13

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How Much Food Do Foragers Need?

AN INTERESTING EMPIRICAL PUZZLE IS POSED BY RECENT OBSERvations on foraging effort among hunter-gatherers. In the mid-1960s, the Dobe !Kung of Botswana reportedly spent no more than 20 hours per week collecting resources that yielded an average of 2,100 kilocalories per consumer day (Lee 1968, 1969). Many anthropologists take these figures to be typical of hunter-gatherers. They expect that work effort is set to meet some general and specifiable consumption need, so that when this need is easily met, foragers work little. When it takes more effort to reach the same goal, workloads increase. Yet, in contrast to Lee's reports on the !Kung, the Aché of eastern Paraguay have recently been observed to work, averaging male and female foragers, at least 35 hours per week for a mean return of 3,800 kilocalories per consumer day (Hill et al., 1984). They procure *more* food than Lee reports for the !Kung, and they work *longer* hours to get it. The Aché data are inconsistent with what has become the received wisdom on hunter-gatherer foraging, and they raise an obvious and important theoretical question: what determines the amount of time hunter-gatherers devote to foraging and the quantity of food they consume?

The Problem

Largely because of the rich ethnographic descriptions (e.g., Lee 1968, 1979; Marshall 1976; Thomas 1959; and films by John Marshall), the !Kung are often identified as prototypical hunter-gatherers—well-nourished foragers who work relatively short hours, rely on the widely available plant foods collected by women for the bulk of their diet, and maintain low birthrates, which prevent population growth from threatening local resources. Though this characterization has been challenged, as applied both to the !Kung themselves and to other hunter-gatherers (e.g., Ember 1978; Lee and DeVore 1968; Truswell and

in M Harris & E Ross (eds) 1987 Food & Evolution: toward a theory of human food habits

Hansen 1979; Wilmsen 1978), it remains remarkably persistent. When anthropologists write about hunter-gatherers, more often than not they write about the !Kung (e.g., Cohen 1977; Harris 1977, 1983; Leakey and Lewin 1978).

The Aché are very different. The per capita daily consumption rates they sustain while foraging are quite high, averaging 2,600 to 5,400 kilocalories, depending on the season (Hill et al. 1984). More than half this total comes in the form of meat. This is especially surprising in view of generalizations about tropical hunter-gatherers (Lee 1968), particularly those of the South American lowlands (Lathrap 1968). These figures are not the result of unusually high local capture rates. Hourly returns for Aché hunters average only 10 to 15 percent higher than those calculated for the !Kung (Hawkes, Hill, and O'Connell 1982; Hill and Hawkes 1983). The difference in return is almost entirely a function of the time Aché men devote to hunting—nearly 50 hours per week per hunter while on foraging trips, more than *twice* the figure reported by Lee (1969) for !Kung men. The contrast becomes even more striking when one considers the difference in women's work effort. !Kung women spend about 12 to 19 hours per week collecting food (Lee 1968; but see recalculation by Hawkes and O'Connell 1981); yet for Aché women, the figure seldom exceeds 10 hours per week.

Stimulated by Lee's description of the !Kung, Sahlins characterized hunter-gatherers as "the original affluent society" (1968, 1972). Wanting little, they could work little to have all their needs met. Yet neither the differences in overall time investment in foraging between the !Kung and the Aché nor the differences in relative time investment between men and women show the pattern that might be expected if some fixed food total were the goal. The !Kung and Aché are both of small stature. They are of about the same height. Yet the Aché eat a great deal more, and they are almost 20 percent heavier (Hill et al. 1984; Howell 1979). If needs were a function of some standard nutritional goal, patterns of caloric intake should be more similar than they apparently are.

Moreover, the Aché are not an isolated case, an oddity among hunter-gatherers with respect to foraging. Other groups described within the past few years (Harako 1981; Hawkes and O'Connell 1981; Tanaka 1980), including the !Kung themselves (Yellen 1977), display patterns of work effort and food consumption quite different from those reported by Lee. These data underline the problem of interest here: how much food will hunter-gatherers eat, and how much time will they spend getting it? Recommended daily allowances and minimum daily requirements do not provide answers to these questions. To label the differences as "cultural" only begs the question. Can we account for the variation in some nomothetic way that will allow us to predict other cases, including patterns in the past?

A Sociobiological Perspective

There is wide agreement among anthropologists that variation in hunter-gatherer behavior is, in some sense, an adjustment to local circumstances—that it is "adaptive." However, opinions differ about the meaning of adaptation. If the direction and the means of adjustment are not specified, adaptation is an empty notion. Supposing that people who depend on local environments suit their pattern of exploitation to the resources available gives us no way to predict which plants and animals they will use as resources, how much they will crop, or what patterns of movement they will display. As circumstances change, what sort of adjustment to suit these changes do we expect? Without some specification of the goal of adjustments, the direction and form they will take cannot be predicted. However, a strict biological notion of adaptation does specify a goal: maximizing fitness. Adaptations are features of living organisms spread by natural selection (Williams 1966), that is, features spread according to the fitness—the relative reproductive success—they confer. If we can take advantage of this rigorous notion of adaptation, we have a powerful explanatory and predictive theory with which to work. The warranting argument is straightforward and simple.

Past selection has shaped capacities and tendencies for enormous flexibility in humans. This flexibility spread in ancestral populations because it was adaptive; it provided a fitness advantage to its carriers. This means it is a flexibility of a particular kind—not flexibility to do anything at all, but flexibility to track locally changing fitness opportunities. Tendencies to do otherwise would lower reproductive success and so continually be extinguished whenever they appeared. If this is so, the changes, the differences, we see in human behavior over time and space need not be the consequence of changing gene frequencies to allow explanation in terms of natural selection. They are the consequence of individuals adjusting to take advantage of changing fitness options. This means that we can use a strict biological definition of adaptation to apply to patterns of human behavior and a fortiori the behavior of hunter-gatherers. Adaptations are features that maximize the (inclusive) fitness of those displaying them. This allows us to set questions about variation in the behavior of hunter-gatherers in a fundamental theory that applies not only to *Homo sapiens* and not only to behavior but to all the changes in hominids throughout the Pleistocene.

From this perspective the key question in the analysis of any particular behavioral trait is how that trait contributes to the inclusive fitness of the individuals who display it. To address this question, one must construct a series of specific hypotheses about the fitness-related goal of the behavior in question, the alternative means available to achieve that goal, and the costs and benefits associated with each.

It is important to note that in such an analysis neither adaptation, selection, nor optimality is directly under test (Maynard Smith 1978). They provide the theoratical motivation for and links of coherence among various hypotheses. Nor is fitness itself usually measured directly. Rather, attention is directed to "design for fitness" (Williams 1966)—that is, to measurable criteria, such as energetic efficiency, that are likely to be closely related to fitness (Pyke, Pulliam, and Charnov 1977; Smith 1979).

If we apply this perspective to the analysis of food acquisition patterns among the !Kung, Aché, and any other hunter-gatherers, our attention is immediately directed to the fitness-related costs and benefits of foraging—that is, to the relative advantages and disadvantages of alternative foraging strategies under different circumstances. To the extent that we can correlate these fitness costs and benefits to features of local ecology, we develop understanding applicable not only to the present but to the Pleistocene as well.

The !Kung

It is ironic that Lee's work on the !Kung, which set a new standard for ecological anthropology, seems to show that !Kung behavior is inconsistent with a biological definition of adaptation. !Kung women, so the data suggest, work relatively little, never exhaust local resources, yet have comparatively few children. This is paradoxical. If there is plenty of food available and plenty of time to acquire it, they could comfortably feed more children than they have. Under these circumstances any tendency to shorten the birth interval and increase the number of offspring would increase parents' fitness. Why don't the !Kung work harder, eat more, and turn more resources into babies? Could it be that in spite of appearances the !Kung are working as hard and eating as much as will give them the maximum number of grandchildren?

Following a lead from Lee (1972), Blurton Jones and Sibly (1978) asked precisely this question some time ago in an essay that remains curiously underappreciated. They measured the labor costs of alternative inter-birth intervals given five assumptions: (1) that women seasonally provide about 60 percent of family caloric intake in the form of mongongo nuts; (2) that mothers usually take children under the age of four on foraging trips; (3) that these children depend heavily on mother's milk; (4) that women could not gather nuts daily because of the processing time these nuts require; and (5) that dry-season camps must be up to six miles from nut groves because of the distribution of groves and permanent water holes. Blurton Jones and Sibly found that with these constraints, the *maximum* backload that did not threaten thermal exhaustion is sustained by carrying the nut-and-baby load set by a four-year birth interval. In other words, !Kung women seem to be working as hard as they safely can in order to get food to support as many children as possible under the prevailing ecological circumstances. The apparent challenge to a biological perspective is provisionally rebutted, at least as far as women's work effort and reproductive strategy are concerned.

But what about *men's* work effort? If more food means more surviving offspring, why don't !Kung men hunt more frequently? It would certainly seem as if their wives should try to persuade them to do so. Can it be that the low level of hunting effort is one that maximizes men's reproductive success given the options available?

If Blurton Jones and Sibly are right, the heat and humidity constraints that limit women's work effort may impede the men's as well. Although hunters do not carry heavy burdens, except when bringing game to camp, the faster pace they sustain in tracking and pursuit may increase the danger of heat exhaustion and raise water requirements. Lee (1979:105–7) notes that "a person walking in the sun at 38°C (100°F) sweats at the rate of roughly 800 cc of water loss per hour, an equivalent of over 3 liters (over 6 lb of water) in a typical working day." If either high temperatures or a relative lack of water limit men's hunting efforts, we might expect to see a pattern of seasonal variability in this activity.

Lee (1968, 1969, 1979) presents quantitative data on hunting for a four-week period in July–August, the coolest and nearly the driest time of year. He says that tracking conditions during this period "encourage more hunting and the setting up of snare lines" (Lee 1979:104), but his data show that men actually hunt on only 31 percent of all possible days.[1]

Additional data are available in Yellen's activity reports for 15 Bushmen camps (1977:appendix B), covering a 28-day period in May–June (cool-dry) and a 42-day period from December to March (warm-wet). No complete data are available for July to November. Yellen shows that men hunted on 47 percent of all days in May and June, and on 73 percent of all days in December through March (Table 13.1). In other words, the !Kung hunt more than five days a week on average in the hot, relatively wet summer, but only about two days a week in the cool, dry weather. The !Kung summer pattern is more like that of the Aché than it is like the !Kung winter pattern. This suggests that it may be water rather than heat stress that limits Kalahari hunters.[2] Only more quantitative information on seasonal hunting effort, water and temperature factors, and variations in prey distribution can clarify the seasonal costs and benefits of hunting. Empirical tests of hypotheses about specific trade-offs are clearly in order. Still, the very high hunting effort evident during the summer is sufficient to encourage the suggestion that !Kung men may well be working as hard and providing as much food as they safely can under the circumstances.

in M Harris & E Ross (eds) 1987 Food & Evolution: toward a theory of human food habits

TABLE 13.1. Hunting Effort Among !Kung Men in a Sample of 15 Camps

Season	*Month*	*Camp number indentification*	*Adult man days of occupation*
Dry Winter	May	7.2	21
		13	25
	June	2	18
		12	15
		16	31
Dry Winter Totals			**110**
Wet Summer	December	4.3	21
	January	4.4	13
	February	1.2	10
		3.1	24
		4.5	4
		5	4
	March	3.2	6
		6	9
		7.1	15
		9	6
Wet Summer Totals			**112**

SOURCE: Tabulations from Yellen (1977: appendix B).

The Aché

Also low-latitude foragers, the Aché of Paraguay are not as well known as the !Kung. There are several references to the Aché (also called Guayaki) in historical accounts before the 1960s (see Metraux and Baldus 1963; O'Leary 1963), but the first modern ethnographic reports that were widely available are those of Clastres (1968, 1972), who studied two of the four living Aché groups. The data used here pertain to the northern Aché, who have come into unarmed contact with outsiders only during the past decade (Hill 1983). Full-time hunter-gatherers until that time, they currently live primarily at a Catholic mission

Adult man days of hunting	*Adult man days of gathering or honey collecting*	*% of days men hunted*	*% of days men spent in food acquisition*
8	1		
13	7		
9	5		
8	1		
14	7		
52	**21**	**47%**	**66%**
14	4		
8	4		
4	2		
15	6		
4			
2			
6			
9			
15			
5			
82	**16**	**73%**	**88%**

(Chupa Pou) but continue to forage frequently in the nearby forest. These foraging trips have been described in reports that include figures on time costs and quantities of resources acquired, as well as analyses of the efficiency of Aché foraging strategies (Hawkes, Hill, and O'Connell 1982; Hill and Hawkes 1983), the seasonal pattern of food acquisition (Hill et al. 1984), the sharing of food resources (Kaplan et al. 1984; Kaplan and Hill 1985), and men's and women's time allocation (Hill et al. 1985; Hurtado et al. 1985).

During the 10 years prior to their first peaceful contact with outsiders (1960–1970), the northern Aché probably numbered between 600 and 800 (Hill 1983). Their traditional range is an area of about 12,000 square kilometers

between 54 and 56 degrees west and 24 and 25 degrees south. This is a well-watered region with many rivers and streams. Most of the area is covered with tropical broad-leaf evergreen forest, which the Aché prefer to open grassland. Rainfall is quite unpredictable from month to month and year to year, although there is a statistically significant difference between wet and dry seasons. Annual average precipitation is approximately 1,600 millimeters. Fluctuations in temperature are much more regular, with an annual January maximum around 40°C and a July minimum of about −3°C. Ecology and climate are more fully described in Hill et al. (1984).

The Aché take a wide variety of animal species. Among the most important are peccaries (*Tajassu tajacu* and *Tajassu pecari*), paces (*Cuniculus paca*), coatis (*Nasua nasua*), armadillos (*Dasypus novemcintus*), and capuchin monkeys (*Cebus apella*). They also exploit numerous plant products, especially those of the palm *Arecastrum romanzolfianum*, from which they take the fruit, the heart, and starch from the trunk. Fruits and honey are also major resources with insects providing a small but consistent component of the diet.

Hunting in closed, sub-tropical forest, cross-cut by many small streams, the Aché are at much less risk of heat stress or dehydration than are the !Kung. Here, too much water can limit hunting. Rain ruins bow strings, blurs tracks, makes the animals difficult to hear or see. The 15 percent of the study days on which men hunt less than two hours are days of heavy rain. Otherwise, and with surprisingly low variance (Hill et al. 1985), men hunt an average of seven hours a day, day after day, in every season.

The simple proposition implicit in the discussion of the !Kung was that more food generally gives higher fitness benefits. Thus, acquisition will not stop when some "minimum needs" are met. Instead, work effort and procurement totals will be limited by the costs (and benefits) imposed by local ecological circumstances. Where these costs are lower, foraging investment should increase accordingly. The higher work effort of Aché men, throughout the seasons, is consistent with this. Two specific findings relevant here are that better hunters spend more time hunting (Hill and Hawkes 1983; Hawkes et al. 1985), and that better hunters have higher reproductive success (Kaplan and Hill 1985).

Why then, if heat and water stress are unlikely and more food is generally better than less, should Aché women spend so little time gathering, an average of less than two hours per day (Hurtado et al. 1985)? The answer to women's low food-related work effort may lie partly in the fact that Aché move camp nearly every day in pursuit of game. The women are responsible for carrying all household equipment and at least some of their children between camps. This suggests the hypothesis that women and their children do better by following the men than they would by establishing a more permanent camp in which gear and children could be deposited while they gathered food in the surrounding

in M Harris & E Ross (eds) 1987 Food & Evolution: toward a theory of human food habits

forest. Two implications of this are (1) that men should do better hunting on days when camp moves, and (2) that on days when camp is not moved, women's foraging effort should increase. In fact, if the days when camp is not moved are separated from the "normal activity" days, the difference in the time women spend acquiring and processing food is substantial. Their foraging time increases 77 percent on the rare days when camp does not move (93 versus 165 minutes).

In addition to trading off foraging for carrying, Aché women face another problem. In an environment where the "safe area" for small children is never larger or more substantial than the temporary camps, the local exigencies of child care may constrain women's foraging. Women's collecting activities may reduce the quality of their child care or significantly increase its cost where there is high probability of danger to children who are not attentively monitored. That child care does constrain foraging is indicated by the kind of foraging women do. They collect those items out of the larger set the Aché exploit whose acquisition is most compatible with child care. The trade-off is quantitatively demonstrated by the reductions in women's foraging efficiency (calories acquired per unit of time) when they are nursing, and also when the number of weaned dependents they have goes up (Hurtado et al. 1985). These data are consistent with the view that more foraging imposes a fitness cost on women, unmatched by its fitness benefit. What women "need" to collect is not set by nutritional minima, but by the fitness opportunity costs of foraging.

Conclusion

Even though provisional and illustrative, this argument about the determinants of variation in foraging effort and food acquisition among the Kung and Aché should be sufficient to suggest the potential utility of a sociobiological perspective in the analysis of human behavior. With respect to foraging, this perspective suggests that features of local ecology such as the presence of injurious flora and fauna, the distribution and availability of water and food resources, and seasonal changes in these will affect the costs and benefits associated with food acquisition. The expectation is that variable patterns are adaptations in the narrow sense—that is, they tend to maximize (inclusive) fitness. Whether arguments like this are ultimately compelling will depend on the results of further analyses of these and larger, more comprehensive data sets, especially those collected specifically for the purpose of testing sociobiologically derived hypotheses about behavioral variability.

From a sociobiological perspective, patterns of behavior are expected to favor options that tend to have the highest fitness payoffs. Leisure, food, com-

in M Harris & E Ross (eds) 1987 Food & Evolution: toward a theory of human food habits

fort, security, health, power, affection, are not ends in themselves but means. More food generally means more grandchildren. If and when it does not, we expect acquisition to be limited accordingly. From this perspective many differences among modern foragers, and differences within and between local groups and across time among our Pleistocene ancestors, may be the result of fitness-enhancing adjustments to fairly immediate local constraints.

It is not enough to see the rather different work effort and consumption patterns of the !Kung and the Aché as the adventitious results of recent history. By taking advantage of the concept of adaptation in the strictest biological sense, we may be able to account for some of the variety in the present in the way that will help us understand the past. Among other things, it may prevent us from giving up on the simple answers too soon.

Appendix

The foregoing description of the variation in foraging patterns between the !Kung and the Aché does not attend to the larger political and economic network in which both populations are embedded. This is an important general issue, independent of the merits of sociobiological perspectives. Can it be useful and clarifying to focus on the behavior of modern hunter-gatherers, and their local ecology, to the exclusion of wider historical contexts? In fact, given the special features of the modern world, can research on modern hunter-gatherers ever inform us in any general way about human foragers, especially in the prehistoric past?

It is widely recognized that modern hunters are not pristine living relics of the Pleistocene. As Schrire (1980) has shown, the !Kung have alternately made their living as farmers and pastoralists as well as hunter-gatherers for at least the past four centuries and have often been the clients of more powerful neighbors, just as they are today.

The Aché case is somewhat less clear but has some similar features. The northern Aché have been economically independent of its agricultural neighbors in the recent past, having only hostile contact with them until the establishment of local mission-sponsored settlements in the early 1970s. At that time the Aché suffered enormous losses from disease. In 1978 the mission colony of Chupa Pou was created and is now home to more than two hundred Northern Aché. From here many continue to take extended foraging trips, sometimes longer than two weeks, into the surrounding forest, where they support themselves entirely by hunting and gathering in a manner they claim to be like their full-time foraging of a few years ago. The more distant past remains clouded. Their language is closely related to that of the surrounding horticultural Guaraní Indians. It may be that they have ancestors in common, the Aché having been displaced by warfare to become refugee foragers sometime before the arrival of the Spanish in the 16th century. Such a pattern is probably not uncommon among lowland South American hunter-gatherers (Isaac 1977; Lathrap 1968).

Some (notably Isaac 1977 and Schrier 1980) have argued that the historical circumstances of the !Kung and the Aché and other 20th-century foraging groups make them inappropriate sources of information and inference about "real" hunter-gatherers, especially those of the remote past. It is as though their recent history, with its episodes of disease, depopulation, and displacement, and its periods of dependence on horticulture or pastoralism, has somehow tainted them, made them "unrepresentative" as foragers. Moreover, it is argued that the social, political, economic, and ecological circumstances in which modern foragers are encountered are so much the product of colonialism and the reach of industrial capitalism, and so unlike the prehistoric past, that one cannot hope to learn anything useful from them apart from documenting the disastrous results of their contact with state societies. From that perspective studies of the foraging patterns of modern hunters that do not focus on the play of wider regional economic and political forces in their lives are, at best, deeply misguided.

This conclusion can be challenged on several grounds. Most importantly, it implies little hope for a nomothetic understanding of human behavior. All societies differ from each other and change over time. Each occurs in a unique social and ecological setting. Any synchronic description slices out a unique set of events. It is the variability within and between societies and over time, the pattern in the differences observed ethnographically or inferred archaeologically, that we seek to explain. The descriptive convenience of typing societies—as "hunter-gatherers," for example—should not divert us into a search for archetypes in which the variability, the original object of inquiry, is cast aside as an imperfection, due to the damage of recent history, in some representations of the type. Any society anywhere has a recent history, and disease, depopulation, and displacement are not unique to the modern world.

The question is, how do we go about explaining the variety? Although any particular instance of human behavior has some unique shape, we also expect that there are common processes that dictate this shape. How else do we account for the remarkable commonalities in the evolution of human behavior worldwide over the past hundred thousand years? If common processes are not at work in such phenomena as the independent near-simultaneous emergence of agriculture in several parts of the world at the beginning of the Holocene, or the subsequent, again more or less simultaneous and independent, emergence of state societies in a smaller number of cases, the coincidence can only be seen as astonishing.

If we expect general principles to govern the larger pattern of temporal changes, we must also expect them to govern short-term patterns. The apparent uniqueness of modern circumstances must be accountable as well. We *might* use our sociobiological perspective to focus on the effects on modern foragers' behavior of particular features of their current state of dependence. The Aché mission shapes the opportunities available to individual Aché. We might seek to identify these alternatives, and the fitness-related costs and benefits of each, and make testable predictions about which of the array individual Aché will pursue. We might expect, for example, that variations in the amount of time individuals choose to spend at the mission or in the forest will depend on the respective fitness-related costs and benefits of each, and that these may vary with such factors as the age, sex, and health of those individuals, as well as with the changing mix of other individuals in either place, including potential mates, kin, and rivals. In this way

a series of testable hypotheses can be developed about the effects of the mission on Aché behavior. The mission has changed the array of behavioral opportunities, but the process of choosing among them continues.

In general, as in this paper, our focus of attention in studying the Aché has not been on the effects of the mission. Instead, we have focused on the behavior of the Aché observed away from the mission, in the forest. We have made the working assumption that certain behavioral strategies in the forest are shaped by the behavioral options in the forest. In other words, we assume that once Aché leave the mission to live entirely dependent on hunting and gathering for a week or two, some aspects of their behavior are shaped by the opportunity costs of foraging for different resources in different ways, and by the opportunity costs of foraging itself relative to other activities. We expect that people who spend significant portions of their time foraging in familiar habitats for their own subsistence in the company of kin, with mating opportunities largely limited to local groups, are likely to shape much of their behavior to these conditions. Such expectations are empirically vulnerable. If other factors—such as mission activities, features of the larger regional or world economic system, or historical circumstances not embodied in currently measurable options and constraints—overwhelmingly influence their choices, then correlations with local foraging conditions will be swamped.

Surely many Aché (and !Kung) behaviors depend entirely on the opportunities shaped by the larger state society in which they are embedded. But some behavior may be more powerfully governed by local ecology. If it is possible to account for much of the difference in work effort and food procurement by focusing on the opportunity costs set by such features as temperature and the distribution and abundance of water and wild plant and animal resources, we have a strong foundation for constructing expectations about foragers elsewhere, including behavior in particular times and places in the Pleistocene. As long as we construct and test theoretically motivated hypotheses about behavioral variety, we will check any tendency to give too much weight to the costs and benefits of immediate foraging options. It is important to know how much of the variation we can account for in this way. Unless we try, we may forfeit the richest line of evidence we have about human behavior in the Pleistocene.

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Notes

1. The alternative work opportunities for men at Dobe during Lee's 28-day sampling period may have made hunting significantly less attractive than during the same season in other years (Hill 1983).

2. There are, however, some puzzling inconsistencies. For example, Lee (1979: 104–5), citing observations reported by Marshall (1976:140), says that in the dry, hot spring (August–November), "the men say the heat makes the animals less wary and their movements are more predictable, so they are easier to stalk and kill. This fact is reflected in the kill statistics: October was a consistently good hunting month in terms of number of large animals killed." If water stress was a danger, one would have expected relatively *low* hunting effort during this period. Unfortunately, no data are available on the average number of days men actually hunt during this season.

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