga pastoralists. They collected tubers in all seasons, berries throughout the wet, baobab most often in the early dry. Most of the food was eaten by the collector and members of her immediate household. Children over the age of five foraged on their own in small groups, or in the company of their mothers and grandmothers. Target resources were mainly plants, but older boys took small game whenever possible. Boys generally ate what they collected right on the spot; girls were more likely to gather enough to bring back to camp (Hawkes et al., 1995).

Men hunted in all seasons (O'Connell, Hawkes, & Blurton Jones, 1988a, 1990, 1992). Their principal targets were large ungulates, mainly giraffe, zebra, and impala. All were shot

with bow and arrow (usually poisoned). Hunting took two forms, *ambush* and *encounter*. Ambush hunting was practiced only in the late dry, when prey were concentrated around a small number of perennial water points. Hunters worked alone or in pairs, mainly at night, from blinds overlooking the more heavily used waters or along nearby game trails. Since men were always armed, encounter hunting was effectively pursued in all seasons, whenever they were away from camp. At every opportunity, men also *scavenged* kills made by other predators (mainly lions), sometimes killing the predators themselves in the process (O'Connell, Hawkes, & Blurton Jones, 1988b).

Once a carcass was acquired, news spread quickly. The location of a carcass was pinpointed by word of mouth, and also by circling vultures and, at night, the calls of lions and hyenas. Not only those tracking the animal but often other men, women, and children converged on a kill site (O'Connell et al., 1988a). Large carcasses were routinely butchered on the spot; then brought back to the hunter's camp, usually with the help of other residents. Carrying parties varied in size from 2–25, depending on the size of the carcass (O'Connell et al., 1990). If the animal was very large, residents of other camps might also come to carry meat, though generally to their own rather than to the hunter's camp. Much meat was often consumed at the kill, sometimes over periods of several hours (O'Connell et al., 1992). Meat returned to camp was allocated by household before transport. Once there, it was usually cooked and consumed by members of the household to which it was initially assigned, though it was not uncommon for others to join in the eating. Meat was also shared with visitors from other camps drawn by news of the kill to the camp of the hunter. The larger the carcass, the more likely such visitors were to appear.

In addition to meat and plants, the Hadza living in Tli'ika also collected honey from early wet through early dry. Most of it was eaten at the various collection sites. When sizable amounts were brought back to camp, only a fraction was left visible and open to claim by those present.

Both meat and honey were occasionally exchanged with non-Hadza neighbors for corn, millet, tobacco, and marijuana. The main impediment to this trade was the difficulty of accumulating food in a Hadza camp. In this climate, meat dries quickly in the sun, forming a protective rind that extends its edibility. But meat left in the open draws attention: there are usually plenty of Hadza ready to eat it.

3. Data sets

The information on time allocation, large game acquisition, and meat sharing used to test hypotheses drawn from the simplest propositions related to risk reduction reciprocity come from an array of data sets. Here we describe those data sets, listed in Table 1, and the procedures used to construct them.

3.1. Daylight time allocation and late dry season night-time hunting

Quantitative data on time allocation were gathered throughout the 1985–1986 study period by means of "instantaneous" camp scans, focal-person follows, and observations of

Table 1
Description of the data sets used in this analysis

Name of data set	Form of measure used	Collection dates
(1) Daylight time allocation (14 men)	(a) seasonal averages of individual men (b) normalized seasonal scores	1985–1986 (7 seasons)
(2) Night-time hunting effort (5 men)	number of nights out/days resident	1985, late dry season only
(3) Overall hunting acquisition	(a) captures/man/day >2000 hunter-days	1985–1986 (7 seasons), 1986, 1988 and 1989
	(b) kg(live weight)/hunter-day (c) kg(live weight)/resident consumer-day	
(4) Individual hunting acquisition rates (14 men)	(a) overall captures/days resident (b) seasonal captures/ days resident	1985–1986 and 1988
(5) Meat sharing (18 men)	(a) 113 household meat shares (kg of meat) (b) 80 parcels acquired and received by a resident man	1985–1986 and 1988

departures and returns summarized in daily logs of camp residents' activities (Data set 1, Table 1). Scans were spot checks on the activities of all individuals present in camp at the time of the scan. They were distributed throughout the 12 daylight hours, never more than two per hour on any given day, with an average of 13 scans per day. Running totals were kept of the number of scans completed during each daylight hour to ensure even distribution across the day. This work produced a sample of roughly 1700 scans, each including observations on about 10–40 individuals.

The activities of residents absent during a scan were determined from follows and daily activity summaries. Follows provide detailed records of the behavior of one or more individuals accompanied by Hawkes or O'Connell on day-trips away from camp. Activity summaries were compiled at the end of each day. Data from scans and follows were collated and any gaps in the records for particular individuals identified. These were sometimes filled simply by inquiry. When a resident's location at the time of a particular scan could not be determined, that person was recorded as "not seen." The data set so produced includes more than 50,000 behavioral records, each identifying a particular subject, activity, and location at a particular point in time.

This time allocation sample was partitioned for analysis by season on the basis of camp location and activities (Table 2). Visitors and those resident for only a few scans in a single season were eliminated from that subset because we could not see how visitors or people moving to or from another camp spent the rest of an observation day. And, although the scans across each season sample all hours of the day fairly evenly, they do not do so every day. Time budgets calculated on small numbers of days may be distorted accordingly. Unmarried men, who move frequently among camps, are under-represented as a consequence.

Time budgets were then calculated for each camp resident for each season, resulting in a sample of 245 individual time budgets. People resident in the study camp in more than one season had separate time budgets for each season. Ninety Hadza individuals are represented, each time budget (representing one person-season) based on an average of 114 ± 5 observa-

Table 2
Seasonal conditions, number of days observed, number of camp scans, number of large animals taken by members of the focal camp during 1985–1986 time allocation sample period, Data set 1, in Table 1

Season	Condition	Days observed	Number of camp scans	Large animals taken
1 (September–October)	late dry	47	195	30
2 (November–December)	early wet	18	173	2
3 (December)	early wet	9	85	3
4 (January)	early wet	5	52	0
5 (March–April)	late wet	14	383	1
6 (May–June)	late wet	21	359	2
7 (July–August)	early dry	30	460	5
		[= 144]	[= 1707]	[= 43]

tions.[1] Total observations in time budgets vary because the number of scans varies by season, as does the number of days any particular subject was resident in each camp. Here we use all the seasonal time budgets we have for married men (14 men, 37 time budgets) to estimate daylight hunting time. This is Data set 1a in Table 1.[2]

In the late dry season of 1985, men spent some nights ambush hunting from blinds. We use the number of nights a man spent ambush hunting divided by the number of days he was resident of the study camp that season as an index of his night-time hunting effort (Data set 2, Table 1). Night-time hunting is treated separately because it does not trade-off against daylight activities in the simple, direct way that daylight hunting does.

Activity patterns and diet vary by season, and the pool of subjects varies among seasons as well, so seasonal variation could obscure other relationships. For example, men spent the night in hunting blinds on about 30% of the days in the late dry season of 1985. This night-time hunting is associated with less time allocated to daylight hunting in that season.[3] Any man resident in the study camp only in other seasons could, for that reason alone, show an overall average of more daylight time allocated to hunting. We therefore used normalized

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[1] Distributions are characterized by means ± S.E. throughout.

[2] All the daylight time men spent away from camp in which the primary activity was foraging is counted as hunting time. That includes time spent searching for, pursuing, tracking, butchering, eating, and carrying game, as well as time spent seeking, extracting, and eating honey and baobab, and traveling with women's foraging parties. Not included is time spent traveling to other Hadza camps. Since Hadza men are always armed and alert to potential hunting and scavenging opportunities, not counting "visiting-related" travel time underestimates hunting effort. On the other hand, men engage in foraging activities other than big game hunting. On most days away from camp, men collect plant food snacks and (much less often) small game for themselves. They occasionally bring home small game and sometimes baobab fruit. When accompanying women's foraging parties, they may collect and eat small amounts of the target resource (e.g. Hawkes et al., 1995). In some seasons, they search specifically for honey. But during all this time they are also ready to pursue large prey. Equating daylight foraging time with daylight hunting time errs in both directions, but attempts to increase the precision of the estimate are likely to introduce other biases. We therefore use overall daylight foraging time as our best estimate of daylight encounter hunting and scavenging effort (Data set 1, Table 1).

[3] Daylight hunting time for men and adolescent boys combined: late dry, $n = 8$, mean = 2.4 ± 0.46 h/day; other seasons, $n = 56$, mean = 5.4 ± 0.34 h/day; $P = .002$).

effort scores by season when investigating individual variation in daylight foraging. These are z scores indicating the relationship between a man's average daylight foraging time that season and the mean of the average daylight foraging times of other resident men that season (Data set 1b, Table 1).

3.2. Overall meat acquisition, individual acquisition rates, and meat sharing

Data on men's overall meat acquisition and meat sharing are drawn not only from the 1985–1986 study period, but from later ones as well. Data collection routines throughout were similar to those used in 1985–1986 (see Blurton Jones et al., 1989; Blurton Jones, Hawkes, & O'Connell, 1996; Blurton Jones et al., 1997; Hawkes et al., 1989, Hawkes, O'Connell, & Blurton Jones, 1991; Hawkes et al., 1995; O'Connell et al., 1990, 1992).

Estimates of average men's overall meat acquisition are presented as daily rates, based on camp census data and records of all large animal prey hunted or scavenged by study camp residents during the main 1985–1986 study period, the 1986 and 1988 late dry seasons, and parts of the 1989 wet season (Data set 3, Table 1). This sample includes the 71 large animals taken by hunters resident in the study camp. The sizes of those animals are also used to evaluate biases in the sample of 20 large animals for which household meat shares were weighed (see below). Estimates of the acquisition rates of *individual* men are based on the number of days a man was resident of a study camp during 1985–1986 and late dry season of 1988, and on all the large animal prey he acquired during those times (Data set 4a, Table 1). When seasonal rates are used (Data set 4b, Table 1) these come only from 1985–1986.

Records of household sharing include 113 nuclear family household shares from 20 large animal kills (Data set 5a, Table 1). These are all the cases in 1985–1986 and 1988 in which we weighed the complete set of household meat shares. The 20 prey include 16 of the 71 animals killed by hunters resident in study camps during 1985, 1986, 1988, and 1989, and another four animals that were killed by men then resident in other camps. We include the latter because they represent the between-camp component of Hadza meat sharing.

The household meat shares referred to as Data set 5 (Table 1) are detailed in Appendix A. Shares reported there *do not* include meat eaten or abandoned at the kill site, that taken from the kill to other camps, that distributed to households without married men, or *epeme* (organs reserved for adult men and eaten communally by them just outside camp).

For the majority of the household shares, the acquirer was a resident man. We use this subset to estimate the "balance of accounts" among individual men. Men we observed as residents of a study camp were often living elsewhere, so our window into possible debt repayment is the sample of days they were resident with us. In Appendix A the absence of any entry for a man in the column associated with a particular carcass indicates that he was not a resident of the study camp at the time of that distribution. A zero indicates that he was a resident but received no household share. Where more than one man was responsible for the kill, we give credit for equal fractions of the shares received to each of the acquirers. This results in a sample of 80 parcels of meat, acquired and received by a resident man (Data set 5b, Table 1).

4. Quantitative description of Hadza hunting

4.1. Overall acquisition rates

Meat is an important part of Hadza diets (Data set 3, Table 1). Over 256 days of observation (2076 hunter-days, 1985–1989), Hadza living in study camps took 71 large animals, roughly 10,115 kg (live weight), just under 5 kg/hunter-day, or about 0.7 kg (live weight)/consumer-day (Hawkes et al., 1991).

These high rates reflect the large size of Hadza prey. Rates measured in *numbers* of prey acquired are, by contrast, quite low: 71 animals over 2076 hunter-days, 0.03 prey/hunter-day, or about *one animal every hunter-month*. This low rate is a direct result of focusing on big game: the larger the animal, the fewer there are.

4.2. Variation in hunting time and acquisition rates

Some hunters acquire more large prey than others. For the 14 married men in our individual sample (Data set 4, Table 1), the range in large prey taken/day is 0–0.12, the mean 0.04 ± 0.01. In this sample, there is no relationship between a man's acquisition rate and his age, or the number of children in his household.
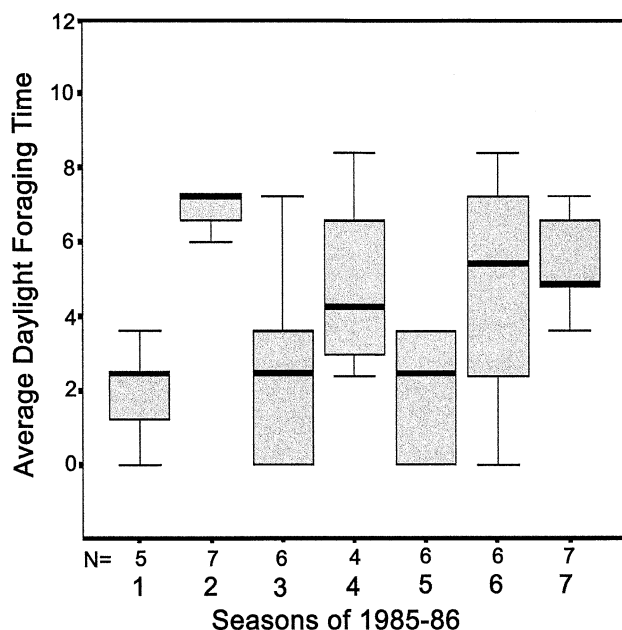

Fig. 1. Seasonal variation in men's daytime foraging effort (hrs/day). From Data set 1, Table 1. The seven seasons, described in Table 2, were distinguished by camp location and resource use. Boxplots indicate the distribution of time allocation averages for individual men resident in the study camp in each season. *N* (along the *x* axis) is the number of resident men each season. The box encloses half the seasonal means. The line inside the box indicates the median (because of the skew, the median is at the top margin of the box in Seasons 1 and 2, at the bottom in Season 7).

The daylight time allocation sample (Data set 1a, Table 1) shows that, on average, men hunted just over 4 of the 12 daylight hours each day (range 0.00–9.36, mean 4.1±2.88). Variation in daytime foraging is not related to the number of children in the household. The marked variation both within and between seasons is shown in Fig. 1.

As noted above, night-time hunting is only practiced in the late dry season, and men spent fewer daylight hours foraging during that season. That suggests a simple trade-off between the two: more night-time effort, longer daytime naps. It raises the possibility that daytime foraging — at least in the late dry — could be a poor index of a man's relative hunting effort. Those who forage more during the day may be the ones spending fewer nights hunting. Data sets 1 and 2 (Table 1) allow a quantitative check that shows just the reverse. The men who spent more nights hunting in the dry of 1985 spent more daylight hours hunting that season as well ($n=5$; $r=.815$; one-tailed $P=.047$). Our use of daytime hunting as an index of foraging effort is thus a conservative measure — it does not overestimate differences in the relative hunting effort of Hadza men.

4.3. Household meat shares

The household meat weights (Data set 5, Table 1, detailed in Appendix A) provide a rough estimate of both the fraction of a hunter's kill eaten by members of his own family and the fraction obtained from kills made by other men.[4] Comparing the characteristics of prey in our total sample of 71 large animals taken by resident hunters (Data set 3, Table 1) shows that the household sharing sample (Data set 5, Table 1) is biased toward very large carcasses. Item 1, Table 3, describes the prey in the household sharing sample; item 2 describes the prey in the total large animal sample. Fig. 2 shows the relationship of household share sizes to total carcass size. Household share sizes vary little across carcasses weighing 40–160 kg, but are larger for those ≥ 180 kg. We thus treat share size in the sample as bimodal: for prey < 180 kg, mean share size=3.14±0.67 kg; for prey >180 kg, mean share size=18.04±1.4 kg.

The average share size is a similar proportion (5–6%) of the edible fraction in both size classes, implying about the same number of shares across the wide size range. However, we think that larger prey not only allow larger shares, but usually allow more of them. We cannot measure the relationship between share number and carcass size directly because we do not have weights for all shares taken from each carcass. But two features of this sample suggest larger prey are divided into more household shares. First, as shown in Fig. 2, the size of shares remains relatively constant across the four-fold range in carcass sizes from 40–160 kg. Second, of the 20 large animals from which household

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[4] We emphasize that "household share" as measured here is not a direct measure of household meat consumption. Two reasons are especially important: (1) Large amounts of meat may be eaten at the kill, not only by the hunter, but also by members of the carrying party, sometimes including the hunter's wife and children (O'Connell et al., 1988a, 1990, 1992). Though we can estimate total amounts consumed in these situations, we cannot partition those amounts by consumer. (2) Back in camp, meat is cooked in the open (O'Connell et al., 1991). Household members eat not only at their own hearths, but also at those of others. Moreover, the larger the animal killed, the more likely news of its demise will draw visitors from other camps, who (as the Hadza put it) "come to help eat meat." We assume these various complications cancel each other out.

Table 3
Weights (kg) of carcasses acquired and shares of edible tissue distributed to men's households. Difference of means assessed with unpaired *t*-tests, one-tailed significance.

	n	mean	S.E.
(1) Large animals in household			
share sample (data set 5)			
(a) estimated carcass weight	20	288	57
(b) estimated weight of edible tissue	20	173	34
(2) Total large animal sample (data set 3)			
(a) estimated carcass weight	71	143	19.4
(b) estimated weight of edible tissue	71	85	11.6
(3) Size of prey (edible portion) in			
household share sample (Data set 5;			
difference of means *P*=.085)			
(a) acquirer a co-resident man (boys excluded)	13	114	25.5
(b) acquirer living elsewhere	4	285	95.3
(4) Share size when acquirer was a			
co-resident man (boys excluded)			
(a) prey <180 kg, difference of means *P*=.389			
acquirer's household	7	2.2	0.8
nonacquirer's households	21	3.8	1.0
(b) prey >180 kg, difference of means *P*=.014			
acquirer's household	8	29.9	5.1
nonacquirer's households	38	13.5	1.2
(5) Share size to nonacquirers' households			
(difference of means *P*=.005)			
(a) acquirer a co-resident man	59	10.0	1.1
(b) acquirer resident elsewhere	39	17.6	2.4

shares were weighed (Data set 5, Table 1), 4 were killed by men living in other camps. Those 4 animals were larger on average than the 13 in that sample that were taken by resident men (item 3, Table 3). The difference is consistent with our observations that large kills often drew people from more than one camp, more households claiming shares as a consequence.

    Mean share size for the acquirer's own household is distinguished from the shares to households of other men in Fig. 2. For a given prey size, the shares to acquirers' own households are indicated on the right (hatched boxes). For the very largest prey (>180 kg), the hunter's household took a significantly larger share (item 4b, Table 3), but this is not so for prey in the 40–160 kg range (item 4a, Table 3).[5]

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[5] This is a surprising pattern given simple expectations of marginal value (Blurton Jones 1984,1987; Winterhalder 1996). An extra kilogram of meat should be more valuable to a household with 3 kg (the average for the relatively smaller — although still very large — prey), than to one with 18 kg (the average for the extremely large ones). One hypothesis is that the hunter who has taken a very large animal knows that visitors from other camps are likely to show up to "help eat." Perhaps they claim a larger share, and co-residents acquiesce, in anticipation of hungry guests. Another hypothesis is that with very large amounts of meat there is a more realistic possibility of carrying dried meat off to trade before it is all eaten.
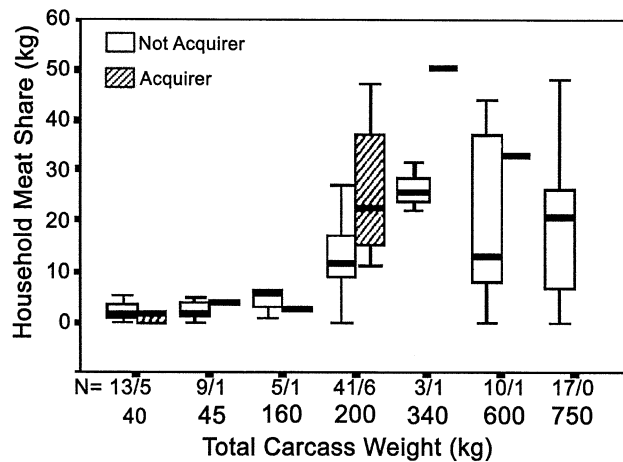
Fig. 2. Household meat share (kg) by total carcass size (kg). From Data set 5, Table 1, detailed in Appendix A. For each prey size, two types of shares are distinguished. The shares to households of resident men who did not acquire the carcass are the open boxes on the left, the shares to the acquirer's household the hatched boxes on the right. N (along the x axis) is the number of shares plotted in each category for carcasses of the indicated size. The largest prey in this sample were killed by men in other camps (see Appendix A), so no hunter's share was measured. For each carcass size, half the shares for each type have values within the box. The line inside the box indicates the median.

In this sample (Data set 5, Table 1), the successful hunter's household took, on average, about 5% of the meat from large prey weighing <180 kg, and about 10% of the meat from prey weighing >180 kg. Other men's households took, on average, about 5% each. Shares from prey taken by men living elsewhere were significantly larger than those from kills by co-residents (item 5, Table 3), a difference reflecting the larger size of these prey (item 4, Table 3). Men in the study camp each got about 6% of the meat when the acquirer lived elsewhere.

5. Hypotheses and tests

5.1. The balance of accounts

On a day-to-day basis, even the men who acquire large animals at the highest rate usually get nothing. With successes both unpredictable and unsynchronized (Winterhalder, 1986), sharing reduces the number of meatless days the family of each hunter would otherwise have to face (Kaplan & Hill, 1985a). But those who give up shares only gain when recipients repay them. The first prediction of risk-reduction reciprocity is that the meat a man's household gets from the kills of others depends on the meat the others get from kills by him (Hypothesis 1, Table 4). If this sharing sample is representative, and men are exchanging meat for meat, then what they get from others should be correlated with what others get from them. But Data set 5, Table 1 (detailed in Appendix A) shows little relationship between these two variables. The amount of meat that a man's household received from the kills of

Table 4
Hypotheses associated with the simplest version of the risk reduction model of meat sharing

Hypothesis	Result
1. The amount of meat that a man's household gets from the kills of others should be contingent on the amount those others have taken from his kills.	no
2. If meat sharing is risk-reduction reciprocity, then poorer hunters should get nothing more often.	no
3. If meat sharing is risk-reduction reciprocity, then poorer hunters should receive less meat from others' kills.	no
4. If meat sharing is risk-reduction reciprocity, then poorer hunters should keep a smaller fraction of their own kills.	
For large prey >180 kg	yes
For large prey <180 kg	no
5. If hunters who acquired fewer large animals maintained good credit by increased effort, then low acquisition hunters should spend more time hunting.	no
6. If acquisition rates vary mostly with effort, then time spent hunting should predict acquisition rates.	no
7. If acquisition rates vary mostly with skill, then overall rates should predict seasonal acquisition rates.	yes

other resident men is not predicted very well by the amount of meat they received from him (item 1, Table 5a).

It is possible that this indicates nothing more than the vagaries of our sharing sample. We explore the sample further to see whether it reflects the variation of the larger universe. Recall that our window into both "contributions" and "repayments" is limited to the time men happened to be co-resident with us. So, in a representative sample, the amount of meat a man supplied to the households of other resident men should depend on the length of time he resided in the study camp. Fig. 3 shows this systematic variation in our sample. A man's overall acquisition rate (large prey taken/days resident in a study camp) must also have determined the amount of meat that other men's households could get from his kills. Fig. 4 shows that the sample captures this pattern. These regularities indicate that the household sharing sample reflects at least some of the wider systematic variation.

A man's overall acquisition rate predicts how much he supplied to other households, but it does not predict the amount of meat that other residents supplied to him (item 2, Table 5a). Other things the same, the longer a man was a study camp resident the more likely we were to record him making a successful capture, and other households getting meat from it; and the more likely we were to observe his household receiving meat from the kills of other men. To remove that source of variation in the sharing sample, we control the number of days a man was a resident. The resulting partial correlation between the amount of meat a man's household received from the kills of others and the amount that other men's households got from kills by him turns the positive correlation between these two variables (item 1, Table 5a) into a negative one (item 3, Table 5a), the *opposite* of that predicted by risk-reduction reciprocity.

Table 5
Relationships among hunting effort (Data set 1, Table 1), acquisition rates (Data set 4, Table 1) and household share size (Data set 5, Table 1, detailed in Appendix A)

(a) Top panel

	n	r	P
(1) Relation between (a) the amount of meat a man's household got from kills of other resident men and (b) meat those men's households got from kills he made	18	0.216	0.195
(2) Relation between (a) the amount of meat a man's household got from kills of other resident men and (b) his own overall acquisition rate	14	− 0.031	0.386
(3) Relation between (a) the amount of meat to a man's household from kills of other resident men, and (b) meat they got from kills he made, controlling the number of days he was resident	18	− 0.243	0.174
(4) Relation between (a) seasonal acquisition rate and (b) seasonal effort, controlling overall acquisition rate	31	0.072	0.352
(5) Relation between (a) seasonal acquisition rate and (b) overall acquisition rate, controlling seasonal effort	31	0.470	0.004
(6) Relation between (a) recipient's household share and (b) his seasonal acquisition rate	85	− 0.294	0.003
(a) prey <180 kg	24	− 0.272	0.009
(b) prey >180 kg	61	− 0.017	0.449
(7) Relation between (a) acquirer's own household share and (b) his seasonal acquisition rate	15	0.345	0.104
(a) prey <180 kg	7	− 0.499	0.128
(b) prey >180 kg	8	0.480	0.115

(b) Bottom panel

	n	mean	S.E.
(1) Relation between the overall success rates of men whose households got shares with those who did not (difference of means: $P=.278$).			
Those not receiving a household share	7	0.048	0.015
Those receiving a household share	78	0.040	0.004
2. Relation between the seasonal foraging effort, of men whose households got shares with those who did not (difference of means: $P=.107$).			
Those not receiving a household share	3	0.69	0.65
Those receiving a household share	59	0.03	0.11

In the upper panel of the table, columns list the number of shares in each sample (n), the beta or partial correlation (r), and one-tailed significance (P). In the lower panel columns list the number of shares in each sample (n), the mean, and the standard error (S.E.). The sample sizes differ among analyses because we do not have data on all variables for all the men.

5.2. Biases against defaulters

The risk-reduction reciprocity model requires discrimination against defaulters. Hunters should distribute shares contingent on the potential recipient's credit. Men who have not
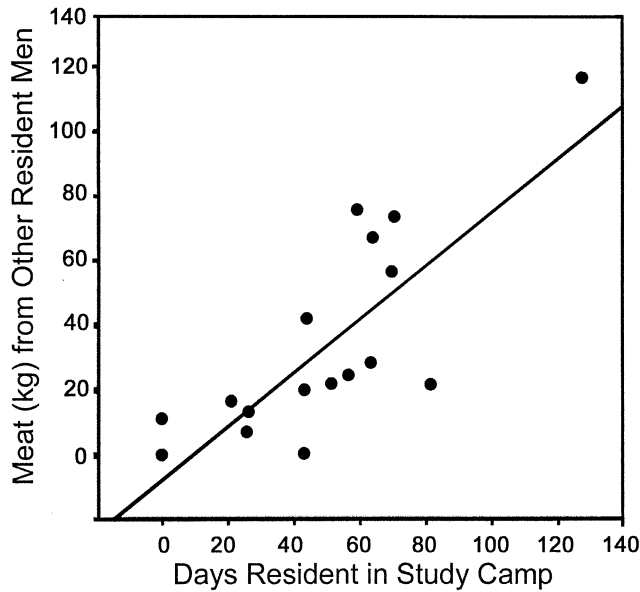
Fig. 3. The amount of meat that men's households received from the kills of other resident men, plotted against the time the men lived in the study camp. From Data set 5, Table 1, reported in Table 2. $N = 18$ men; $r = .780$; $P < .001$.
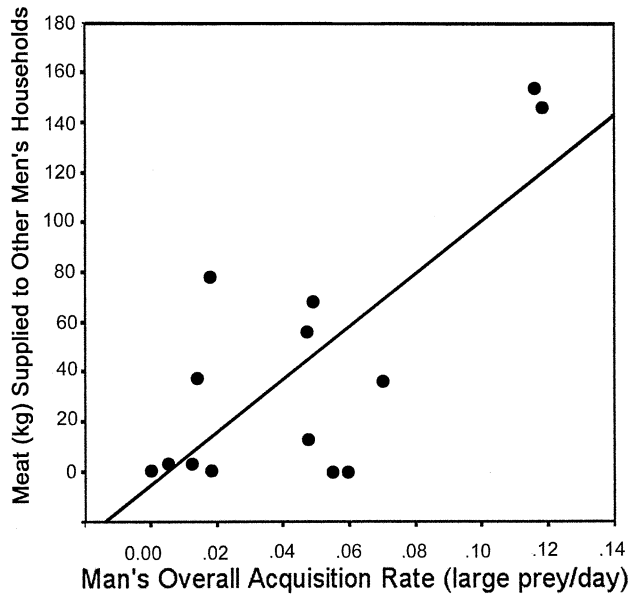

Fig. 4. The amount of meat that men's kills supplied to other men's households, plotted against their overall acquisition rates. Data set 5, Table 1, reported in Appendix A, and Data set 4, Table 1. $N = 14$ men; $r = .750$; one-tailed $P = .001$.

repaid should be excluded or otherwise punished. In our sample of household shares, the successful hunter kept on average 10% *or less* of the meat available from each carcass. For prey < 180 kg (the prey size most commonly taken), the hunter's share was no different from that of other men, about 5%.

Variation around these averages could reflect distributions contingent on debts in at least three ways: The men who acquired fewer animals might be excluded from shares more often (Hypothesis 2, Table 4). The men who acquired fewer animals might get smaller shares (Hypothesis 3, Table 4). The amounts that a successful hunter kept for his own household might vary depending on his own outstanding debts, those who had taken fewer animals owing more to others and so generally keeping less (Hypothesis 4, Table 4). Before running these tests we explore possible components of the differences in hunting success.

5.3. Effort and skill

The unpredictability of successes for Hadza big game hunters could prompt them to keep score not only of captures, but of each other's effort as well. Even the most successful hunters cannot expect to kill a large animal every week or two. In the face of this risk, Hadza men might see actual strikes as something beyond the hunter's control. This could make the *time* a man spends hunting an index of the quality of his credit. If luck can always change, those who spend more time hunting might seem better credit risks. If effort counted, then low effort hunters might be excluded more often, or get smaller shares.

The distinction between effort and acquisition rate points to a complication for hypothesis testing. If acquisition rate depended on skill, more large prey being captured by more skilled hunters, men might compensate for low acquisition rates with increased effort. Such complementarity could equalize everyone's accounts. High acquisition rate hunters might have little debt because of the meat they supply. Low acquisition rate hunters might reduce their debt by working harder. The apparent effects of either skill (acquisition rate) or effort (relative foraging time) on a man's debts would be reduced accordingly.

We can check to see if there is complementarity between effort and acquisition rate. If low acquisition rate hunters tried to improve their credit by increased effort, men who took fewer animals should have spent more time trying (Hypothesis 5, Table 4). They did not. Fig. 5 (from Data sets 1 and 4, Table 1) shows just the reverse. It was the men with high overall acquisition rates who spent more hours hunting. If we restrict attention to the late dry season and focus on night-time effort, the same holds true. Dry season hunting success rate is positively correlated with night-time hunting ($n = 5$, $r = .789$, $P = .053$). The hunters who took the most prey that season were the ones who spent the most nights out.

Of course, this could mean that acquisition rate is itself largely a function of time spent hunting. The high correlation might just be due to counting the same thing in two different ways. Higher acquisition rates (prey/day) might generally result *mostly* from longer hours, not from differences in skill (Hypothesis 6, Table 4). We try to distinguish the relative importance of differences in skill from differences in effort with partial correlations.
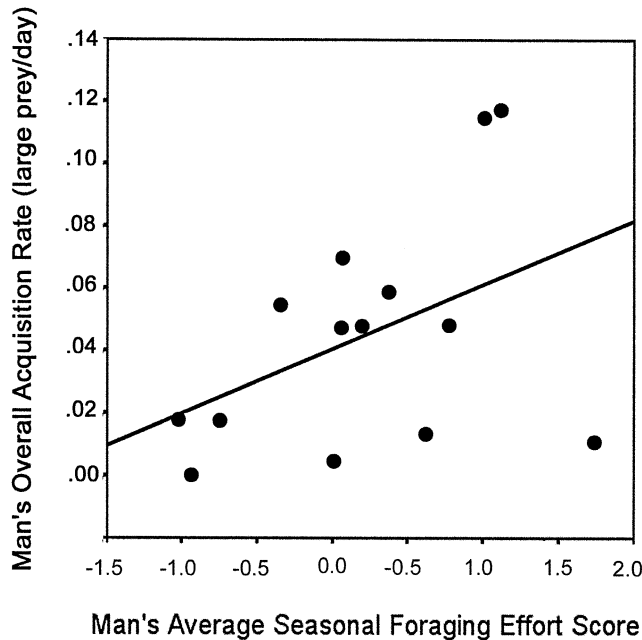
Fig. 5. Men's overall acquisition rates plotted against the average of their normalized seasonal effort scores. From Data sets 1 and 4, Table 1. $N = 14$, $r = .441$, one-tailed $P = .057$.

Using seasonal effort scores, seasonal acquisition rates, and overall acquisition rates, we first control overall acquisition rate. Removing it (total prey taken over total days observed — a measure that *might* reflect hunting skill), there is no relationship between the relative amount of time a man spent hunting and his success that season (item 4, Table 5a). On the other hand, if differences in skill underlie differences in overall acquisition rate, then men who have higher acquisition rates overall should have higher seasonal acquisition rates when effort differences are controlled (Hypothesis 7, Table 4). They do (item 5, Table 5a). Success in a season is predicted by overall acquisition rate, not by relative foraging effort. Even so, hunting is so unpredictable that skill (as reflected in this measure) accounts for less than a quarter of the variance in seasonal success rates.

5.4. Differential sharing depending on debts

Does a man's acquisition rate have an effect on whether or not his household gets any meat in a distribution (Hypotheses 2, Table 4)? Of the 113 household shares, 85 went to households of men who were not acquirers of the prey animal the shares came from, and on whom we can score seasonal hunting success. There is no significant difference between the overall acquisition rate of the men who got household shares and those who got none (item 1, Table 5b). For 62 of the 113 household shares to nonacquirers we can score the recipient's seasonal foraging effort. There is no significant difference between the seasonal effort of the men who got and those who did not get household shares (item 2, Table 5b).

It is rare for a household to be excluded[6] (<10% of cases), so samples are small. But the failure to find the difference consistent with Hypotheses 2 in Table 4 is unlikely to be due to sample size. The direction of the difference in both cases is *opposite* to the one predicted.

If a man's low hunting success rate does not make exclusion from the sharing distribution more likely, what about the *size* of shares he gets from the kills of other men? Do poorer hunters get smaller shares (Hypotheses 3, Table 4)? Item 6, Table 5 shows they do not. Since share sizes differ so much depending on prey size (Fig. 2; item 4, Table 3), we divide the sample into shares from prey weighing more or less than 180 kg (items 6a and b, Table 5a). This division shows that higher acquisition rates do not result in larger shares in either size range. The relationship is in the opposite direction to the one expected if share sizes decreased with increasing debt.

Finally, we look at the size of the hunter's share of his own kills (Hypothesis 4, Table 4). Low success rate hunters, with more debts to pay, should keep less of their own kills. The association between share size and overall success rate should be positive. It is (item 7, Table 5a). However, if the sample is further divided by prey size (as indicated by Fig. 2, and item 4, Table 3) more successful hunters keep relatively larger shares of their own kills only with the very largest prey (items 7a and b, Table 5a).

These data and analyses do not support the proposition that the shares households receive from the kills of others are contingent on reciprocal shares from kills made by the hunter in those households. At least 90% (usually more) of the meat of large prey goes outside the hunter's household. In our sample of household shares, the men who supplied more meat to others did not get more meat from them. Poorer or less hard working hunters were no more likely to be excluded from the kills of others, or to get smaller shares. While the relationship between a hunter's own share size and his acquisition rate was positive for the very largest prey, this was not so for prey weighing <180 kg (the size most often taken by Hadza hunters). In the more common cases, the difference was in the opposite direction to that predicted by risk reduction reciprocity. Moreover, the men who were more skilled hunters spent *more* time at it, magnifying the disproportionate contribution they made to the diets of their neighbors. To the extent our sample is representative, the meat hunters supplied to others was not repaid by meat from them. The proposition that hunters share meat so they will get meat repayments later is, on these grounds, implausible. Risk reduction reciprocity does not explain the persistence of widespread meat sharing among the Hadza.

6. Is the meat the hunter's property?

The risk reduction reciprocity model assumes that hunters control, and so can adjust, the distribution of the meat of their prey. We are not the first to report that Hadza

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[6] Our impressions were of insistent effort by adults of both sexes to claim shares at kill sites. We are surprised to find 9 of 113 cases in which a resident man did not get a household share. In one of those, the man whose household got nothing was himself credited with the kill. This was an impala (case #49), killed in the morning. After much eating at the kill site, the only meat the hunter's wife carried back was the epeme portion that went to the men's place.

hunters do not control the distribution of carcasses. Our general observations are consistent with those of others (e.g., Barnard & Woodburn, 1988; Woodburn, 1998). The larger the animal, the stronger the magnet to potential claimants. The style of interaction at kill sites exemplifies what Peterson (1993) called "demand sharing." Arguments over shares and share size are not uncommon; claims often take the general form, "Where's mine?"

Social anthropologists have explored a wide array of practices that regulate access to resources, most of which differ substantially from private property rights. Local traditions often include entitlements to resources that users cannot transfer, and rights of use often do not entail the right to exclude other users (see Hann, 1998 for review). These limits determine what assets are actually owned — in the sense widely used in economics — by individuals. The diagnostic feature of economic "ownership" is the right to consume a good directly or indirectly through exchange. Goods that one cannot exclude others from consuming are in the public domain (Barzel, 1997); those one can keep for exclusive use are private property. A perfectly public good cannot be used exclusively by anyone *and* consumers can use it concurrently; i.e., its consumption by one person does not reduce the amount available to others. Ostrom and Ostrom (1977) usefully distinguish these two independent dimensions, labeling them "exclusion" and "subtractability." Since both excludability and subtractability are more continuous than discrete, few goods are perfectly private or perfectly public. But some goods allow more concurrent consumption; and sometimes exclusion is impossible, or its costs are too high to pay.

From this perspective, a large carcass among the Hadza is like a public good until it is distributed (Hawkes, 1993). Instead of a set of exchanges with the hunter, the process of distribution is more like appropriation from the public domain. Many claimants are explicit in their demand for shares. Voices are often raised and demands are more insistent around food sharing than good manners might allow elsewhere. This prompts questions about whether a distinctively demanding style indicates a different process underlying meat sharing among the Hadza than among other modern foragers.

The style contrasts, for example, with the manners evident among the Ache, foragers in the New World tropics who are generally much more soft-spoken. People of all ages and sexes regularly offer portions of food to anyone watching them eat. Food sharing *etiquette* is strikingly different in these two cases. But some features of the distribution process are similar. Not only is meat very widely shared among the Ache (Kaplan & Hill, 1985a; Kaplan, Hill, Hawkes, & Hurtado, 1984), with no bias in the shares to better hunters or their wives and children; but, as with the Hadza, hunters play no role in meat distributions (Hill & Kaplan, 1988; Kaplan, Hill, & Hurtado, 1990). Usually an older Ache man takes on the final carving of cooked meat, and all watch as he distributes shares. Observers frequently criticize portion size and call for adjustments. Once others know of a hunter's kill, he is in no position to choose who gets meat or how much.

Among the !Kung, who like the Hadza are residents of the arid Africa tropics, there is a *nominal* owner of a large carcass: the owner of the arrow that first penetrated the animal, not necessarily the hunter who took that shot (Lee, 1979; Marshall, 1976). Marshall (1976, p.

297–299) describes the role of this "owner of the animal," who may "start off the distribution in the direction of his own relatives," but who has no control over the destination of shares. Waves of sharing include visitors, even though they are not close relatives, and finally "everybody gets some meat." Only after "the primary distribution and primary kinship obligations have been fulfilled" do people own portions.

Then,

> . . . when an individual receives a portion of meat, he owns it outright for himself. He may give and share it further as he wishes . . .

After ownership is established, owners may exchange their property,

> . . . the giving of meat from one's own portion has the quality of gift giving. . . .then the person who has received a gift of meat must give a reciprocal gift some time in the future.

The distribution procedures among the Ache, !Kung, and Hadza differ, but in none of them can the hunter, or anyone else, exclude others from shares of the animal. This is the common pattern among ethnographically known foragers (Wiessner, 1996). The hunter has no opportunity to control the size or final destination of shares, let alone obligate recipients to repay him in future meat — or anything else. As Woodburn (1982, p. 441) says of the Hadza,

> . . . entitlement [to shares] does not depend in any way on donation. Some men who are themselves regular recipients never themselves contribute.

Speaking of meat sharing, Woodburn (1998) asserts categorically that "sharing is not exchange." Our quantitative tests are consistent with that conclusion.

7. Discussion

We have focused on the hypothesis that hunters are exchanging meat-now for meat-later because it underlies the long held notion that the risky business of hunting supplies the basic motivation for human social interdependence (e.g., Cosmides & Tooby, 1992). That is the hypothesis that gives rise to the characterization of hunters "storing meat in the bellies of their neighbors" (e.g., Pinker, 1997). Hypotheses other than meat-for-meat exchanges have also been suggested. Hunters might, for example, trade shares for other goods and services (Kaplan & Hill, 1985; Winterhalder, 1986). The property rights question raised above is (perhaps usefully) assumed away in this hypothesis. Formidable accounting problems remain. Ever-changing scores in different currencies, not all readily divisible, require daunting feats of coordinated calibration. And, as laid out by Trivers (1971), self-interested actors should often have conflicting views of who is in arrears to whom and how much. The trade hypothesis focuses on the potential overall productivity that could be gained from divisions of labor, as famously explained by Adam Smith (1776). Perhaps those tendencies noted by Trivers contribute to explaining why the advantages of divided labor are not so easily achieved. The lack of occupational specializations has long been noted among most ethnographically described hunter–gatherers, including the Hadza, Ache (Hill & Hurtado, 1996), and! Kung

(Lee, 1979). Men's work is hunting. All Hadza men hunt,[7] even those who are not very successful at it.

The data analyzed here do not show meat-for-meat repayments. If our conclusions are correct, and if they apply generally, they remove the usual basis for arguments about hunting as family provisioning. Risk-reduction reciprocity proposes that meat sharing makes hunting a viable strategy for supplying household subsistence in spite of its risks of failure. But if a hunter is not repaid in meat or some other food, then he has no family provisioning insurance. Other foods rarely come in lumps big enough to feed the household and also pay off debts. If a hunter is repaid in some currency other than food, this does not reduce his daily risk of failing to supplying nutrition to his household.

Instead of meat exchanges with the hunter, the process of sharing large carcasses looks more like hungry consumers harvesting shares from the same rich patch. The hunter's success at either killing the prey or appropriating it from the primary predator is what makes that possible. And everyone knows who acquired the carcass. The effects on the hunter's reputation are not the same as title to the meat. Of course people sometimes do have property rights in food and exercise their ownership by trading it to others. As noted above, Marshall reported just that for personal shares of meat among the !Kung — after the waves of sharing and everyone has some. What happens initially with large animal carcasses is different. The carcass is more like a public good. By using conventions instead of costly fights to distribute shares, claimants incur fewer conflict costs (Maynard Smith, 1982; Sugden, 1986). Looked at this way, the cost the hunter pays is not that he gives up shares — he might actually increase his cost if he tried to keep more (Blurton Jones, 1984, 1987). Before he goes hunting he knows what will happen if he catches a large animal: most of it will go to others (Bliege Bird, Smith, & Bird, 2000). The hunter's cost is better measured as the time and effort he spends to provide the meat bonanza for so many.

7.1. What does the hunter get?

From this perspective, the question is not "why do hunters share meat" but "why do they go after it in the first place?" Hunters know that when they take a large animal they will not control the distribution of the meat, but they also know that others will learn who acquired it (Bliege Bird & Bird, 1997; Bliege Bird et al., 2000). Practices like those of the !Kung, in which the nominal ownership of a large animal is assigned to the owner of the arrow that first penetrated the prey, illustrate the important difference between credit for the kill and control of the meat. The owner of the arrow may or may not be the hunter who shot it. Marshall (1976, p. 287) observes that, by this practice, "the society seems to want to extinguish in every way possible the concept of the meat belonging to the hunter." But men talk endlessly about hunts and hunting (Blurton Jones, & Konner, 1976; Lee, 1979; Marshall, 1976), rehearsing the "minutest details." Lee (1979) was able to collect lifetime

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[7] One man never happened to be hunting during any of the scan samples we used to measure time allocation in the late dry season of 1985, so his time budget for that season shows no time spent foraging. But we know that he did hunt because he killed one large animal that season. His acquisition rate was 0.029 prey/days resident for the late dry.

retrospective histories from !Kung men in which each participant enumerated all the large animals he had ever killed. Hunters themselves, and all those who listen to the storytelling, soon know — whoever the *nominal* owner of the carcass — which man it was that made the kill.

This is a basis for the hypothesis that an especially important benefit a man earns for himself by hunting big animals is favorable attention that affects his social standing relative to other men (e.g., Dowling, 1968; Hawkes, 1993). The hyperbole[8] that Thomas (1959, p. 182) captures in her description of one influential !Kung man indicates just this effect.

> ... it was said of him that he never returned from a hunt without having killed at least a wildebeest, if not something larger. Hence the people connected with him ate a great deal of meat and his popularity grew.

Any man choosing to hunt small animals or to gather plant foods instead would be less desirable as a neighbor since his success would provide little for others to claim.

Patterns observed among Ache foragers were an initial stimulant for argument along these lines (Hawkes, 1990, 1991). In the forest, Ache camps are usually very temporary (Hill, Kaplan, Hawkes, & Hurtado, 1987). Staying for only one night, people limit the effort of clearing space by setting nuclear family fires very close together. Unless — *until* — it is raining, no structures are built. In this setting it is not possible to eat without the close scrutiny of all your companions. Excluding others from any foods that cannot be eaten quickly is more difficult than in settings where distance and walls separate consumers. Not only large animals, but small ones are widely shared by Ache foragers (Kaplan & Hill, 1985a, 1985b; Kaplan et al., 1984).

The extremely wide and even sharing of meat and honey so well documented for the Ache, and the lack of participation or control by the hunter in meat distributions (Hill & Kaplan, 1988; Kaplan et al., 1990) pose the question of incentives for the hunter himself especially clearly. Hunters do not get more meat for their own families. But other benefits to hunters have also been well documented in this case. Kaplan and Hill (1985b) reported that better hunters were more often named as lovers by Ache women and better hunters had more surviving children. In a larger sample, Hill and Hurtado (1996) found that better hunters had much higher fertility than other men. Those with better hunting reputations may have frequently displaced competing suitors for more fertile women, a possibility further suggested by the extreme fragility of marriages. Ache women had, *on average*, 10 husbands by the age of 30 (Hill & Hurtado, 1996).

If hunting is status rivalry among men, then successes are displays that establish and maintain a hunter's relative position. Bliege Bird (1999; Bliege Bird et al., 2001) has focused attention on the signaling function of hunting displays. Because they reveal something of a man's qualities, hunting and other aspects of men's foraging strategies could be at least partly explained by Zahavi's handicap principle (Grafen, 1990; Zahavi, 1975, 1990, 1995; Zahavi & Zahavi, 1997; see review in Johnstone, 1997). This is a principle of signal selection. Only displays that are costly to the showoff reveal otherwise hidden qualities. Paradoxically, it is

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[8] This is a habitat where hunters usually bag no more than two or three large antelope in a year (Lee, 1979).

the "wastefulness" of displays that makes them reliable signals. They must be too costly to be worth faking. Both showoff and audience then benefit when signal recipients treat the showoff differentially as a consequence.

Darwin (1871) developed the theory of sexual selection to explain the evolution of armaments and ornaments that seemed so extravagant and wasteful given an expectation that natural selection would favor features that increase the probability of survival. Zahavi's handicap principle solves the riddle of waste by showing it to be the very thing necessary to guarantee signal honesty and so make signaling systems stable. The handicap principle helps explain evidently wasteful peacock's tails and red deer roars and perhaps an increasingly broad array of human patterns (Boone, 1998; Miller, 2000; Neiman, 1998; Smith & Bliege Bird, 2000). It parallels and vastly extends the range of applications for arguments like those Veblen (1899) long ago offered for "conspicuous consumption."

Hunting and meat sharing have not seemed to present the same kind of puzzle. Rather than wasteful, hunting and meat sharing have been viewed as key to the survival of our ancestors (e.g., Foley, 1997; Isaac, 1978; Kaplan, Hill, Lancaster, & Hurtado, 2000; Washburn & Lancaster, 1968). In nonhuman primate species, males do not procure any significant fraction of the food that others eat. Among humans, including people foraging for a living, men often contribute a substantial component of the average diet (Hill, 1982; Kaplan et al., 2000; Lee, 1968). As noted above, Hadza big game hunters provided an average of 0.7 kg (live weight) per consumer/day during the study period described here. Although this average is not a realistic measure of nutritional benefits because it obscures the extreme variance, meat is an important and highly valued element of the Hadza diet. The appearance of male food procurement has been underlined as a key transition in hominid evolution (Kaplan et al., 2000; Lancaster & Lancaster, 1983; Lovejoy, 1981). The standard assumption has been that men's work evolved as paternal effort. A contrary hypothesis is that men's hunting evolved and is often maintained by status competition among men (Blurton Jones, Marlowe, Hawkes, & O'Connell, 2000; Hawkes, 2000). But among the ways that hunting displays are unlike peacock's tails or ungulate racks, one is especially important. More than revealing hidden qualities, this form of male competition also results in substantial material benefits to others (Hawkes & Bliege Bird, 2001).

In modern human communities that depend on foraging, men often pass up resources that would increase the daily nutrients going to their own wives and offspring (Bliege Bird, 1999; Bliege Bird et al., 2000; Hawkes, 1990, 1993; Hawkes et al., 1991; Hawkes, O'Connell, & Blurton Jones, 2000; Hill et al., 1987). This does not mean that men make little contribution to subsistence, but the differential contribution they make to the nutrition of their own families may be quite small — a surprising pattern given common expectations that men's work is largely paternal effort. The status rivalry (or showoff) hypothesis highlights how much of the meat that women and children eat comes from men *other than* their own husbands and fathers. This hypothesis can contribute to accounting for the effort men put into hunting when they do not exercise control over the meat of their kills (Hawkes, 1992b). It may help explain aspects of both the initial evolution and the wide variation in men's contribution to subsistence both within and between

communities — such an important human departure from the pattern among our close primate kin.

Acknowledgments

Appendix A. *Distribution of meat from 20 large animal carcasses across nuclear family households in the study camps, 1985–1988*

Prey animals define the columns and individual men the rows, with entries in the body of the table indicating the size of the meat share from an individual animal arriving at a specific man's household area. The acquirer's household share is in **bold**. Absence of an entry in a man's row means he was not living in the study camp when the animal defining the column was distributed. A zero means that he was living in the study camp, but that no meat arrived at his household. All weights were taken or estimated on the basis of observations made when the meat arrived in camp.

Carcass numbers and *dates of acquisition* are those reported by O'Connell et al. (1988a, 1990). *Method of acquisition*: Ambush, Encounter, Scavenged (see text and O'Connell et al., 1988b for additional details). *Estimated total weight* is the mean adult weight per taxon reported by Coe, Cumming, & Phillipson (1976). Total weights for carcasses acquired by scavenging are estimated at 80% of this figure; see O'Connell et al. (1988b) for rationale. *Estimated mean edible weight* is 60% of estimated mean total weight. *Acquirer's ID* is the code number assigned to the man who acquired the carcass. *Resident boy* means that the hunter was a teenager living in the study camp; *not resident* indicates that the acquirer was living in another camp. In the column at left, *man's ID* identifies the adult man, all husband/fathers of nuclear family households. Numbers in each carcass column show the weights (kg) of meat from that kill initially arriving at the household of the man in that row. Data on amounts consumed or abandoned at the kill or distributed to other households or as *epeme* (meat reserved for adult men and eaten outside camp) are not included. Weights listed for carcasses 24 and 39–66 were obtained with the use of a hanging spring scale. For all other cases, weights are estimated based on the lists of parts distributed to each household and weights of the same parts reported by Lupo (n.d.) for zebra and Blumenschine and Caro (1986) for bovids.

Case no.	22	23	24	28	29	30	35	37	39	41
Date	21-Oct-85	21-Oct-85	22-Oct-85	29-Oct-85	30-Oct-85	31-Oct-85	11-Dec-85	29-Dec-85	26-Mar-86	24-Apr-86
Species	Zebra	Zebra	Warthog	Zebra	Warthog	Zebra	Impala	Eland	Giraffe	Giraffe
How acquired	Ambush	Ambush	Encounter	Ambush	Encounter	Ambush	Encounter	Encounter	Encounter	Encounter
Estimated total weight (kg)	200	200	45	200	45	200	40	340	750	750
Estimated edible weight (kg)	120	120	27	120	27	120	24	204	450	450
Acquirer's ID	144	144	149	not resident	resident boy	141	149	149	not resident	not resident
Man's ID										
140	11.00	30.20	4.90	9.50	4.00	24.70	5.40			
141	13.50	11.50	4.10	18.20	1.70	**15.50**	9.80	31.90		3.50
143	16.20	8.50			1.10					
144	**26.00**	**11.50**	0.00	10.50	1.90	20.50	1.60			
145	17.20	16.20		38.50	1.40	8.50	0.00	25.80		
147									7.00	9.50
148									26.50	37.00
149	10.50	11.00	**4.00**	21.20	1.70	23.20	**1.00**	**50.10**		
150							1.60	22.50	20.50	32.00
151									12.00	
152									13.50	
153									20.50	6.00
160										
166										
173										
174										
175										
190										

Case no.	42	43	44	46	47	49	62	64	65	66
Date	19-May-86	26-May-86	28-May-86	13-Jun-86	1-Aug-86	7-Aug-86	12-Sep-88	16-Sep-88	1-Oct-88	9-Oct-88
Species	Impala	Giraffe	Giraffe	Zebra	Zebra	Impala	Giraffe	Zebra	Zebra	Zebra
How acquired	Encounter	Encounter	Scavenged	Encounter	Encounter	Ambush	Scavenged	Encounter	Encounter	Scavenged
Estimated total weight (kg)	40	750	600	200	200	40	600	200	200	160
Estimated edible weight (kg)	24	450	360	120	120	24	360	120	120	96
Acquirer's ID	141, 148, 153	resident boys	150	147	149	190	resident boys	not resident	173	174, 136[a]
Man's ID										
140										
141	**5.50**	22.70	8.00	15.70	9.50	3.70	44.00	17.00		3.00
143										
144										
145										
147	1.50	56.30	11.50	**18.90**	9.10	0.00				
148	**1.50**	20.50	6.50	9.80	8.40	3.20				
149				11.80	**47.30**					
150	0.90	48.00	**33.00**	11.80	8.30		37.50	10.50	22.50	6.00
151		0.00	11.80							
152		5.70								
153	**1.50**			6.10						
160	0.00		0.00	0.00	8.50	5.40				
166						1.00	37.50	27.40	19.80	20.50
173							26.90	0.00	**37.20**	1.00
174							14.10	7.60	0.00	**2.60**
175								11.80	13.70	5.80
190					13.20	3.60	**0.00**			

[a] 136 is a young adult man who was only briefly a resident of the study camp.

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