How Much Is Enough? Hunters and Limited Needs

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The notion that hunter–gatherers need little and so limit what they take from available resources has been extremely influential in anthropology. We present an optimal foraging model that suggests testable predictions that are inconsistent with the postulate of "limited needs." We evaluate these predictions in light of data from the Aché of eastern Paraguay and other groups, and find that the hypotheses based on the limited needs postulate are generally falsified, whereas those derived from the optimal foraging model are generally supported.

Key Words: Hunter–gatherers; Optimal foraging; Hunting effort; Limited needs; Lowland South America.

The idea that hunter–gatherers have "limited needs" has been a central element of anthropological theory for more than two decades. Nevertheless, this notion is flawed critically in at least two respects. First, it provides no means to explain how "needs" are set, why they vary among hunter–gatherers and others, or how and why they become "unlimited." Second, and perhaps more important, it is empirically inaccurate. Foragers do *not* behave consistently in the manner predicted by the postulate of limited needs.

To illustrate the latter point, we construct a simple qualitative model of optimal foraging grounded in the theory of natural selection. The model is based on the assumption that the ultimate goal of foraging is not only to obtain food, but more generally to maximize reprodutive success. We use the model to develop three hypotheses about the allocation of time to hunting. These hypotheses are paired with opposing predictions based on the postulate of limited needs. We then test these hypotheses with data on the Aché of eastern Paraguay. We find that predictions based on "limited needs" are not supported, whereas those based on fitness maximization are more successful. Tests with data from other groups, with one exception, also fail to fit the limited needs prediction but are again consistent with fitness maximization. Guided by our optimal foraging model, we propose a testable hypothesis that may identify the reasons behind the exceptional case.

We conclude that as a descriptive generalization about foragers, the "limited needs" view is inaccurate. Associated notions of system homeostasis and conservation are also without foundation. The results reported here show that joining an ecological perspective with sociobiology (Blurton Jones 1976), a union never broken in evolutionary ecology, allows the construction of simple testable hypotheses that revise basic assumptions in a most constructive way, and so potentially contribute to the explanation of form and variation in hunting and gathering cultures across both space and time.

THE PROBLEM

Throughout the first half of this century, political economists and anthropologists (Childe and White, among others) held that technical innovations that allowed the production of surplus played a key role in cultural evolution in that

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they freed certain individuals in a few societies from the onerous task of food procurement or production and enabled them to get on with the creative work of building culture. In an influential article published in 1957, Harry Pearson objected to this line of argument, offering in its place an early statement of the limited needs hypothesis. He observed that people in the simplest societies found plenty of time to devote to "nonutilitarian" activities. Surplus production, he argued, was better seen as the product of certain social institutions that extract more labor. Surplus was a consequence, not a cause of the growth of culture.

Eleven years later, several papers in the *Man the Hunter* volume (Lee and DeVore 1968) made limited needs a key element of the new conventional wisdom concerning foragers. Lee (1968), for example, reported that Bushmen subsistence required only 12–19-hour work week, while Sahlins (1968) tagged hunter–gatherers everywhere as members of the "original affluent society," who pursued a Zen strategy of wanting little and, as a consequence, having all they wanted. Birdsell (1968) reiterated his view that Pleistocene and recent hunters limited their populations to ensure long-term equilibrium with local resources. These and other more recent contributions (especially Sahlins 1972) reinforced the notion that foragers typically acted to conserve local resources by stopping work when the modest requirements of immediate subsistence were met.

The recognition that foragers were not continually threatened with starvation was an important contribution of the ethnography of the 1960s, but the conclusion that hunters typically had limited needs begs an important question. Although a nutritional minimum is theoretically calculable (Harris 1959), the definition of needs, nutritional or otherwise, varies greatly across time and space, even among hunters. Moreover, it is undeniably the case that some Paleolithic foragers domesticated plants and animals, and in the process adopted a life that, according to some elements of the conventional wisdom, was demonstrably less affluent. Cohen (1977) focused on the riddle posed by a model of affluent hunters for the origins of agriculture, and disputed the homeostasis of popular views. Yet at the center of Cohen's argument that long-term population pressure is the key to cultural evolution is the postulate of limited needs: hunters, affluent in Sahlins's sense, are found to increase their pressure on resources to support an ever growing population. Sahlins (1972, p. 82) phrases the problem of economic development as "getting people to work more, or more people to work," and like Pearson, finds the solution in the appearance of social and political institutions that extract more labor from the populace (see also Bender 1978). The obvious questions this raises are: when, where, and most important, why do these institutions emerge? For Cohen, the intensification of labor comes from population pressure, groups differing in the rates of growth they tolerate. Again, what accounts for the variation?

OPTIMAL FORAGING MODELS: AN ALTERNATE APPROACH

One way of tackling problems of variation in time allocated to food procurement involves the use of optimal foraging models grounded in the theory of natural selection. Such models are commonly employed by evolutionary biologists to describe and explain variation in the subsistence-related activities of nonhuman organisms (Charnov and Orians 1973; Pyke, Pulliam and Charnov 1977; Krebs, Stephens, and Sutherland 1983), and are increasingly seen as potentially useful in the study of human behavior as well (Smith 1984). Since the currency commonly used in these applications is energetic efficiency (see Smith 1979; Christenson 1980), some analysts (especially anthropologists, e.g., Harris 1979; Orlove 1980; McCay 1981) have separated the models from the underlying theory of natural selection. Our approach is to use natural selection explicitly. We assume that culture is the consequence of the inclusive-fitness-maximizing behavior of its past and present participants (Alexander 1979). Behavior that will maximize inclusive fitness is determined by the options and constraints of any particular time and place, that is, by the ecological context, including the behavior of other individuals.

This does not mean that we expect different behavior to imply genetic differences, or a change in behavior always to mean a change in gene frequencies. We use selection theory to study what is largely phenotypic variation. As contexts vary, different behavioral responses will enhance the reproductive success of individual actors and their close kin. We assume that humans have been and continue to be selected for extreme behavioral flexibility. That flexibility can be formed by selection only if it results in opportunisitic adjustments that give fitness benefits outweighing their cost. Paradoxically, it is this marked phenotypic flexibility that makes humans especially likely to track changing fitness opportunities quite closely.

There is anthropological ambivalence about the applicability of natural selection to human behavior. Some who draw on optimal foraging theory have coupled it with an assumption of limited needs (e.g., Earle 1980; Christenson 1980; Reidhead 1980; Keene 1981). The incompatibility between fitness maximization and limited needs, given other things we know about human foragers, has not been obvious.

The model described here is constructed on the assumption that foragers generally behave so as to maximize their fitness, Natural selection is not peripheral but central. The model leads us to expect that under conditions we think may be common, fitness maximizing foragers will make adjustments to changes in return rates that are generally the opposite of those aimed at meeting limited needs.

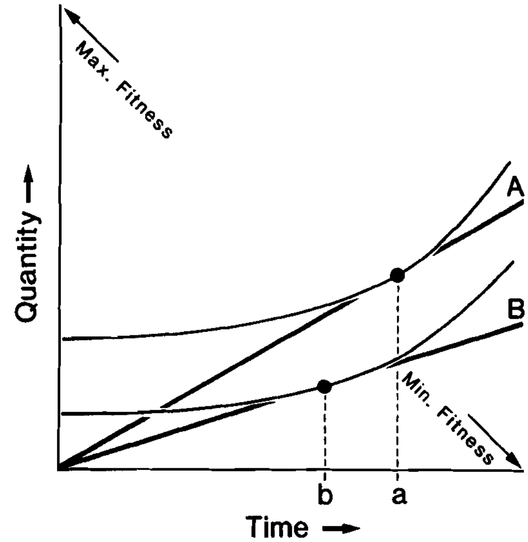

Figure 1. The relationship between hunter's return rate, time spent hunting, and fitness when hunting gives high fitness returns relative to other activities and when the fitness payoffs for other activities remain constant. We expect this to be the common pattern for hunter–gatherers.

THE MODEL

Consider a situation in which there is a direct relationship between time spent hunting, the amount of game acquired (measured in total weight or its equivalent in calories or nutrients), and the relative reproductive success of the hunter. The more time spent hunting, the more game acquired, the greater the fitness gain; and conversely. This means there will be a fitness payoff for foraging efficiently, that is, for maximizing the rate at which game is taken, summarized graphically in Figure 1. Maximum fitness levels are achieved toward the upper left corner of the graph, where relatively large quantities of game are acquired at relatively low cost in time. Fitness gains are much less at the lower right hand corner, where some quantity of game is taken at relatively high cost in time. Running between these points are a series of equal fitness curves of some shape such that every point on any given curve indicates a rate of prey acquisition producing a fitness return equal to that at any other point on the curve. As a first approximation, it seems reasonable to assume that these curves are shaped by diminishing returns, that is, beyond a certain point at any given rate of capture, increments of time produce steadily *decreasing* returns in fitness. This means that the fitness curves are bowed upward, as in Figure 1. Taking five monkeys an hour for the tenth hour produces a lower return in fitness than taking five monkeys an hour for three hours.

Diminishing return curves may vary between two extremes: shallow, with returns falling off slowly (Fig. 1); and steep, with returns dropping rapidly (Figure 2).[1] Among hunter–gatherers, we expect them to approximate the former more often, primarily because hunters use food to gain fitness in many different ways, not only to meet their own nutritional needs and those of their close kin but also to attract mates and to give away to others in return for future assistance, cooperation, and alliance. All of the latter are potentially beneficial to the survivorship and reproductive success of the giver and his close kin. [This may be especially true for male hunters (e.g., Siskind 1973), which implies that these curves may differ between the sexes.]

[1] We are indebted to Bruce Winterhalder and George C. Williams for clarifying suggestions.

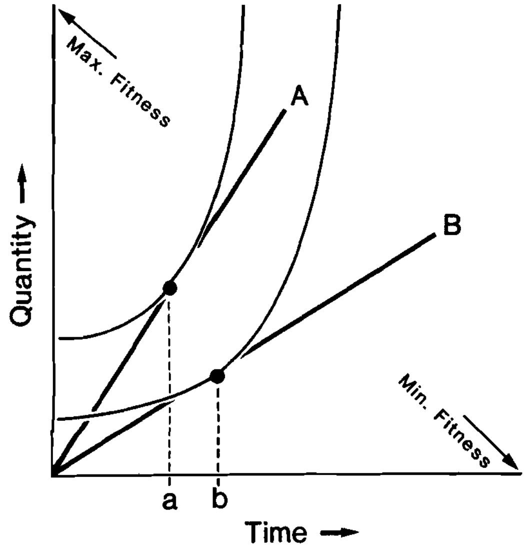

Figure 2. The relationship between hunter's return rate, time spent hunting, and fitness when the fitness payoffs for hunting diminish rapidly. We expect this to be rare for hunter–gatherers.

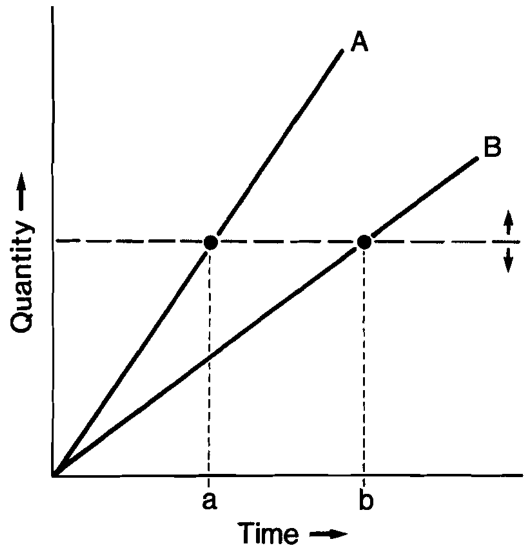

Figure 3. The relationship between hunter's return rate and the acquisition of a fixed need.

Fitness payoffs beyond the satisfaction of immediate energetic or nutritional needs are reflected in the preoccupation with food, especially meat, commonly reported ethnographically (Lee 1968; Sahlins 1972; Hayden 1981). Circumstances that alter this situation for hunters may be fairly rare. A rapid falloff in fitness returns for continuing to forage would occur if other activities, which are in conflict with foraging, have an unusually high fitness payoff, or must be performed to avoid a relatively high fitness cost, for example, if unusual mating or trading opportunities occur or if offspring must be protected from unusual threats (see below). Circumstances like these are depicted graphically by the steeply ascending fitness curves shown in Figure 2.

From this graphic model, we can develop testable predictions about covariation in foraging returns and the amount of time spent foraging, given the critical simplifying assumption that fitness returns for other activities remain constant. Each prediction embodies a set of hypotheses about behavioral constraints and time frame that collectively define an optimal solution. Inconsistency between predicted and observed behavior means that one or more of these embedded elements is incorrect and must be rejected. Neither natural selection nor the notion that foragers behave optimally with respect to fitness is itself being tested (Maynard Smith 1978).

The model geometrically specifies an optimal solution to the problem of time allocation to foraging given the goal of maximizing reproductive success: for any return rate, forage until the return rate line intersects the highest fitness curve. Optimal foragers should hunt just long enough to equalize the marginal fitness returns gained from foraging versus nonforaging alternatives. As long as fitness payoffs for a high return activity increase with greater investment while those for available alternatives remain constant, fitness is maximized by devoting more time to the high return activity. Under circumstances we expect to be fairly common (Fig. 1), the optimal strategy when confronted with a higher return rate (A) is to spend more time foraging (a) than if the return rate were lower (B,b).

This strategy is different from that implied by the limited needs postulate. Figure 3 shows the pattern of time allocation to hunting expected as a function of some standard required intake. The higher the return rate, the less time spent hunting (A,a versus B,b), precisely the opposite of that predicted by our model under conditions we expect to be fairly common. It is, however, *the same* as that predicted under conditions we expect to be fairly rare (Fig. 2), a point to which we return later.

HYPOTHESES

We offer three paired hypotheses as a means of determining whether foraging behavior is more consistent with the limited needs postulate or our fitness maximization alternative:

1. The first applies to daily variation in hunting conditions. Under the circumstances we expect to be fairly common (Fig. 1), hunters maximizing fitness should spend more time hunting on days when returns are relatively high, and less time when they are relatively low. Conversely, hunters seeking to satisfy limited needs should meet their requirements more quickly and stop hunting sooner on days when returns are good than when they are bad.
2. The second hypothesis concerns differences in levels of hunting skill. Under conditions we expect to be common, hunters who achieve higher average return rates should spend more time hunting than less skillful hunters. Conversely, where limited needs set the goal, better hunters should meet requirements more quickly and stop hunting sooner than their less skillful peers.
3. The third hypothesis deals with technologies of different efficiencies. Under the circumstances we expect to be common, hunters maximizing fitness will spend more time hunting when equipped with tools that produce a high return rate, and less time when using those that produce a low return rate. Hunters seeking to satisfy limited needs will do the reverse: hunt less with more efficient technologies, more with less efficient.

We test these hypotheses with data from the Aché of eastern Paraguay.

THE ACHÉ

There are a few references to the Aché in historical accounts written before the middle of the twentieth century, but the first modern ethnographic reports are by Pierre Clastres (1968, 1972), who worked among two Aché ("Guayaki") groups in the 1960s. The data presented here are from a third, the Northern Aché, who have come into unarmed contact with outsiders only within the past decade (Hill 1983). They now live at a mission agricultural colony established in 1978, but continue to take foraging trips, of several weeks in length, away from the mission. Their traditional range lies at 24°–25° South latitude, between the Rio Parana and the Rio Paraguay. It is characterized by gently rolling hills and low valleys, the former covered by broadleaf evergreen forest, the latter by tall grasses. The climate is marked by hot summers (daily January maxima to 41°C) and cool winters (July minima to −3°C). Annual average rainfall varies locally from 1500 to 1700 mm, although year-to-year differences in total amount and seasonal distribution are often extreme (see Hill et al., 1984).

The Aché take a wide variety of animals, including peccaries (*Tayassu pecari, Pecari tajacu*), pacas (*Cuniculus paca*), coatis (*Nasua nasua*), armadillos (*Dasypus novemcintus*), and capuchin monkeys (*Cebus apella*). They also exploit numerous plant products, especially of the palm *Cocos romanazoffiana*, from which they take fruit, the heart, and starch from the trunk. Insects provide them with important resources, notably larvae and honey (Hill et al., 1984).

Recent fieldwork has shown that the Aché do quite well as foragers in a region sometimes characterized as poor in resources, especially game (e.g., Lathrap 1968; Meggers 1971). On a sample of 65 foraging days in 1980, the Aché consumed an average of 3600 calories per person per day while foraging, 80% of those calories coming from meat (Hawkes, Hill and O'Connell 1982; Hill and Hawkes 1983).[2] This has at least two important implications. First, because they do so well as hunters, the Aché might be especially likely to stop foraging as "needs" are met. Second, apart from tooth necklaces and bone picks, they make little use of animal products for anything other than food. There is nothing like a requirement for skins to complicate the assessment of game needs.

[2] Since this article was written the Aché date set has been expanded. We now have a sample of 153 foraging days (137 whole days), covering different seasons of 1980, 1981, and 1982. In foraging trips of 5–15 days in length, with parties ranging from 9 to 68 Aché (3278 consumer days), people consumed an average of 3827 calories per day, 47%–77% of these calories coming from meat (Hill et al., 1984).

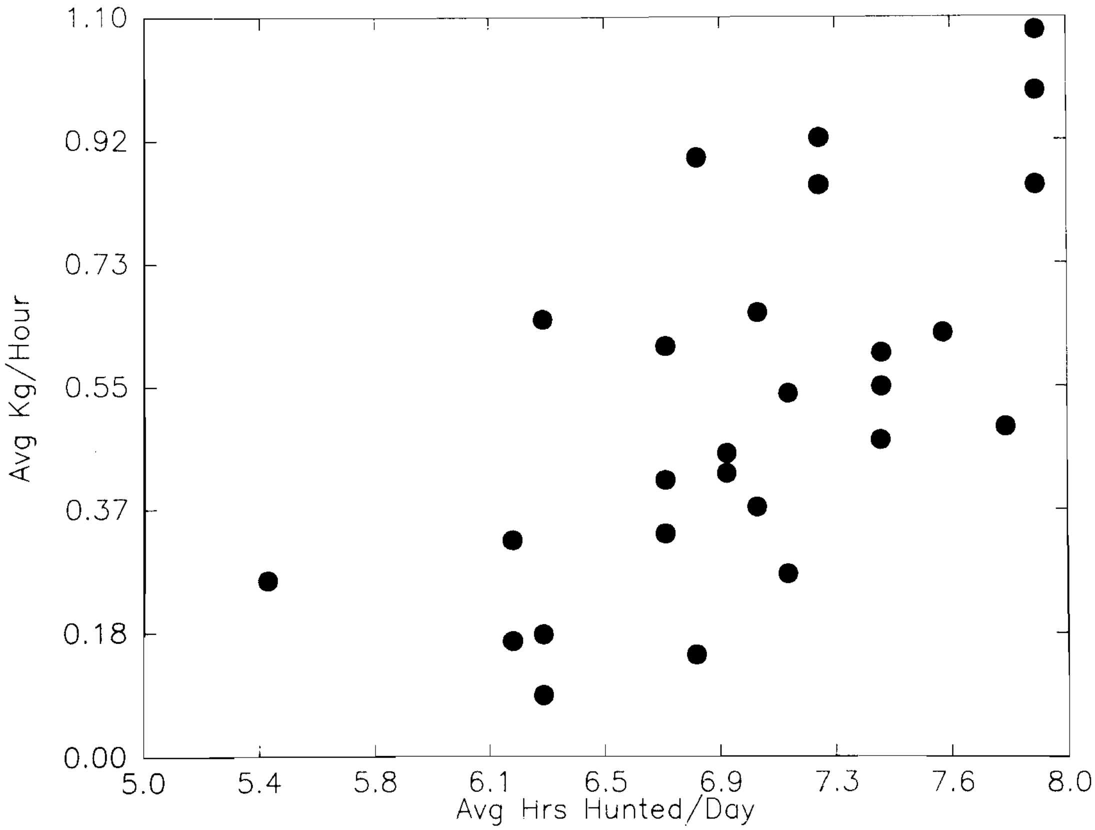

Figure 4. The relationship between average hourly return rate and the average daily hunting time for 27 Aché hunters, $r = 0.64$ (Hill and Hawkes 1983).

TESTS

Data subjected to analysis are drawn from a sample of 58 days of observation (636 hunter-days), March–July 1980. Rainy days, when no hunting took place, and hunter-days when the hunter in questions was ill and could not hunt were eliminated from consideration. During this period, we kept a record of each animal killed, its weight, and the identity of the hunter who killed it. We are confident that little if any game taken escaped our notice. Measurement of time invested in hunting was more difficult. Aché foragers move camp every day, the men hunting individually as they move, the women following along with the camp gear. Times when men left camp in the morning were recorded, as were those when they rejoined the women in the evening. Each day, the activities of one or two hunters selected at random were monitored closely. The movements of other hunters were recorded where possible. From these data, estimates of hunting times for all hunters were constructed. Inevitably, these estimates are somewhat less than precise. (See Hill et al., in press, for additional data and further analysis.)

Hypothesis 1: Daily Variation in Hunting Conditions

The fitness maximization model leads us to expect that foragers will hunt longer on days when the hunting is better; the limited needs model suggests the reverse. For the 58 nonrainy days the linear correlation between the average rate per hunter in kilograms per hour and the average number of hours per hunter is 0.11, not significant, suggesting neither of the paired hypotheses. However, when we consider hunters individually there is a daily pattern. We have data on seven or more hunting days for 27 men, showing an average of 6.9 hours of hunting per day. On 73 of these 445 man-days individuals succeeded in taking game at a rate of 1 kg/hr or

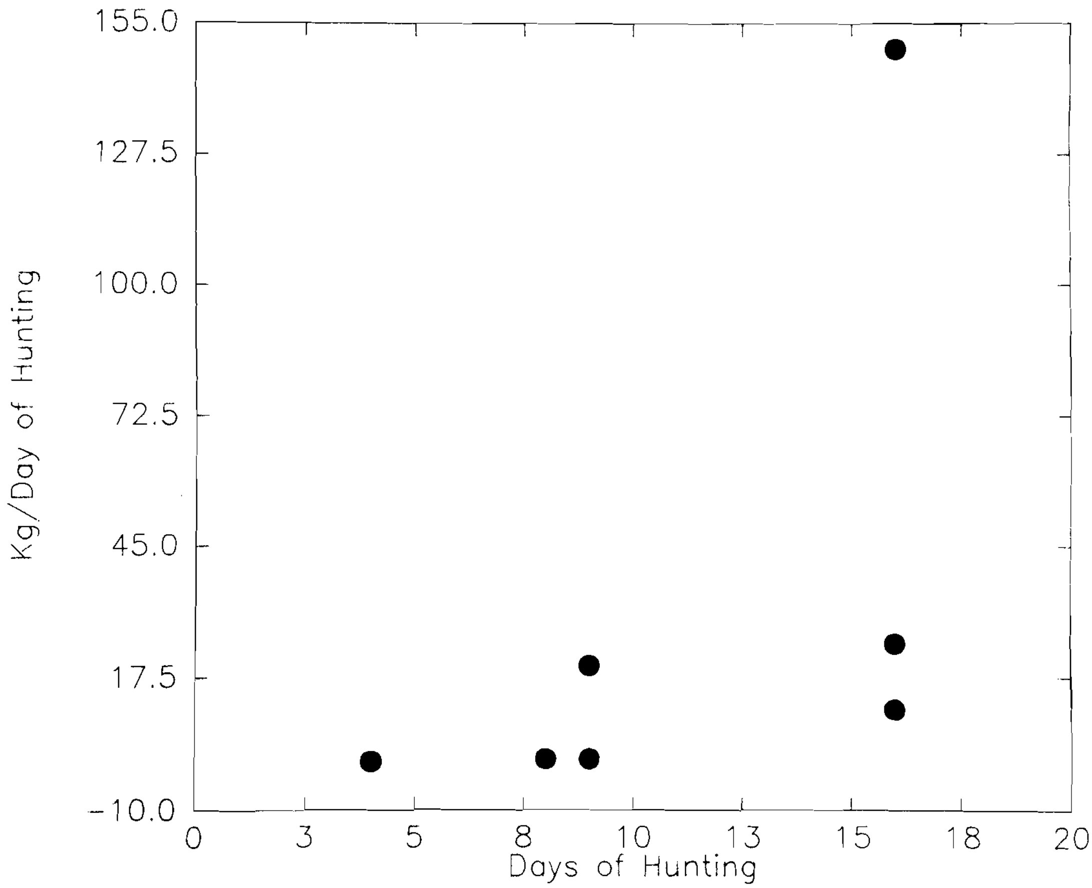

Figure 5. The relationship between average daily hunting returns and numbers of days hunted for seven Dobe hunters, $r = 0.54$ (Lee 1979, p. 268).

better. On 45 of these high return days (61%) men hunted longer than the 6.9-hour average; on 28 days they hunted the average time or less. Hunters spend more time hunting when they are having a good day ($p > 0.05$).

Hypothesis 2: Differences in Individual Skill

Average return rates gained by individual Aché bow hunters range from 0.1 to 1.1. kg/hr during the study period. The fitness maximization hypothesis leads us to expect that better hunters will spend more time hunting; the limited needs model suggests the reverse. Figure 4 shows that for the 27 hunters for whom we observed 7 or more hunting days, there is a strong correlation between average hourly return rate and average time invested in hunting each day ($r = 0.64$; $p < 0.01$) (Hill and Hawkes 1983). Better hunters do indeed work longer, a result consistent with the fitness maximization hypothesis, and inconsistent with limited needs.

Hypothesis 3: Differences in Technological Efficiency

The Aché use both the bow and arrow and the shotgun, though access to guns and ammunition is limited. On 71 man-days of shotgun hunting, returns averaged 10.79 kg/hunter-day, or about 1.6 kg/hunter-hr. On 537 man-days of bow hunting, returns averaged 3.45 kg/hunter-day, or about 0.54 kg/hunter-hr. The fitness maximization model predicts that hunters with shotguns will spend more time hunting than those with bows; the limited needs model suggests the reverse. Bow hunters spend about 6.45 hours per day hunting on average, shotgun hunters about 6.88 hours. Though the difference is in the direction predicted by the fitness maximization model, it is not statistically significant.

DISCUSSION

The results of our analysis are mixed. All three limited needs predictions are rejected, but one of the fitness maximization hypotheses is also. Data from groups other than the Aché provide the basis for further comment.

Hypothesis 1

Bruce Winterhalder (1977) compared seasonal variation in the efficiency of moose hunts among the Boreal Forest Cree with variation in the frequency of hunting, expecting from the perspective of optimal foraging theory that hunts would be *more* frequent at times when return rates were higher. As one of his informants remarked: "Well, in January and February it is pretty hard to get them [moose]. And not too many people go out. In March and April the people start going more and it is easier to get them [moose]" (Winterhalder 1977, p. 328). People hunt more when returns are better. Moreover, Winterhalder (1977, pp. 344–45) suggests that hunts conducted during seasons when returns were generally poor "were in fact conducted on individual days with environmental conditions usually associated with efficient foraging."

These remarks are especially interesting in light of a comment by Eric Alden Smith (1979, p. 66) on the same data:

> This case is probably a good example of a "time minimizing" approach to efficient energy capture (to use Schoener's [1971] phrase); thus we can predict that any increase in available energy would lead to reduced foraging time, and not to any increase in the total energy captured by the population.

Our fitness maximization model leads us to be skeptical of that prediction. Winterhalder's remarks can be read in a very different way: more energy gained per unit of time, more time invested.

Hypothesis 2

Aché behavior is consistent with the fitness maximization hypothesis that better hunters will hunt more. Data from two other groups are also consistent with this hypothesis. Richard Lee recorded the major activity of the day for all members of the Kung camp at Dobe over a 4-week period. He notes that "seven men (six residents and one visitor) did 78 days of hunting and four men did no hunting at all" (Lee 1979, p. 207). There is a positive correlation between the success rate of these individuals and the number of days spent hunting ($r = 0.54$; Fig. 5).

Stuart Marks (1976) reports hunting times and return rates for Bisa hunters based on a sample of more than 1500 hours of observation. Seventy five percent of all recorded time spent hunting is attributed to eight individuals, all of whom lived in the study area for at least 6 months during the study period. Among these men, better hunters hunted more ($r = 0.82$; Fig. 6).

Raymond Hames's (1979) data from the Yanomamö show a different pattern.[3] Hames recorded hunting times and game bagged by bow hunters over a 216-day period. These show a *negative* correlation between individual return rates and time spent hunting ($r = -0.65$; Fig. 7), which is inconsistent with the fitness maximization pattern we expect to be fairly common among hunters (Fig. 1). It is consistent with *both* the limited needs argument *and* the fitness maximization pattern we expect to be relatively rare, that in which fitness returns from hunting fall off rapidly (Figs. 2 and 3). Hames suggests a limited needs explanation for this pattern: "One may hypothesize that to some extent time allocated to hunting is limited by hunting success (or ef-

[3] The fitness maximization model presented here was originally constructed for foragers. We now recognize our error in extending its application to horticulturalists without consideration of the changes this must entail. We are dissatisfied with our failure to treat more explicitly here the relative fitness values of alternative activities, especially as both the available alternatives and their costs and benefits must differ between horticulturalists and foragers. For foragers, as we argued, hunting is likely to be among the activities with the very highest fitness payoffs for men and these payoffs are likely to diminish slowly because of the many fitness benefits beyond a hunter's own nourishment that meat may be used to extract. But if there *are* other activities that give higher fitness payoffs, individuals should turn to them whenever they have the opportunity. For horticulturalists it will frequently be the case that gardening tasks are a better investment—in fitness terms—than hunting. Although there will be periods when time cannot be profitably invested in gardening, the gardening alternative alters the *average* opportunity costs for hunting. Mixing the horticultural Yanomamö and Bisa with the foraging Aché and Kung obscures this important difference. The Bisa data probably fit the forager pattern because these hunters are professional specialists who provide meat for their lineages, and these men may get higher fitness returns from distributing meat than from gardening.

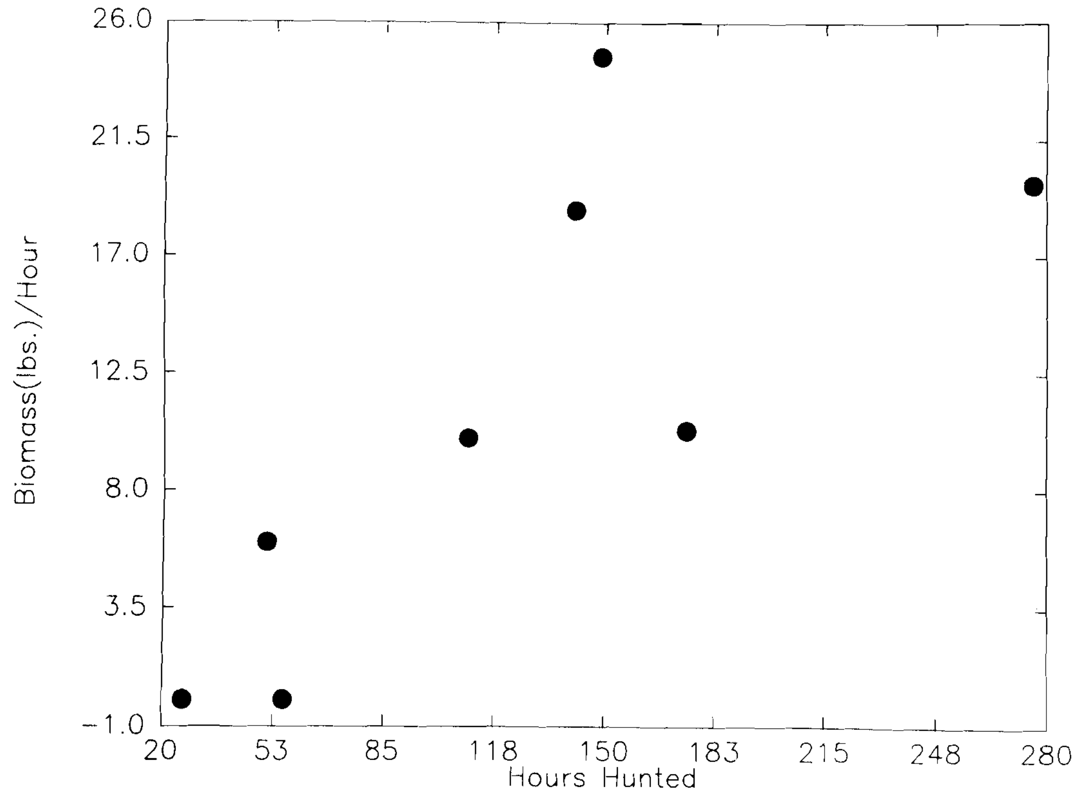

Figure 6. The relationship between average hourly hunting returns and hours hunted for eight resident Valley Bisa hunters $r = 0.82$ (Marks 1976, p. 203). Lubeles's time and returns with Marks's rifle are excluded. Jamesi's hippo, apparently killed under special circumstances, is excluded. Hippo is not eaten by the Valley Bisa (Marks 1976, pp. 78–80, 202).

ficiency) thus preventing overexploitation" (Hames 1979, p. 250). Skeptical of this view, we wonder whether there is an unusually high fitness cost for hunting among the Yanomamö. The answer may be yes. Yanomamö men compete for covert liaisons with women within villages. Neighboring enemies also threaten the abduction of wives and the murder of juvenile sons (Chagnon 1967; Chagnon and Hames 1979; Biocca 1970). Absence from the village on hunting trips may thus entail significant fitness risks.

The perspective of fitness maximization makes this a plausible suggestion, but more important, guides us to propose a test.[4] If Yanomamo hunters are divided into two categories, those with wives and children and those without, the fitness tradeoffs for the two groups should be different: fitness costs of leaving the village should be much higher for the former than the latter. Among men *with* wives and children, better hunters might be expected to return to the village more promptly, since fitness gains from continuing to hunt would be offset by the potential high cost of remaining away. Among those *without* wives and children, better hunters might be expected to stay out longer, since returns from continued hunting would not be so strongly offset.

Yanomamö examples drawn from Hames's work are used by Donald Symons (1979, pp. 158–62) to illustrate the common association between hunting success and other aspects of fitness. Symons relates Hames's vignette about a poor hunter who tried to compensate for this handicap by working hard at other tasks. If hunting gives a higher fitness payoff than alternatives, and the cost of hunting for unmarried men

[4] With the help of Nicholas Blurton Jones, personal communication.

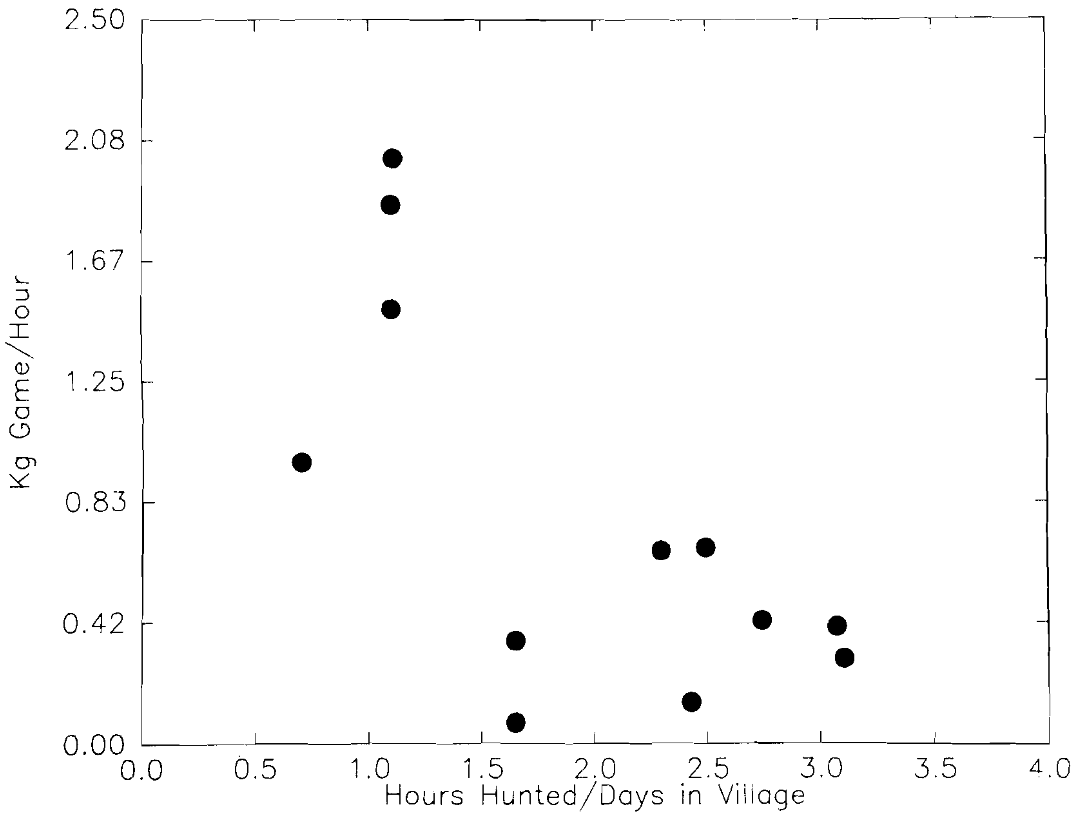

Figure 7. The relationship between average hourly return rate and the average number of hours hunted each day. These 12 Yanomamö hunters were in the study village, $r = -0.65$ (Hames 1979, p. 242).

is not high, then the covariation between skill and time spent hunting for these men should be as depicted in Figure 1. The weaker prediction to be drawn from this elaboration of the model is that hunters without wives and children would hunt *more* (n) than hunters with such dependents (w) (Figure 8). This rather counterintuitive prediction is contrary to the one that might be derived from the limited needs postulate, namely that hunters with wives and children would be expected to have higher domestic needs and so hunt more. We lack the data to test either of these predictions.

Hypothesis 3

The test of the relationship between time investment and technological efficiency using Aché data was inconclusive. Hames (1979) has also addressed this issue with data on Yanomamö hunters armed with bows and Ye'kwana hunters armed with shotguns (cf. above). The former gained an average return of 10.57 kg/hr, the later 2.48 kg/hr. The Ye'kwana spent an average of 63 minutes per day hunting, the Yanomamö 122 minutes per day, leading Hames (1979, p. 246) to remark that "the most visible immediate effect of the shotgun on Ye'kwana life is a decrease in the amount of time spent hunting." This result is inconsistent with our first fitness maximization hypothesis, but consistent with both limited needs and our second fitness maximization hypothesis.[5]

We are unable to distinguish between the latter two hypotheses with available data, but can propose a test similar to that outlined above. If

[5] Other differences between the Ye'kwana and the Yanomamö may be sufficiently great that the critical assumption of constant alternatives is seriously violated when only hunting times are compared.

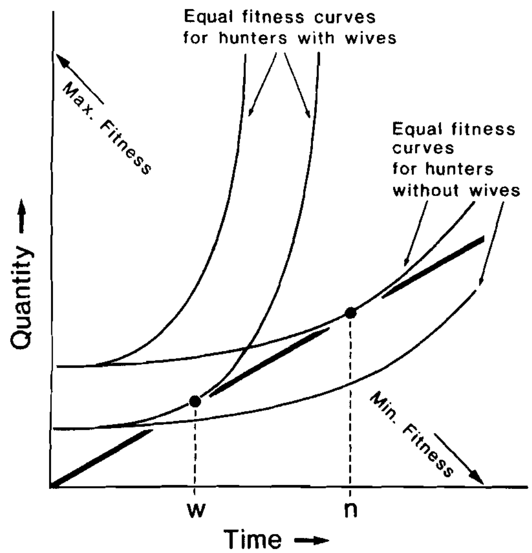

Figure 8. The relationship hypothesized between hunter's return rate, time spent hunting, and fitness for Yanomamö hunters with wives and children compared to those without.

hunters armed with shotguns curtail their hunting time because of the fitness costs of being away from home, we expect that *all hunters* with wives and children will incur higher fitness penalties for absence from the village, and that among this group, those equipped with shotguns will reach a point of diminishing returns sooner and spend less time hunting than those equipped with bows. Among hunters without wives and children, the costs of absence will be lower, so that those with guns will devote more time to hunting than those without. Again, this counterintuitive prediction is the reverse of that expected on the basis of a limited needs postulate.

CONCLUSION

The limited needs postulate and its corollary that hunters minimize the time invested in hunting are contradicted by many of the data presented here. An alternate hypothesis, derived from the theory of natural selection, that hunters hunt more when returns are good as a means of maximizing their inclusive fitness fares rather better, although it too is challenged by some of the Aché observations and by the Yanomamö and Ye'kwana data. We have proposed a further series of tests to determine whether these data are more consistent with limited needs, or, as we suspect, with a pattern of fitness maximization that may be fairly rare. In any case, the limited needs postulate, which is a basic element of the textbook view of hunters, is shown to be frequently inaccurate.

The alternative presented here can only be judged provisionally, although its partial success is encouraging. The reunion of ecological and sociobiological approaches that it represents may allow us to reevaluate assumptions about other patterns of culture as well. A focus on fitness maximization promises to make a significant contribution to the description of hunter-gatherer behavior and to the explanation of the variation it displays through time and space.

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