Sharing and Collective Action

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9.1. INTRODUCTION

9.1.1. Purpose

Frequent sharing and exchange of goods and services are striking features of human social life. People under the widest array of circumstances seem more interdependent than other primates because so much of what anyone consumes is acquired, modified, and transported by others. Students of hominid evolution have speculated on both the causes and effects of this difference between humans and other apes and monkeys (e.g., Isaac 1978; Tiger and Fox 1971). At the same time ethnologists have long noted a wide and patterned range of variation in the character of cooperation and exchange across types of human social organizations (Service 1962; Fried 1967; Sahlins 1968b).

Recently these generalizations have been complicated by increasing appreciation of the sharing and cooperation that occur among nonhumans (e.g., Boesch and Boesch 1989; de Waal 1989b; Emlen 1991) and of the variation in sharing within and between human societies of similar social scale and subsistence type (e.g., Kaplan and Hill 1985b). Evolutionary ecologists are interested in measuring and explaining this variability, not only between species, and between communities of the same species, but also variation associated with resource types and contexts, as well as the sex, age, and relationships of the individuals involved. The topic is a broad one. I focus especially on food sharing among ethnographically known hunter–gatherers and subsistence cultivators to illustrate some of the patterns, the explanatory problems they present, and some of the competing hypotheses that evolutionary ecologists pose to account for them.

9.1.2. Overview

The chapter begins with a brief discussion of the contrast between the phenomenon labeled "reciprocity" by ethnologists and "reciprocal altruism" by behavioral ecologists (section 9.2). The usages overlap to some degree but the differences are important. The discussion reviews some ethnographic patterns for later reference. When goods are collectively consumed, those who provide the goods contribute benefits to others. This engages the problem of collective action: If those who provide more do not consume more, those who provide less obtain greater net benefits. As a consequence, individuals often serve their own interests by providing less of a collective good than would best serve the group. Some influential treatments of this problem are reviewed (9.3), and the economic logic and the kinds of explanations that are favored by evolutionary ecologists investigating these topics described (9.4). Three models used to explore problems of sharing and collective action are introduced (9.5). The models illustrate three kinds of explanation—delayed reciprocity, mutualism, and manipulation—and underline the overlap of the latter two. The following section (9.6) reviews the effects of time lags, ancillary benefits, and resource "lumpiness" on collective action. Some applications to "the sexual division of labor" are briefly discussed. Finally (9.7), ethnographic examples in which variations in patterns of food sharing have been described are summarized and examined in light of issues raised in preceding sections.

9.2. TWO MEANINGS OF RECIPROCITY

The field-defining contribution to the ethnology of "reciprocity" is Mauss's 1925 *Essay on the Gift* (Mauss 1967). In it he argued that giving and receiving gifts was the mechanism for making social contracts with strangers in the absence of state institutions. Levi-Strauss subsequently labeled giving and receiving the principle of reciprocity (1949, English translation 1969) and called it the fundamental rule of human society. These influential ideas about the social effects of transfers of goods were complemented by White (1959) and Polanyi (1957), who saw that social relationships could profoundly affect transfers. In some contexts, they argued, the flow of goods between individuals and groups is governed by the social relationships, not by the value of the goods themselves. Polanyi labeled exchanges ruled by the social relationship between equivalent parties "reciprocity." Sahlins (1965) constructed an influential synthesis incorporating these generalizations and added an important empirical observation: Much that ethnologists call reciprocity is not literally reciprocal. He cited numerous ethnographic reports in which goods moved mostly in one way. Sahlins noted that the disposition to give or share without concern for balancing accounts is characteristic of relationships between good friends and close kin. He labeled this "generalized reciprocity." Where social ties are more distant and fragile, exchanges must be more literally reciprocal to maintain the relationships.

Reciprocity in evolutionary ecology refers to Trivers's "reciprocal altruism" (1971) in which individuals take short-term costs for their sharing or assistance, in exchange for delayed but larger return benefits. This usage emphasizes that the repayment to reciprocators results in an overall net benefit, so that they are acting in their own self-interest. Reciprocal altruists discriminate against those who do not return favors. Otherwise they would be vulnerable to exploitation by "free riders" who took the benefits dispensed but did not reciprocate themselves. Unchecked by sanctions, free riders net higher benefits than those who repay assistance, and so evolutionary ecologists expect free riding to increase in frequency against unconditional sharing. In contrast, commensurate-return gifts govern the reciprocity of ethnology only at the edges of sociability where the relationships are fragile. Otherwise it is the *lack* of attention to balancing accounts, the "sustained one way flow" that is diagnostic (Sahlins 1965, 1972). If this ethnological characterization is an accurate description of empirical patterns, the reciprocal altruism model does not explain them. These different uses of the same word are recognized here by restricting the term *reciprocity* to reciprocal altruism unless otherwise indicated.

9.3. THE PROBLEM OF COLLECTIVE ACTION

The perspective of evolutionary ecology directs attention to likely differences between individual and group interests. It focuses on the fitness costs and benefits to the individuals involved in any behavior pattern. The tendency for "individual selection" to swamp "group selection," so influentially exposed by Williams (1966a; see 2.2.2), is also the problem of collective action described by Olson (1965) for human social groups. Olson showed that individuals acting in their own self-interest will often fail to provide goods that are used in common by members of their social groups, even though all members agree on the value of these common goods and even on the means to achieve them. G. Hardin (1968), taking his title from instances in which individuals increase their own net benefits by overgrazing a common pasture, called this the "tragedy of the commons." The problem has drawn attention from a long line of commentators in Western political philosophy. R. Hardin (1982), cites Plato as well as Hobbes, Hume, J. S. Mill, and Adam Smith. All note what Hardin (1982) calls "the back of the invisible hand."

Paradoxically, both sides of the invisible hand can have welfare-enhancing as well as welfare-inhibiting effects, depending on whose welfare is at issue (Hirshleifer 1982). The conflict between individual and group interests unravels powerful cartels and monopolies as well as participation in community enhancement projects. The interests of individuals are rarely either perfectly coincident or mutually exclusive, so that characterizing "a group" as even having "an interest" may obscure differences in the costs and benefits that affect the behavior of each member.

Olson relied on the distinction made by Samuelson (1954) between private goods, which can be divided up for consumption, and public goods, which are consumed concurrently (see also 10.4). If someone pays for lighthouses, public radio, or community defense, all can consume them, including those who did not pay. One person's consumption of a public good does not preclude others from consuming the same unit. Since goods can fall along a spectrum from perfectly public to perfectly private, complex technical problems have emerged around the distinction. But as Hardin points out, "the good need not be a public good in the narrow, technical sense" (1982:5) to engage "the logic of collective action." The classic example of a private good is a loaf of bread. It is perfectly divisible and you are excluded from consuming any slice I consume. Yet if I make a loaf of bread and cannot refuse you a share without paying a cost, the loaf is our collective good. For the present discussion the important point is that where individuals can consume a good whether or not they pay for it, those not paying have the advantage—unless there are separate incentives for those who pay.

Sharing gives benefits to those who did not pay for them, a prime opportunity for free riding. Taylor, in an investigation into alternative solutions to the problem of collective action, observes that general sharing promotes free riders. It is the fundamental difficulty in "intentional communities," explicitly constructed on cooperative charters, where free access to goods and services is not denied to those who do not work:

> In all these intentional communities a central problem was inequality of work effort. Every adult member of a community was expected to put in a certain number of hours of work, or to contribute as much labor as he was able; but since an individual's rewards were not dependent on the amount or quality of his work, there was always the temptation to be a free rider on the efforts of others—to find excuses for not working some days, to put little effort into the work to contribute the minimum amount of work acceptable. There are few studies of any of these communities which do not furnish examples of such free riders, and it is my impression that it is the chief source of discontent in contemporary communes. (1982:123)

What then of the sharing among hunter–gatherers? Sahlins's influential analysis of the "original affluence" of hunter–gatherer societies (1968a, 1972) led him to suggest that sharing was the source of their "nonacquisitiveness." Sahlins began with three generalizations documented from

an impressively wide array of sources. First, he showed that ethnographically known hunter–gatherers do not spend more time in food acquisition than do cultivators. In fact, work efforts are often surprisingly modest (1972:14–28). Sahlins used only two quantitative data sets, but Hames (1989) has since found the same pattern in a larger sample (see also Chapter 7). Second, foragers are commonly reported to be quite prodigal with occasional plenty. They feast now rather than storing for later (Sahlins 1972:29). Third, there is the "sloppiness" of hunter–gatherers, who are not careful of their possessions (1972:12). These three patterns suggested to Sahlins the "zen road to affluence": Foragers must want little, since they do not work as hard as they might, do not save, and place little value on their material goods. So "wanting little, they have all they want."

To account for the modest wants at the root of zen affluence, Sahlins nominated a central contradiction faced by foragers: that between mobility and accumulation (1972:33). If local resources can be exhausted or if distant resources come into season, those who move more easily may have fuller stomachs. Having less means less to move. But he argued further that limited wants are not a direct practical response to transport costs but instead a response to the family organization of band societies. People do not treasure stocks of goods because accumulation depends on refusal to give or share. A stingy person is the opposite of a "good kinsman," and forfeits the esteem of kin–neighbors. If it is "bad" not to share and so all share, then "an attempt to stock up food may only reduce the overall output of a hunting band, for the have-nots will content themselves with staying in camp and living off the wherewithal amassed by the more prudent" (1972:32).

By this reading, Sahlins is arguing that the "limited needs" of foragers are set by sharing, which makes food and other objects collective goods. This makes food procurement—and even artifact manufacture and maintenance—a collective action problem. The examples he adduced and the characteristics he noted are all quite consistent with the view that a free rider problem sets "standards of living" low among many ethnographically known foragers. Several ethnographic reports as well as synthetic accounts that have subsequently appeared are also consistent with this view. Wiessner's rich description of !Kung San sharing is a particularly clear example. She reports that

> in deciding whether or not to work on a certain day, a !Kung may assess debts and debtors, decide how much wild-food harvest will go to family, close relatives and others to whom he or she really wants to reciprocate, versus how much will be claimed by freeloaders. A person may consider whether the extra effort is worthwhile, or if time would be better spent gathering more information about the status of partners and trying to collect from one of them. . . . Limiting work effort over the long run can result in bringing lower than possible mean income. (1982:79)

So ethnologists have recognized that sharing can make "work" a collective action problem. But if these are effects of sharing, why the sharing? Ought it not to be self-limiting? If more sharing leads to less work, there must be less and less to share. Yet the empirical generalizations suggest variation in sharing (as well as work). Moreover, this construction implies three mutually exclusive extremes: One is to acquire no more than one can immediately consume, another is to acquire more and share it, and a third is to acquire more and store it for future consumption. Each of these possibilities occurs empirically, sometimes even in the same household. This variability provides the opportunity to test alternative explanations.

9.4. THE ECONOMIC LOGIC OF EVOLUTIONARY ECOLOGY

9.4.1. *Trade-Offs and Conflicts of Interest*

Evolutionary ecologists seek to explain how any pattern they study is maintained. Economic logic is central to the inquiry. That makes two notions especially important. First, in a world of limited time and other resources, individuals regularly face trade-offs. If more is invested in one thing, less can go to something else. This, in turn, poses questions about the costs and benefits of the behavior under study. Why not more or less work, more or less sharing in any particular case? What adjustments are possible? What would be the costs and benefits of these alternatives?

The second important notion is that while there are often overlapping fitness interests among individuals, perfect coincidence is rare. For example, we may both eat better if one of us kills an antelope, or if we clear the drainage ditch between our gardens (the antelope and the cleared ditch are collective goods); but only one of us need track the animal, and my garden may suffer more than yours if the ditch remains clogged. Where social interactions are involved, behavior that would maximize the fitness of one party is unlikely to maximize the fitness of the other. This is so even among the closest of kin. Moreover, the costs and benefits for alternative actions often depend directly on what others are doing. If the costs and benefits for each depend on the choices others make, what outcomes can be predicted?

9.4.2. *Four Kinds of Explanation*

Kin Selection. Explanations that seek to predict how (and under what limits) patterns of sharing will be maintained fall into four categories. First, there is kin-selected altruism, in which individuals assist others whose consequent gains in reproductive success are gains to the benefactor's inclusive fitness (Hamilton 1964; see section 2.2.2). Assistance given by parents to offspring, as well as some assistance given to other kin, will be consistent with kin-selected altruism as long as the cost to the benefactor is less than her probable gains in inclusive fitness.

Note that although individuals have more overlapping inclusive fitness interests with closer kin, only identical twins have identical genetic interests. The inclusive fitness of even mothers and their infants is only partly coincident (Trivers 1974). This means that the remaining explanatory categories that do not depend on shared inclusive fitness are relevant not only to interactions among nonkin but kin as well, with appropriate adjustments in expectation for the inclusive fitness each gains and loses in the fitness costs and benefits to the other.

Reciprocal Altruism: Delayed Reciprocity. The second kind of explanation developed in evolutionary ecology to account for persistent transfers of benefits from one individual to another is reciprocal altruism, perhaps usefully termed "delayed reciprocity," where a short-term cost to the "altruist" is exceeded by benefits returned to him later (Trivers 1971). Here the current shares given up are the "advance payment" for the future shares to be returned. Theorists have noted that if individuals live long enough and interact repeatedly with the same others, and especially if individuals can provide highly beneficial services to others at low cost, those who participate in delayed reciprocity will have higher fitness than those who do not (Trivers 1985).

Immediate Mutual Benefits. The third category might be called mutualism, where individuals all do better, *in terms of immediate accounting*, by mutual assistance. If, for example, there are economies of scale in some resource procurement activity, then individuals who join in mutual procurement and then mutual consumption might do better than those who do not. But self-interested actors will often fail to produce collective goods even though they would gain substantial benefits. The benefits alone are an insufficient explanation for cooperation. A complete analysis will consider the controls on "cheating." This requires an evaluation of the costs and benefits to hypothetical free riders who try to join in consumption without participating in the procurement.

Manipulation. Fourth, there are cases of manipulation, coercion, or social parasitism in which individuals contribute to the fitness of others because it would cost them more not to. In the preceding example individuals who pay the cost of procurement may do so because, in spite of the free riders, they net a gain. Even if they would do better without free riders, the cost of excluding them may be higher than the benefit. Intuitively mutualism and manipulation seem distinct, but actually there is considerable overlap between them. Since individuals rarely have an identity of interests, and since individuals differ in myriad ways, costs and benefits are unlikely to fall evenly on cooperators. Thus mutualism grades into manipulation where benefits are unequal and individuals help or share because the cost of not doing so would be higher. Paradoxically, as Olson noted (1965:35), there is thus "a *surprising tendency for the 'exploitation' of the great by the small*" (original emphasis). Any who stand to gain more from a collective good will find it in their own interest to "bear a disproportionate share of the burden." Inequalities of wealth and power can thus serve the interests of those low in the hierarchy by increasing the provision of collective goods (see section 10.2.4). Of these four categories of explanation, this chapter will focus on the latter three. For further discussion of kin selection see section 2.2.2.

9.5. INTERDEPENDENT COSTS AND BENEFITS: THREE MODELS

9.5.1. *Frequency Dependence and Game Theory*

Whether or not sharing yields net benefits to those who give depends on what recipients do. The infinite regress created by such interdependencies is initially daunting. But these are precisely the problems familiar to economists (Schelling 1978). Game theory was originally developed by von Neumann and Morgenstern (1944) to deal with such frequency-dependent choices (See Luce and Raiffa 1957). Applications by economists and political scientists to problems of sharing and collective action are usually *not* (sometimes quite explicitly not) motivated by evolutionary theory. But some of their modeling provides results of direct interest to evolutionary ecology. The technique allows the exploration of trade-offs and calculation of outcomes where individuals have conflicting interests and where the costs and benefits of the various options depend on what others do. Evolutionary ecologists have thus found game theory to be a particularly useful analytical tool (Maynard Smith 1982a; see section 2.2.3).

The simplest games involve two players and two strategies that can be represented by a matrix in which one player's options define the rows and the other's define the columns. The four cells contain the payoffs for each of the possible combinations of strategies. Of the large variety of possible games, one, the Prisoner's Dilemma, has stimulated an enormous literature (see Chapter 2, Box 2.2). That game and a second, Chicken, which has received a fair amount of attention as well, are especially useful ways to represent problems of sharing and collective action.

The example of group size will serve to illustrate the games. It is itself a problem of some anthropological interest (see Chapter 10) and can, as in this illustration, involve a collective-action problem. How large will groups be under different circumstances? The case of special-purpose hunting groups may be one of the simplest (Smith 1981; Hill and Hawkes 1983; see section 10.2.1). Similar problems may confront gardeners cooperating on a swidden. If the harvest per gardener varies with the number of cooperators, then some number(s) of cooperators will maximize individual harvest rates. For illustration, assume that the number of cooperators that maximizes this rate is two. Two solitary gardeners both do better if they join together. Imagine now a third gardener choosing whether to garden separately or join the group of two. If groups of three have higher rates/person than solitary gardeners (though lower rates/person than do groups of two) the gain to the third gardener, if she joins, is the difference between her rate alone and her rate as a member of a group of three. If each of the gardeners is trying to maximize her own rate, there is a conflict of interest between the current cooperators and this potential joiner. If she joins, their rate goes down, hers goes up.

9.5.2. *The Prisoner's Dilemma and Reciprocity*

There is another potential conflict of interest here, *between* the two current cooperators. Since they stand to lose if the newcomer joins, they may either allow her to join and take the cost of reduced rates or try to exclude her. Since it is in her interest to join, assume that it will cost the excluder(s) to keep her out. If one of the current cooperators could exclude her, which of them will provide this collective good? Perhaps this cost of excluding the potential joiner could be shared. The current cooperators face a collective action problem that can be represented as a 2 × 2 symmetrical game. One possible game is represented in the following matrix, where the letters are used to define the cells and the numbers in each cell indicate the value of the payoffs to row if she plays the indicated strategy against the intersecting strategy of column:

Payoff matrix 1

	Exclude	Don't exclude
Exclude	$c = 3$	$a = 1$
Don't exclude	$d = 4$	$b = 2$

The payoff to row depends on what column does. In this game, if column excludes, row will do better to let column take the whole cost and not to exclude, that is, $d > c$. If column does *not* exclude, row will also do better not to exclude, since otherwise row will pay the whole cost herself, that is, $b > a$. Whatever column does, row will do better not to exclude. Since this is a symmetrical game, either player's payoffs appear in the cell defined by her strategy as row and her opponent's strategy as column. If Alice excludes and Ann doesn't, the payoff to Alice is indicated in cell *a*, the payoff to Ann in cell *d*. The strategy that dominates this game is to allow the joiner into the group. Maynard Smith called strategies that dominate a game evolutionarily stable strategies (ESS; section 2.2.3). Since not providing the common good dominates in matrix 1, this is an example of a Prisoner's Dilemma (Chapter 2). If each player acts in her own interest the joiner will not be excluded. The potential joiner's exclusion is a collective good for the current cooperators. They have a collective action problem because it is not in their individual interests to provide this good, even though they would both have done better if only they had cooperated.

Where games are repeated and players can make their responses contingent on previous rounds with the same opponents, patterns emerge in Prisoner's Dilemmas that are impossible with "one-shot" games. Trivers relied on this in his model of reciprocity (1971). He and others have seen this opportunity for contingent strategies to be the key to the evolution of cooperation. To model some possibilities, Axelrod (Axelrod and Hamilton 1981; Axelrod 1984) invited contestants to enter strategies in computer tournaments in which each played a series of two-person Prisoner's Dilemma games against all the others, with a total score for each strategy determined by the average of its scores over each series. In every game, each player could either cooperate or defect. Submitted strategies specified the basis for choosing between these moves. The winning strategy (submitted by the game theorist A. Rapoport) was tit-for-tat (TFT), in which a player cooperates on the first play and then responds in each subsequent round with whatever the opponent played last time. This is the strategy of reciprocal altruism, in which individuals forgo the temptation to defect in the company of other reciprocators, and so, as long as their opponents cooperate, they accumulate delayed rewards for cooperation.

In his analysis of the tournament results, Axelrod noted that strategies that were "nice, retaliatory, and forgiving" generally did better than their opposites. Nice strategies began by cooperating; thus they took immediate advantage of any tendency in their opponents to cooperate. Quick retaliation for a defection prevented exploitative strategies from abusing their niceness. But quick forgiveness was as important as quick revenge. Those that forgave after a single retaliatory defection avoided long costly periods of mutual recrimination. Axelrod pointed out that TFT never did better than any opponent in a series. It won because it took advantage of mutual cooperation when the opportunity arose, but, unlike a strategy of pure cooperation, it did not allow itself to be exploited. Its short memory was a clear asset since

holding a grudge slowed return to mutually advantageous cooperation. TFT did well itself by allowing others to do well too, but not at *its own* expense.

Axelrod (1984) deduced very general implications about delayed reciprocity and the evolution of cooperation from these results. However, the special characteristics of the tournaments have since been emphasized by the construction of alternative models showing TFT to be less robust. Boyd and Lorberbaum (1987) show that TFT may be collectively stable, that is, no other strategy doing better against it than it does against itself, but not evolutionarily stable. Other nice strategies can do as *well* against it as it does against itself, and so TFT cannot prevent them from increasing in frequency. Hirshleifer and Martinez-Coll (1988) show that (for the same reason) in triadic playoffs, TFT players support the persistence of unconditional cooperators. Since TFT stops cooperating with defectors, it limits their success, which limits the damage defectors can do to unconditional cooperators. Cooperators "free ride" on TFT's punishment of defectors. The presence of these cooperators is an opportunity for defectors, in turn, to free ride on them. Hirshleifer and Martinez-Coll also show that introducing a probability of error can reduce the ability of unconditional cooperators to free ride and made TFT a more likely ESS. But as Rasmusen (1989:120ff.) points out, accidents can readily catch two TFT players in a "miserable alternation" of irrational punishments.

Sugden (1986) suggested a variant that Boyd (1989) calls "contrite tit-for-tat," which avoids this problem. With it, individuals "apologize" for their mistakes by taking their punishment but then cooperating rather than replying with further defection. Boyd (1989) showed that contrite TFT can be evolutionarily stable. In addition to the problems that these contributions reveal about the interplay of strategies even with small groups of players, the larger the group of players the more difficult it is for delayed reciprocity to persist (Taylor 1987; Boyd and Richerson 1988a).

Another source off vulnerability for delayed reciprocity is the time between a cost incurred and the compensating benefit returned. Iterated games differ from single contests because the possibility that players might meet again allows their current choices to influence subsequent decisions. "The future can therefore cast a shadow back upon the present and thereby affect the current strategic situation" (Axelrod 1984:12). Axelrod noted that the shadow of the future will be larger if replies are more frequent, smaller if they are not (more on this in 9.6.1.).

Recall that delays of notable length are *diagnostic* of the pattern that Sahlins labeled "generalized reciprocity." This prompts a search for benefits (or costs) other than future repayment as possible determinants of sharing. The focus on the payoff structure of the Prisoner's Dilemma and on delayed reciprocity as the solution to the riddle of cooperation may have defined the problem too narrowly. Models that posit different payoff structures and are less dependent on delayed returns provide some insights.

9.5.3. Chicken and "Cooperation" (with a Bit of Manipulation)

There is another form that the group size problem introduced in (9.5.1) might take. Assume that one of the current cooperators can successfully exclude the potential joiner, and that the cost to one member of keeping him out is less than the cost to that member of letting him in. This reverses the order of payoffs for cells *a* and *b* in payoff matrix 1. The game is then not a Prisoner's Dilemma. Allowing the joiner into the group is no longer an ESS. The game is now Chicken (Rapoport et al. 1976), familiar to evolutionary ecologists as one form of the Hawk–Dove game (Maynard Smith and Price 1973; Maynard Smith 1982a; Chapter 2, Box 2.1). In Chicken, row would do better not to pay any of the cost of excluding the joiner if column excludes, but if column fails to exclude, row would do better to pay the cost of exclusion herself than accept the greater loss of allowing the joiner into the group. Taylor (1987; Taylor and Ward 1982) has argued that many collective-action problems are better represented by games other than the Prisoner's Dilemma. Chicken is one of them.

Maynard Smith first used game theory (Maynard Smith and Price 1973) and first elaborated the concept of an ESS (Maynard Smith 1974a) to address a question of direct relevance to the topic of sharing. He asked what strategy natural selection would favor among potential consumers meeting over a resource. Imagine two individuals arriving at a food item. Consider first two alternative courses of action. One strategy is Hawk: fight for exclusive use of the valuable, escalating the fight as necessary to win or until injured and defeated. The other is Dove: never fight, share the resource, or retreat if a competitor threatens a fight. To construct a payoff matrix for individuals playing these two strategies against each other, Maynard Smith defined the following payoff variables (ignoring here the cost of display): V, the value of the resource (i.e., the gain in fitness it provides), and C, the cost of injury in a fight over the resource. Entries in the matrix show the payoff to row against column, assuming that any Hawk is likely to win about half its contests with another Hawk:

Payoff matrix 2

	Hawk	Dove
Hawk	$(V - C)/2$	V
Dove	0	$V/2$

If the value of the resource is greater than the cost of defending it ($V > C$), then Hawk is the ESS. A Hawk does better both against other Hawks and against Doves than a Dove does. Under these circumstances the payoff structure is a Prisoner's Dilemma. When both play Hawk, they earn lower payoffs than if they both played Dove, yet neither player acting in its own interest will choose Dove because it can be exploited by a Hawk free riding on Dove's defenselessness.

If $C > V$, however, the payoff structure is no longer a Prisoner's Dilemma. It is Chicken. Neither pure Hawk nor pure Dove is an ESS, since Hawk does better than Dove in a population of Doves, and Dove does better than Hawk in a population of Hawks. For these payoffs the ESS is a mixed strategy. At the ESS there can be no relative increase in either Hawk or Dove, that is, neither can do better than the other. So the ESS can be calculated from the payoff matrix by solving for the relative frequency of encounters with Hawks at which the average payoffs to Hawk and Dove are equal. In this case the ESS is to play Hawk with a probability of V/C in any encounter. Any individual playing either Hawk or Dove with probabilities different from V/C for Hawk and $1 - (V/C)$ for Dove does worse overall than those adopting the ESS. Thus some cooperation or sharing is in the immediate self-interest of the players.

Taylor and Ward (1982) and Taylor (1987) argue that such payoff structures may be quite common. Jousting knights and jalopy-driving teenagers would prefer that the other guy swerve, but would prefer to chicken out rather than suffer the dire consequences if no one backs down. Chickens abound: from fetching the daily load of firewood to claims on a resource and fending off predators. With Chicken neither pure unconditional cooperation (Dove) *nor* pure unconditional defection (Hawk) is an ESS. The mixed strategy that *is* the ESS depends on the relative value of the goods being produced or contested and the costs associated with providing or fighting over them.

The payoff structure for a contest over an existing good, the Hawk–Dove game, differs from the payoffs for procuring or producing a good that all can use. The second of these can be represented as follows. Imagine here a public good, like a campfire or community defense, which is not divisible and is consumed concurrently by both players. If only one contributes and that contribution ensures that there is some fraction s (where $0 < s < 1$) of the good, then that much benefit is available to both. The payoff structure looks like this:

Payoff matrix 3

	Cooperate	Defect
Cooperate	$V - C$	$sV - C$
Defect	sV	0

If $C > V(1 - s)$ and $C > sV$, then this is a Prisoner's Dilemma. Row will do better to defect whatever column does. But if $sV > C > V(1 - s)$ (which requires that $s > 1/2$) this is a Chicken. Row will do better to defect if column cooperates but if column defects row will do better to cooperate. Any public good that can be provided in increments with incremental benefits might pose this payoff structure. If, on the other hand, $C < V(1 - s)$ and $C < sV$, then *cooperation* is the best strategy for row whatever column does. Unconditional cooperation would then be the only ESS.

Compare this payoff structure to the Hawk–Dove game (inverted from above to make that easier):

Payoff matrix 4

	Dove	Hawk
Dove	$V/2$	0
Hawk	V	$(V - C)/2$

In this game there are no production costs, the good is divisible, and exclusion is possible. The goods in question are different, the costs are different, but both games can be Prisoner's Dilemmas or Chickens. If $V > C$, then row will do better to play Hawk whatever column does: a Prisoner's Dilemma. If $C > V$, then this is a game of Chicken.

Maynard Smith (1974a) defined a third strategy in the Hawk–Dove game that uses an arbitrary asymmetry between the contestants to decide who gets the resource. His conditional strategy, "Bourgeois," uses the following convention. Play Hawk if you arrive first at a resource ("the owner"), and play Dove if you arrive later ("the intruder"). The payoff matrix that includes this strategy, and assumes that either player is equally likely to be the first to arrive at a resource, looks like this (again ignoring the cost of display):

Payoff matrix 5

	Hawk	Dove	Bourgeois
Hawk	$(V - C)/2$	V	$(3V - C)/4$
Dove	0	$V/2$	$V/4$
Bourgeois	$(V - C)/4$	$3V/4$	$V/2$

In general, a strategy is an ESS if its diagonal entry is greater than any entry in that column, that is, it does better against itself than any other strategy does against it. Consider first the Hawk column of the matrix, which shows how all others do against Hawk. If the cost of injury (C) is greater than the value of the resource (V), Hawk as a pure strategy can never be an ESS because $(V - C)/2 < 0$ and Dove, never paying the cost of a fight, will always be able to invade a population of Hawks. Inspection of the Dove column shows that Dove can never be an ESS since both Hawk and Bourgeois can invade a population of Doves (because $V > V/2$, and $3V/4 > V/2$, respectively). The Bourgeois column shows that if $V < C$, then this arbitrary asymmetry, which settles each contest with other Bourgeois unambiguously without a fight, can invade a population of Hawks. Since the Bourgeois strategy is to play Hawk only as the first arriver, it will play Dove when arriving second and so give up to Hawk half the time. In the other half of its encounters with Hawk, Bourgeois will be first to arrive and so it will fight (winning the resource in half of those fights and paying the cost of injury in the other half). Bourgeois also outcompetes Dove, because $V/2 > V/4$, regardless of C. Hence Bourgeois is an ESS, in fact the only ESS in this game. Players using this strategy play Hawk half of the time and Dove half of the time in their contests with both Hawks and Doves. Bourgeois players do better than either Hawks or Doves against other Bourgeois because they never pay the cost of injury when they meet each other, but, unlike Dove, they do not always yield the resource to Hawk.

9.5.4. *Tolerated Theft and Manipulation*

Blurton Jones (1984, 1987b) has discussed a third payoff structure for problems of sharing and collective action. He pointed out the potential importance of payoff differences likely to arise in contests over resources that (1) are divisible, (2) come in package or clump sizes large enough that the value of successive bits diminishes to consumers, and (3) are unpredictably acquired. A resource with the first two features can be characterized by a gain curve of diminishing marginal value with each successive bit consumed (Figure 9.1). If resources are unpredictably acquired, individuals will have unsynchronized successes. Those who have consumed more will value the remaining bits of the resource less than will others. If all individu-

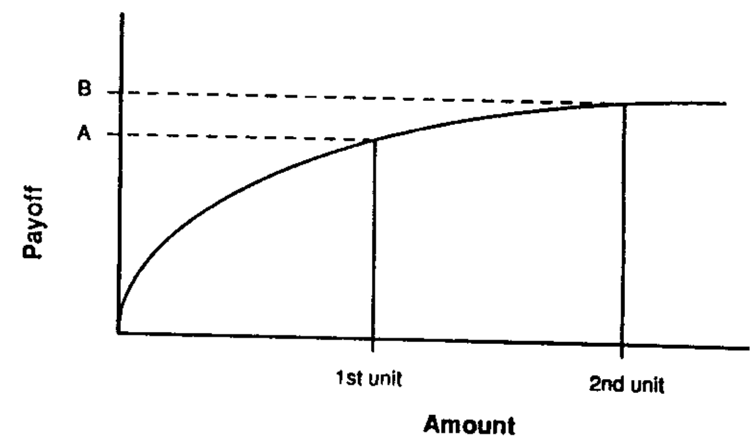

Figure 9.1. A gain curve of diminishing returns showing that initial units of a resource are worth less than subsequent units. The fitness payoff for consumption is on the y-axis. The amount of the resource consumed is on the x-axis.

als will pay a cost to get or keep the next unit commensurate with the value it has for them, and if individuals have similar competitive abilities, those who have more will relinquish additional amounts to those who have less. They will "tolerate the theft" because the cost of defending the extra is more than its worth to them. (See 10.3.2 for further discussion of tolerated theft.)

The group size problem would contain this kind of asymmetry if the joiner would gain more than the current members would lose were he to join them. Under those circumstances it would be in the interest of the joiner to take a higher cost to enter the group than a current member could afford to pay to exclude him.

The tolerated-theft model focuses attention on the importance of differences in the value that the same amount of the same resource may have to different consumers, as well as the consequences of different types of gain curves. Under some circumstances, the relationship between the payoff and the amount of the resource could be convex up, gains accelerated rather than decelerating, or it could be linear—constant increases in value for each additional unit—or even sigmoid (see Figure 10.5). But a diminishing-returns curve is likely to represent a wide array of empirical circumstances. The familiar notion of superabundances is nicely accommodated by this model. It allows discrimination of "relative" superabundance, the extreme being resources available in sufficient richness that the gain curve of all consumers in a group reaches the asymptote at which they get no additional benefits for additional consumption.

With tolerated theft, goods that are divisible, that display a payoff curve of diminishing returns, and that are asynchronously acquired will come to be distributed so that each individual keeps no more than she can economically defend. Since the costs of defense will depend on what others have, economically defendable amounts cannot be calculated directly from one individual's gain curve and her current holdings. It is a relative matter. Whenever anyone has more than others, the extra portion will be worth more to those who do not have it. They will thus be ready to pay more to get it than holders of equal competitive ability can afford to pay to keep it. As Blurton Jones noted, the movement of goods in many ethnographic contexts seems very much this sort of distribution by threat. On the other hand, marked differences in coercive power, or resources with accelerating gain curves, can result in very unequal resource distributions, as discussed in section 10.3.2.

The Cost of Sharing. A slight modification of Maynard Smith's Hawk–Dove game allows us to consider the effect of resources that vary in size or richness relative to the appetite or consumption capacity of users. Define another variable: L, the change in value imposed by sharing with another consumer. Whereas matrices 2, 4, and 5 assumed that a user lost ½ the value of a resource if it was shared, substituting $V - L$ for $V/2$ will show what

happens as the "cost of sharing" varies. Incorporating this variable alters the payoff matrix as follows.

Payoff matrix 6

	Hawk	Dove	Bourgeois
Hawk	$(V - C)/2$	V	$(3V - C)/4$
Dove	0	$V - L$	$(V - L)/2$
Bourgeois	$(V - C)/4$	$V - L/2$	$V/2$

The Hawk column is unchanged. If $C > V$, Hawk cannot be an ESS. If $C < V$, it is an ESS, but it may not be the only one. Consider the Dove column. The variable L allows Dove to be an ESS, but only if L has a negative value, that is, if sharing the resource with another individual *increases* the payoff to Dove. This may be the case if the resource is very large relative to Dove's appetite, so that Dove's consumption is not reduced, *and* there is some additional benefit from the presence of another feeder. For example, if predators (or raiders) are a serious danger, the presence of others as alternative targets and as additional eyes and ears may allow Dove to spend less time in vigilance and so more in consumption. Or it could be that other sharers actually increase Dove's productive efficiency. Any cooperative task in which additional hands increase the per capita returns (e.g., building a barrier for fish, harvesting a very perishable crop, driving game), could have these payoffs (Hames 1990; Smith and Boyd 1990; and Kaplan et al. 1990). As long as L is negative, Dove will be an ESS.

The Bourgeois column shows that Bourgeois can be an ESS only if $C > V$ *and* $L > 0$. If $C < V$ and $L > 0$, then Hawk is the only ESS. If $C > V$ and $L < 0$, then Dove is the only ESS. If $C < V$ *and* $L < 0$, then both Hawk and Dove are ESSs. When both are ESSs then one *or* the other will be reached—the ESS is a pure strategy, not a mixed one (Hawk *and* Dove) as in matrix 2. Which ESS prevails depends on the relative frequencies of the strategies when the game begins. If Dove is at high frequency, neither Hawk nor Bourgeois can increase in frequency against it, but if instead Hawk is at high frequency, then neither Dove nor Bourgeois can invade it.

9.6. DISCOUNTING, DIFFERENT KINDS OF BENEFITS, LUMPINESS, AND ASYMMETRIES WITH SPECIAL REFERENCE TO SEX

9.6.1. *Time and Discounting*

The observation that the patterns labeled reciprocity in the ethnographic record are rarely literally reciprocal prompts analysts to ask why one-way flows persist in these cases. A simple answer could be that benefits are usually reversed in the long run. While long delays make literal reciprocation hard to observe and measure, short-term "imbalances" could add up to longer-term balances. But there are reasons to suspect that long delays in themselves make future favors less likely to compensate current costs.

The relative value of future benefits depends on the discount rate and the length of the delay between a good given and a good returned. The discount rate is the proportional decline in the present value of a good when its expected consumption is a unit of time into the future. For example, the interest rate is a measure of how much the value of money is discounted over time. Money loans cost more as the value of a dollar returned declines with higher interest rates and longer delays to repayment. So also the future compensating benefit must increase with larger discount rates and longer time delays if the present value of that future benefit is to exceed the temptation to defect.

Those who study the rates at which rewards lose their value as delays lengthen report extremely high discount rates for both human and nonhuman subjects (Logue 1988; Kagel et al. 1986; Rogers n.d.). If discounting is steep and if, moreover, there are long delays as ethnographic reports suggest, then the value of any expected repayment may be insufficient to account for the persistence of sharing.

The longer the delay, the lower the value of the expected repayment for two reasons. First, the future is always uncertain. Givers may themselves not be around to receive the future returns. Current recipients may not be around to reciprocate. The longer the distance into the future, the greater the likelihood that something might interrupt the repayment (Taylor 1987; Stephens 1990; Clark 1973). Second, the longer the delay, the higher the likely opportunity costs (alternative dispositions of the favor, which could draw quicker net benefits). Delay means losing chances to "earn interest" on the investment in the meantime (Stephens 1990). In sum, as Axelrod (1984) noted, the longer the time between goods or assistance given and anticipated return, the smaller the shadow of the future, and so the larger anticipated future benefits must be to offset current costs.

The discounting problem is not restricted to reciprocal altruism. Other costs and benefits that might play a role in the persistence of sharing often imply some delay. Consider, for example, tolerated theft. What costs of not sharing might others impose? Physical threats would not be very credible from smaller and weaker contestants (Kaplan and Hill 1985b; Kaplan et al. 1990). But crying complaints, even (perhaps especially) from a very small child, might pose not only the cost of irritation, but more general disapproval with important fitness consequences. These consequences of social disapproval, like refusal of subsequent sexual access or of support in later disputes, are delayed and so should be discounted accordingly.

There is another issue that involves time in a different way. Reciprocity is

expected where the same individuals interact regularly and can swap benefits often. Axelrod noted that one way to enlarge the shadow of the future is to make the relationship more "durable." Paradoxically, if Axelrod's tournaments are a relevant model, this is not because of "long track records" to establish trust. As Axelrod's analysis of his results indicated, tit-for-tat was successful in part because of its *short* memory. Instead of "holding a grudge" this strategy won partly because it responded only in terms of the very last play. In his tournaments, strategies that did have longer memories got caught up in mutual recriminations. As noted above (9.5.2), contrite reciprocity is an ESS when there is some probability of mistakes because it so quickly recovers from an exchange of defections with "apologetic" cooperation and "forgets" the past. These models contradict the view that long-term relationships are ripe for reciprocity because time allows an accumulation of confidence. What counts is the future. From this perspective, it is not a past of mutual trust that makes friends and neighbors better candidates for reciprocity than strangers but the greater likelihood that they will be around tomorrow.

9.6.2. *Different Kinds of Benefits*

Olson (1965) talked about the role of "selective incentives" in extracting collective goods, and emphasized that these must themselves be private goods, that is, "they must distinguish between those individuals who support action in the common interest and those who do not" (1965:61, fn. 17). Kaplan and Hill (1985b) suggested that exchanges of different kinds of benefits, which they called trade, were important among the Aché. They showed that men who were more successful hunters were more often named as sexual partners and had more surviving children (1985a). Winterhalder (1986) called exchanges "involving goods or services in addition to food," "differentiated exchange," and suggested that this would be likely to occur where some individuals were consistently more successful than others at acquiring food. It seems likely that, other things the same, people would prefer companions who were more generous over those who were less. They might, as a consequence, treat those they prefer favorably so as to increase the likelihood of their continued proximity.

The fitness value of "favorable treatment" among nonhuman primates has been emphasized by Smuts (1985), who describes friendships between adult male and female anubis baboons and points out the important consequences these may have for the fitness of both. Although anthropologists have tended to see "divisions of labor" in food acquisition as the basis for cooperation in other aspects of social life (e.g., Isaac 1978; White 1959), a view that encompasses other primates suggests the converse argument:

Exchanges of nonfood goods come first. Contributions of food may then be an additional way to elicit other fitness-enhancing goods. Ethnologists have long noted associations between generous food distributions and higher social status. Sahlins summarizes this:

> Insofar as the society is socially committed to kin relationships, morally it is committed to generosity; whoever, therefore is liberal, automatically merits the general esteem. . . . The economic relation of giver-receiver is the political relation of leader follower. (1972:133)

If esteem and deference are associated with sexual favors, support in disputes, or favors to children of the esteemed, then "generosity" has fitness benefits that may be greater than its fitness costs.

These hypotheses about "selective incentives" do not, however, escape some of the problems noted for more literal delayed reciprocity. First there are the problems of delay (9.6.1), and second the familiar problem of free riding. While the selective incentives themselves may be private goods to the recipient, they elicit collective goods. This makes the *contribution* of the selective incentives a payment for the collective good. So such contributions themselves pose collective-action problems. Some might do better to free ride on the favor giving of others, with favor giving consequently underprovided. Prisoner's Dilemmas and Chickens could occur throughout. Favors to elicit favors for food providers could add more nests of Chickens. Both prospects of future benefits (i.e., some version of delayed reciprocity) and also short-term costs (i.e., tolerated theft, Chicken) may be operating at the same time. To be more concrete, Wiessner's description (1982) of the choice of *hxaro* partners and the fostering of partnerships among the !Kung shows attention to both probable future and more immediate benefits and costs.

9.6.3. *Lumpiness and Thresholds*

The character of the goods themselves has important effects on the kind of collective-action problems arising. If goods cannot be provided in continuous increments but only in large "lumps," this affects both sharing and work. Food resources that are acquired unpredictably in large packages tend to be more widely shared (see 9.7). Hunters cannot bring down part of a giraffe. If each forager, knowing that most of his prey will be consumed by others, can still expect to get more food for himself (and his family) by hunting big game, then in making the best choice to feed his family he also provides a collective good. Whether his direct consumption payoff is sufficient to account for his work will depend on his costs, including the opportunity cost of things he might have done instead. Among the Hadza of Northern Tanzania men specialize in hunting and scavenging large animals.

Recent observational and experimental data show that in this case (Hawkes et. al. 1991), hunters would provide a more regular income for themselves and their families with alternative foraging strategies, for example, hunting small prey in addition to large game. Since Hadza men continue to be big-game specialists, other incentives for providing these collective goods are implicated.

Tasks in which several must cooperate to gain any payoff at all may be prone to critical-mass effects, which limit free riding because moderate participation is unstable (Schelling 1978:91ff.). Hirshleifer's (1983) modeling and Harrison and Hirshleifer's (1989) experiments show that individuals tend to contribute to a public good that depends on the "weakest link," that is, when the failure of one member to contribute is fatal to the whole. Expensive and lumpy goods may stimulate both more work and more sharing than cheaper, smaller lumps (Taylor and Ward 1982). If there are more potential participants than the minimum required, however, games of Chicken arise over who shall complete the working group.

The size of the lumps, the relative value of lumpy goods, and the steepness of thresholds differ from one time and place to another. Ecological variation in local resources along these dimensions, as well as in other features of local circumstances such as the density of enemies and competitors, will lead to different kinds of collective-action problems, with implications for both work and sharing.

9.6.4. *The Sexual Division of Labor*

The sexual "division of labor" is the standard term for typical task differentiation between women and men. The implication of the label—that *family* (or larger group) agendas somehow set the optimal allocation of work, dividing jobs so as to best serve "family interests"—is so widely taken for granted as to seem simply a factual description. But a collective interest, even for a family, can pose collective-action problems.

Sugden (1986:33ff.), building on Schelling (1960), showed how readily consistent distinctions among players that do not initially affect costs and benefits can come to do so, developing into conventions that turn symmetrical into asymmetrical games. In asymmetrical games the same strategy has different payoffs for different players. Only a few players need initially respond to the distinctions to alter payoffs so that others follow. The success of contingent strategies, like Bourgeois, illustrates the importance even arbitrary distinctions may have in altering games.

As Schelling pointed out (1960:Chapter 3), prominent features are especially likely to trigger conventions. Gender is not only prominent, it can also be associated with initial differences in the fitness costs and benefits of a wide array of production and consumption activities, so that gender-based conventions are especially likely to evolve. Some kinds of work, for example, may exact higher fitness opportunity costs from women than from men (Brown 1970a; Murdock and Provost 1973; Hurtado 1985; Hurtado et al. 1985). And some kinds of work may give greater benefits to men than to women. If people prefer the company of those who share with them, and if they adjust social favors like sexual access and support in disputes accordingly, then men may gain more fitness from sharing and the work that supports it than do women (Hawkes 1990, 1991).

Consider the cooperative group problem posed earlier (9.5.2). Instead of a gardening group, however, make it a local residential group whose members will suffer lowered foraging returns or reduced arable land (per capita) with the arrival of additional residents. Exclusion of newcomers would be a collective good for current members (see 10.2.30). If the current group is composed of a man and a woman, and if size and strength differences require the woman to mount a more expensive defense to give her equal chances of success, then the game over who will do the defending might look like payoff matrix 7 (with the woman as row, the man as column). This is an asymmetrical game in which the payoffs to row, the first number in each cell, are a Prisoner's Dilemma, while column, whose payoffs are the second number, faces a Chicken.

Payoff matrix 7

		(Male strategy)	
		Defend	Don't defend
(Female strategy)	Defend	3,3	1,4
	Don't defend	4,2	2,1

Taylor, considering such a payoff structure (1987:39), notes that the outcome of this game is not at all problematic. Since row's best strategy, no matter what column does, is not to defend, column's best strategy, limited by row's obvious choice, is to defend. The payoff structure commits row not to defend. Schelling (1960) showed that, paradoxically, clear restrictions on one player's choice can provide the committed player a powerful bargaining advantage. If the group includes more adults, however, other collective-action problems are posed. If these payoffs hold for a man and a woman, the simplest additional assumption is that a game of Chicken would arise among the men (see section 10.4.1 for additional discussion). A man would do better to free ride on the defensive actions of others but would prefer to defend than leave the job undone. This would make defending men preferred companions (for both women and men) and lead to hypotheses about selective incentives for the provision of this collective good.

9.7. SOME APPLICATIONS OF EVOLUTIONARY ECOLOGY TO PATTERNS OF FOOD SHARING

Of the models reviewed here, delayed reciprocity has been more often applied than any other to food sharing among hunter–gatherers. Foraging is a chancy business. Many ethnologists and archaeologists have suggested that foragers share food and foraging areas to reduce risks of failure, that is, they give up shares when they can, to claim repayment when in need. By this hypothesis, variation in sharing may be associated with variation in the magnitude of such risks (Draper 1978; Hames 1990; Harpending 1981; Hayden 1981; Jochim 1981; Kaplan and Hill 1985b; Kaplan et al. 1990; Lee 1968, 1979; O'Shea 1981; Smith 1988; Washburn and Lancaster 1968; Whitelaw 1989; Wiessner 1977; 1982; Winterhalder 1986, 1990; Yellen and Harpending 1972). The distribution of sharing and storing as alternative means to increased security has been of particular interest to anthropologists (Sahlins 1972; Binford 1980; Gould 1981, 1982; Whitelaw 1989) including those employing evolutionary ecology (Cashdan 1980, 1985; Smith 1988; Smith and Boyd 1990; Winterhalder 1986, 1990).

Behavioral ecologists studying non humans have also been increasingly interested in risk. Although the classic optimal forager was assumed to make foraging decisions that would maximize mean values for model variables, subsequent modeling has taken variance into account (see Chapter 6, Stephens 1990; and Stephens and Krebs 1986). Both modeling and observation point to situations in which foragers do better to minimize variance, but also situations in which they do better to choose *higher* variance alternatives. Because of the several ways "risk" is defined, individuals sometimes *minimize* their risk of complete failure, by *increasing* their risks of getting less. If nothing but $2000 will stop foreclosure on the mortgage, risking the only $200 on long-shot gambles that give a *possible* payoff of $2000 makes loss of the farm *less* likely than investing the $200 for a sure gain of 20%.

The widespread argument that sharing would be an especially effective means to reduce variance in daily income for foragers under many circumstances has been borne out by formal modeling. Winterhalder (1986) showed that sharing could have large effects on the daily income variance of foragers. Moreover, it took only a few sharers to eliminate most of the variation in the income of participants. Winterhalder considered the alternatives of sharing and storing and showed that two variables—(1) the extent to which successes among foragers are synchronized, and (2) the extent of variation in the success of any individual forager over time—predicted whether sharing or storing would reduce risks of failure more effectively. If foraging success is variable and unsynchronized, then sharing will buffer risk best. If foragers have synchronized successes and failures then sharing will not reduce risk but storing will. Low variation in foraging success will mean that neither sharing nor storing will repay their costs.

Kaplan (1983), Kaplan and Hill (1985b), and Kaplan et al. (1990) noted the wide variation in the extent to which different kinds of food resources are shared. They tested several hypotheses about this variation on observations of the foraging Aché of Eastern Paraguay. The data show the Aché to be notable sharers: On average three quarters of what anyone eats was acquired by someone outside the consumer's nuclear family. Some resources are more likely to go to close kin, but other kinds of resources show no such kin-biased sharing. The extent of this sharing is positively correlated with the average package size of resources and the unpredictability of securing them (Figure 9.2a, b). As Kaplan and associates noted, wide sharing of large and unpredictable resources reduces the variance in daily consumption, lessening the risk of a hungry day. They modeled the "nutritional consequences" of sharing and not sharing various categories of resources, using the Aché data on patterns of daily acquisition and assuming a ceiling on daily consumption. This exercise showed that the benefits for sharing some categories of resources were greater than benefits for sharing others, those in larger and more unpredictably acquired packages giving the greatest increase in "mean nutritional status" when shared. Moreover, almost all individuals and families, including those who produced significantly more than others, consumed more with sharing than they would have done without.

Cashdan (1985) also focused on the variance reduction effect of sharing, and explored the circumstances that would favor sharing rather than storage as a means of reducing risks of failure. Drawing on insurance theory, she noted that for sharing to reduce risks of loss effectively, the possible losses of sharing units must be independent accidents. Thus (as Winterhalder's subsequent formal model showed), where potential sharing units are subject to correlated fortunes, sharing will be an ineffective means of variance reduction. She nominated two variables as especially important in determining the relative costs and benefits of sharing or storing to buffer risk: distance and mobility. The shorter the distance over which losses are uncorrelated and the more mobile the participating units, the more readily sharing can reduce variance and the less it costs relative to storage.

Cashdan compared Basarwa and Bantu-speaking people along the Nata River in Northeastern Botswana, showing that the Basarwa had smaller harvests, often insufficient to last the year. The Basarwa engaged in more interhousehold food sharing, while the Bantu speakers stored more food. The source of smaller Basarwa harvests was their much smaller fields. This was, in turn, the result of more frequent household moves, dictated by opportunities to care for cattle. For these Basarwa, the mobility attendant on acquiring cattle products would make sharing more "cost-effective" than storing.

The authors cited above have pointed to circumstances in which individu-

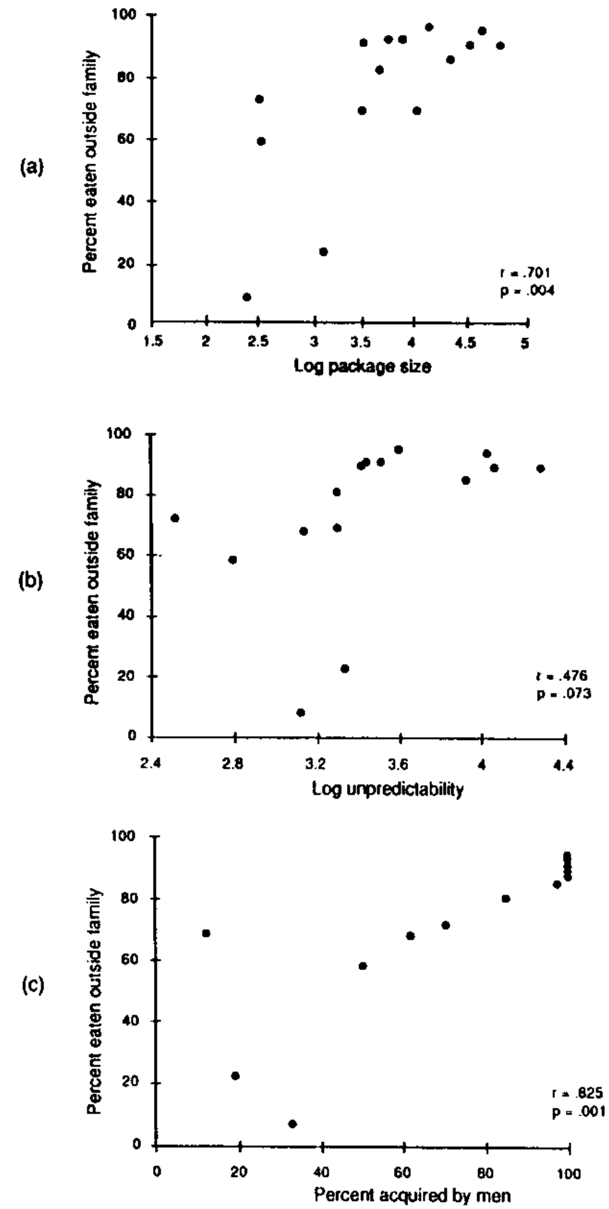

Figure 9.2. Differences in the extent to which Aché resources are shared (Hawkes 1991: figures 1–3). Each point represents 1 of 15 resource types acquired by Aché hunter–gatherers on 9 foraging trips in 1981–1982. On all graphs, the y-axis shows the percentage of times subjects were observed consuming a resource type acquired by someone outside their own nuclear family (Kaplan and Hill 1985b). (a) The x-axis indicates the log of package size, defined as the mean number of calories in a single acquisition of the resource (Kaplan and Hill 1985b). (b) The log of unpredictability, defined as the mean of the standard deviations of the family totals in calories of the resource acquired each day (Kaplan and Hill 1985b). (c) The percentage of total acquisitions of the resource by men.

als reduce their risks of failure if they share because they receive shares when they have little or nothing. If one receives because one has given, then this is delayed reciprocity. But if individuals receive shares whether or not they give them, they can free ride. The shared items are then collective goods, and providing them poses a collective action problem. The expectation of future shares is not the reason for the giving.

The circumstances in which delayed reciprocity would have sizable variance reduction effects are also the circumstances that promote tolerated theft. If successes are synchronized, there is no inequality of holdings to promote theft. Under these circumstances, storing poses no prohibitive defense costs, and so Blurton Jones (1987b) suggested that seasonal gluts might promote storage. On the other hand, marked and unsynchronized variations in acquisition produce large differences between those who have and those who do not. If some are much hungrier than others, the strategy of *not* sharing could be costly. One obvious kind of cost would be the time, energy, and potential injury of a fight, but there may be penalties for refusals to share even in the absence of a physical struggle. Others may see sharers as more attractive companions than nonsharers. They may be readier to join and support sharers in other contests.

Storing can thus occur where the variance in successes is low because there the pressure of "theft" is low. But where the variance in successes is high, so is the pressure for shares. Tolerated theft has the same *effect* of reducing variance in consumption as does reciprocity. But there is a key difference. With delayed reciprocity, individuals who share or cooperate less will get less sharing and cooperation in return. Reciprocity depends on discriminations against those who do not share. Conversely, strategies like tolerated theft, for which net benefits depend on immediate accounting, are not contingent on past (and predicted future) sharing. Assuming equal competitive ability, individuals who acquire more tolerate more theft. Individuals who acquire less take more from others. If some individuals consistently acquire more, then the differential that emerges is a one-way flow to the less successful.

Consider the data on Aché food sharing. The wider sharing of resources that come more unpredictably and in larger packages is consistent with delayed reciprocity to reduce risks of failure, because the cost to a successful hunter of giving up extra bits of a large resource is less than the benefit to him of getting bits from another when he has failed to score himself. As Kaplan and associates point out, this follows from a diminishing-returns shape for the gain curve of nutritional payoff for increasing consumption (as in Figure 9.1).

But risk of failure is reduced by giving shares only if the giving obligates recipients to return them, which implies giving to those more likely to return in future, and not giving to those who have failed to return them in the past.

A striking feature of the Aché data is the *lack* of such a differential. Hunters who "give" more do not get more. Their work provides a collective good.

Tolerated theft offers an alternative framework in which to explain the wider sharing among Aché foragers of large resources that are unpredictably acquired. If the gain curve for consuming these foods is one of diminishing returns, and consumers have similar competitive abilities (cf. Kaplan and Hill 1985b; Kaplan et al. 1990), then the economics of defense will lead to even sharing. From this perspective the question is not why these resources are widely shared, but why they are acquired in the first place. If foragers know these items will be widely shared, if they expect no consumption advantage for themselves (or their wives and children), why do they do the work? How could it be in their interest to pay the acquisition costs? Why not free ride and, as Blurton Jones (1987) asked, be scroungers instead? If there were only two foragers, the problem could be modeled as the game reviewed earlier (section 9.5.3, matrix 3), except that here the resource is divisible. V is the amount of resource acquired if both forage, C is the cost of foraging, s is some fraction of V that one forager could acquire:

Payoff matrix 8

	Forage	Scrounge
Forage	$(V/2) - C$	$(sV/2) - C$
Scrounge	$sV/2$	0

As with matrix 3, this would produce several different payoff structures depending on the values of the variables. The values will determine whether there is a pure ESS. If $(1 - s)V > 2C$ *and* $sV > 2C$, row should forage whatever column does. Here the fraction of the resource a forager can expect to keep is worth the costs paid to acquire it. If the inequalities are both reversed, row should scrounge whatever column does, since the cost is not worth paying, making it a Prisoner's Dilemma. If $(1 - s)V < 2C$ but $sV > 2C$, the game is Chicken with no pure ESS. Note that whatever row does, he will do better if column foragers. Blurton Jones suggested that "prestige" awarded to energetic foragers might, for these reasons, be a form of "self-serving deceit." But why should energetic foragers allow themselves to be duped?

Some resources are more widely shared than others. Why not target resources that could be kept within the family? The question is given special force by the surprising finding that Aché men could more than double their energetic rate of gain by taking palm starch at every opportunity (Hill et al. 1987; Kaplan et al 1990; see section 6.5.1). Instead they choose to hunt and take honey, part of a preference for widely shared foods, which distinguishes men's from women's resource choice (Figure 9.2c). Hawkes (1990, 1991) associates this gender bias in foraging strategies with the hypothesis that mating advantages (Kaplan and Hill 1985a) serve as selective incentives for men to provide collective goods instead of provisioning their families.

Cashdan's data on Basarwa sharing also conflict in some ways with a hypothesis that this is delayed reciprocity to buffer risk. Here, as in the Aché case, a diagnostic feature of reciprocity must be differential sharing, with those most likely to give in the future receiving the most. Otherwise reciprocators are exploited by free riders. If benefits can be enjoyed without paying prior costs, those who do not pay do better. Her data show a clear but *negative* correlation between the number of food items received per household and the number of bags of grain harvested. Those who harvest least receive most. This could only be consistent with reciprocity if those who harvested least this year are likely to harvest most next year. But a year-long time lag and high mobility suggest that uncertainty about repayment would be high. Discounting could be a barrier to reciprocity. Moreover, if Basarwa who have just begun to plough a field are no *less* likely to move than those who have been ploughing longer, those who have been ploughing longer are likely to harvest more next year than those with newer fields. Those who have larger harvests and receive less this year are likely to have even larger harvests and receive even less next year. Those who receive more this year are likely to receive more next year as well. This is a pattern inconsistent with delayed reciprocity.

Tolerated theft on the other hand would level differences. Data are not available to see whether those who harvest little or nothing consume as much as those who harvest more. Again the collective action problem arises. If all have similar consumption levels, then why plow and harvest at all? If "scroungers" can eat as well without paying the cost of farming, self-interested individuals should choose to scrounge.

If we assume similar consumption for all (due to tolerated theft) then some of the elements of the problem of whether to plant in this situation could be represented by payoff matrix 8, with plowing rather than foraging the alternative to scrounging. As above, the value of the variables would determine the game. As with the foraging version, whatever row does he would do better if column ploughed. As with the case of Aché hunters, some other benefits dispensed to those who plow might encourage their industry. But the striking pattern in this case is how truncated that industry is. While harvest depends on field size, which depends on years plowed, the Basarwa move much more readily and so plow the same fields for much shorter periods than their Bantu-speaking neighbors. Changing opportunities to care for the cattle of Bantu speakers is the suggested reason. But, as Cashdan notes, this pattern is unlike arrangements for cattle tending elsewhere in Botswana, where the cattle come to the tenders rather than vice versa. Perhaps the reason Basarwa households move so often is precisely to avoid exploitation by scrounging kin and neighbors. If more productive fields only mean more insistent begging, more tolerated theft, households may find little benefit in expanding their fields and less cost in moving, which reduces their productivity and the pressure on them to give. As Blurton Jones suggested, the dynamics of tolerated theft may be implicated in the otherwise paradoxical observation that often small-scale cultivators do not plant quite enough to meet annual family needs.

Comparison of these analyses of Aché hunting and Basarwa farming highlights the following question: Under what circumstances do those who provide collective goods net benefits for themselves even though some free ride on their work? Why would Aché hunters gain by hunting long hours, with better hunters hunting even longer than other men (Hill and Hawkes 1983, Hawkes et al. 1985), while (the hypothesis is) Basarwa farmers do not gain from and so do not sustain high levels of productivity? If better hunters earn favors for their hunting among the Aché, why would not better farmers earn favors among the Basarwa?

This returns attention to the collective-action problem that Sahlins found pointing to "the zen road to affluence." In spite of free riders, there is empirical variation in the amount people work as well as the amount they share. Again, consider three mutually exclusive extremes: One is to acquire no more than one can immediately consume, another is to acquire more and share it, and a third is to acquire more and store it for future consumption.

Features of local ecology such as the lumpiness of resources, the way they are encountered in both space and time, the effects these have on the costs and benefits of sharing versus not sharing, the costs and benefits for alternative subsistence strategies, the opportunity costs of foraging or farming, and the extent to which these differ according to sex differences, may all affect the payoffs for work.

Details of local circumstances set the constraints and the trade-offs: the costs and benefits for possible alternatives. Aché hunters apparently earn quite unambiguous fitness benefits for their industry. Each man faces trade-offs—more hunting means less of something else—and optimizing these trade-offs depends on what the alternatives are and the costs and benefits of each. Special features of the Aché foraging pattern, in which the entire party moves through the forest rather than returning each night to the same central place, surely affect the suite of possible alternative activities available to men. Further exploration of the constraints and costs and benefits would attend to such details of local circumstance, including not only the character and distribution of resources in the forest, but the way these affect the behavior of other people who are potential mates, competitors, and allies.

Wiessner's discussion of !Kung San sharing cited above underlines the point. Much of the sharing follows special rules and operates between carefully chosen partners. Wiessner describes !Kung sharing as reciprocity to reduce risks. But she reports the prevalence and importance of tolerated theft, and also the effect it has on reducing "mean" levels of productivity. This pattern among the !Kung sharply contrasts with the Aché. Foraging Aché men spend almost 50 hours a week in food acquisition (Hill et al. 1985). Lee reports that !Kung men at Dobe spent less than half that (Lee 1979:278). As Wiessner's descriptions indicate (and see Shostak 1983) people prefer companions and neighbors who are energetic foragers with more to share to companions who share less or have less to share. Why do the !Kung not dispense favorable treatment to those inclined to active foraging so that compensating benefits make more work the best strategy, at least for some? From the perspective employed here, answers would be sought in two directions. First, what are the patterns of income foragers can earn given the character of local resources? What daily rates are likely and how large and predictable are the resources foragers can acquire? Some prey species may be very large and so very widely shared. But, if successful captures are sufficiently rare, the value of hunting neighbors may not be high. So favors given to encourage them may be few (Hawkes 1990: 165–166). Second, what are the opportunities forgone when foraging? Wiessner's comments cited above suggest more high-benefit/low-cost alternatives to foraging among the !Kung than the mobility pattern of the Aché allows.

Returning to the Basarwa, there is a second difference between the Aché and the Basarwa patterns, especially pertinent to the issues of this chapter. Among the Aché, *men* hunt; among the Basarwa, *households* farm. While individual men are expected to have numerous and important conflicts of interest with other men as well as with women and children, members of households not only have conflicts of interest with members of other households, but with each other as well. Thus what any "household does" will be, from this perspective, the outcome of its individual members each acting from self-interest. Even if it were the case that men who are industrious farmers are preferred neighbors by members of other households, benefits dispensed to them to encourage their continued industry might not be benefits to the fitness of their wives. Women who are industrious farmers might be preferred neighbors but fitness costs to them of energetic farming might be higher than for men. And while both men and women might benefit from neighborly dispensations of food or solicitude toward offspring, some favors neighbors could return to men might have less value to women (e.g., sexual favors and support in disputes over sexual access). Moreover, household members might see different costs and benefits for sharing with different claimants. Collective-action problems posed by defending household goods against persistent demands could result in Prisoner's Dilemmas or games of Chicken in which "household fortunes" suffer. Only further research can show how much of the difference between Basarwa, !Kung, Aché, and others can be explained from this perspective.

9.8. SUMMARY

Among hunter-gatherers and small-scale horticulturalists, many goods are collectively consumed. The common pattern labeled reciprocity by ethnologists is paradoxically distinguished by the lack of definite commitment to reciprocate. With widespread sharing, some can take a "free ride" on what others give. This may point the way to Sahlins's "zen road to affluence," where people work less than they might because any extra will be consumed by others.

If collective-action problems dampen work effort, sharing patterns still persist. Moreover, both work and sharing vary from one ethnographic setting to another, and among seasons, resources, and the age and gender of workers. More systematic investigation of the costs and benefits and the sources of their variability is indicated.

The costs and benefits to individuals who share varies with the effects this sharing has on what others do. This reverberating interdependence makes game theory a suitable framework for building models to suggest the circumstances in which those who share do better than those who do not. Three of the kinds of explanations that evolutionary ecologists employ to account for sharing patterns are discussed. The first is reciprocal altruism, which, unlike the reciprocity of ethnology, entails definite, though delayed repayment for short-term costs. The game known as the Prisoner's Dilemma has been widely used to illustrate the problem of collective action, and to explore the possibility of cooperation among self-interested actors using the strategy of delayed reciprocity. Mutualism is the second kind of explanation. Individuals may sometimes do better in terms of immediate personal costs and benefits if they share than they would if they did not. The game of Chicken, best known to evolutionary ecologists as a version of the Hawk–Dove game, shows how easily mutualism can turn into manipulation, which is the third kind of explanation. Individuals may be manipulated or coerced into sharing because it costs too much not to. The payoff structure of tolerated theft shows how the costs of *not* sharing can be too high to be worth paying.

Four issues arising from discussion of these models deserve emphasis. First, because the future is uncertain, individuals are expected to discount the value of benefits that are delayed. Observation and experiment are consistent with this expectation and encourage skepticism toward the view that ethnographers miss compensating returns for sharing because their observation periods are short. Steep discounting makes the value of future benefits and thus the probability that they might compensate current costs, diminish rapidly with hypothesized longer delays.

Second, where those who give do not thereby gain greater shares of the collective good, other benefits, selectively awarded, could provide incentives for continued giving. The character and value of such selective incentives also depends on specific features of local circumstances. Such incentives, however, can pose other collective-action problems. If favors are given to sharers to promote their continued sharing, others could free ride on the favor givers.

Third, the suite of goods that people acquire or produce may be more or less "lumpy." If lumps are large, individuals may be unable to acquire "just enough" for their own consumption. If expected consumption makes the cost worth paying, at least for some, collective goods may be provided as a consequence. Thus, the character of the goods themselves and the local alternatives to providing them determine whether collective-action problems arise.

The fourth issue is the strong effect that differences among individuals can have on the payoffs for strategic interaction among them. This can happen even if initially the differences are quite arbitrary. Prominent differences may be especially likely to stimulate conventional responses. A few individuals responding in consistent but different ways can alter the payoffs for all and generate a convention that is then self-reinforcing. Gender as a prominent asymmetry would be a likely basis for frequency-dependent conventions. Moreover, it is associated with fairly consistent differences in fitness costs and benefits for various activities. This makes it an even more likely basis for the development of conventions, as individuals adjust their behavior to take advantage of frequency-dependent payoffs.

Some particular applications of models and concepts from evolutionary ecology to ethnographic patterns of food sharing are summarized and problems are revisited as they apply. The hypothesis that sharing is a means to reduce risks of failure has appealed to a wide array of scholars, including those employing the perspective of evolutionary ecology. Aspects of the empirical variation in sharing seem consistent with this hypothesis; that is, items that are large and unpredictably acquired, like game animals, are often shared. But if these items are consumed collectively, a producer's contribution now has no effect on the shares he can claim in the future. Tolerated theft suggests a simpler explanation for the wider sharing of large unpredictably acquired goods. But it does not explain why they are acquired in the first place. Modeling and measuring the payoffs for this work will include appraisals of the local alternatives and of possible selective incentives, with continuing attention to why and how these might vary among and within communities.

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Competition, Conflict, and The Development of Social Hierarchies

James L. Boone

10

10.1. INTRODUCTION

This chapter outlines some evolutionary ecological approaches to analyzing and explaining the formation of hierarchical social groups among humans. Following the approach of methodological individualism (section 2.3.1), this chapter is built around the idea that the size and structure of social groups can be explained in terms of the aggregate consequences of individual behavioral strategies aimed at maximizing access to or control over limiting resources through competitive and cooperative interaction with other individuals. Such strategies involve costs in the form of investment of time, energy, resources, and—under some conditions—bodily risk. At the same time, individuals organizing and cooperating in groups rather than acting solitarily accrue benefits related to acquiring, producing, processing, and defending access to resources.

Thus the process of group formation may be seen from a cost-benefit point of view, wherein individuals weigh the costs of group affiliation (increased competition for resources, increased exposure to disease) against the benefits (enhanced access to resources or mates) versus the costs and benefits of leaving the group for a less competitive environment or affiliating with another group under more favorable terms. Where benefits outweigh costs, groups should form and continue to grow as long as all the members benefit relative to dispersal or alternative affiliation. Sections 10.2.1 and 10.2.2 present some simple optimization models that define more rigorously the conditions under which group formation occurs.

The question then arises: If groups form out of mutual self-interest, how can we explain the development of inequality and exploitation within groups? The answer to this question revolves around the issue of resource competition within and between groups and the "stay or leave" option that