EXPLAINING VARIANCE IN REPRODUCTIVE SUCCESS AND FOOD SHARING IN UST'-AVAM

by

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The following individuals read and discussed the thesis submitted by student Joellie Rasmussen, and they evaluated her presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

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DEDICATION

This thesis is dedicated to Grandpa Jon—I know you'd be proud of me. And to Wren, who was my inspiration.

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ABSTRACT

In light of somatic and reproductive tradeoffs modeled in evolutionary theory, this thesis conducts two analyses of men's behavior in the indigenous hunter-gatherer community of Ust'-Avam, northern Russia. First, a food-distribution network of men's hunting documented in 2001 and 2003 is analyzed considering evolutionary models of food sharing: kin selection, reciprocal altruism, generosity signaling, and costly signaling. The frequency of inter-household food transfers from 36 donor households to 102 recipient households are examined using matrix regression with independent variables representing embodied, material, and relational wealth. This analysis does not support the costly signaling model, but provides robust evidence for kinship, reciprocity, and generosity. Alongside evidence of hunter's unidirectional food transfers to kin, hunters share reciprocally with kin and other highly skilled hunters. Furthermore, hunters appear to be sharing with the needy, rather than accumulating wealth, additional wives, or allies. Male fertility patterns of 272 Ust'-Avam men were analyzed using the same embodied, material, and relational wealth variables. Hunter skill (embodied) and hunter wealth (material) are found to be the strongest predictors of men's age-adjusted reproductive success and age at first birth. Cash income, educational level, and number of close kin do not significantly predict men's reproduction. Hunter production appears to be invested in their wives and existing offspring. Thus, the first analysis illustrates kin selection, reciprocity (kin irrespective of productive ability and non-kin with high cumulative producer capacity), and generosity. The second analysis illustrates male parental investment effects for good hunters. Considering the cost of transportation out of the community and few wage labor opportunities for men, food production and distribution patterns are highly prosocial, and the behavior of men who are skilled and outfitted hunters appears also to provide some reproductive advantage.

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LIST OF ABBREVIATIONS

RS	Reproductive Success
MRQAP	Multiple Regression Quadratic Assignment Procedure
HBE	Human Behavioral Ecology

CHAPTER ONE: INTRODUCTION

Theoretical Background

Many anthropologists look to hunting and gathering societies to provide insights into the behaviors of human ancestors. Knowing that all humans had hunting-and-gathering economies prior to the development of other means of subsistence allows anthropologists to examine modern day hunter-gatherer societies in hopes of explaining the evolution of certain human traits. One of these traits is food sharing. In this thesis, I examine the hypotheses of food sharing as mechanisms for the evolution of cooperation and test data collected from Ust'-Avam male hunters. As many anthropologists have asked in other study areas, I ask why hunters in this community share food. What predicts these food transfers? How do these results support food sharing hypotheses? The findings from the results of the following analyses contribute to a larger debate, which seeks to answer why humans share food and how food-sharing evolved. Food-sharing is a cooperative behavior, and outside of provisioning, it seems to be a behavior at odds with natural selection. Food sharing is a universal human trait, and is found ubiquitously in hunter-gatherer societies, leading to evidence that the trait was selected for.

In addition to examining why and how these hunters share food, I will also be examining their reproductive success and the effects of variables representing three different types of wealth. The first part of my thesis examines what a hunter does with the food he has acquired and chooses to distribute. The second part examines what a hunter does with the food he decides to keep. Does he invest this meat into gaining access to new mates, investing it in potential offspring with other women? Or does he invest his resources into his current mate and offspring? Furthermore, how does his wealth and skill affect these decisions?

A hunter deciding whether to invest his resources into gaining access to additional mates or investing them in his current mate and offspring is an example of a tradeoff. These two choices are not mutually exclusive. A hunter is likely to distribute some of the meat or fish he acquired, and keep the rest. A hunter may also spend more time acquiring knowledge, skills, and material wealth, and, in doing so, foregoes investing this time and his resources in producing offspring. Rather than invest his resources in current offspring, he is choosing to invest his resources in future offspring.

Borgerhoff-Mulder (2000) examines life history traits as tradeoffs of quantity-quality of offspring and current versus future reproduction decisions among the Kipsigis. Borgerhoff-Mulder found the women among the Kipsigis were producing an optimal number of children, but the men were producing a suboptimal number of offspring. Women were making decisions in the quantity-quality tradeoff of offspring that lead to them gaining optimal fitness. They were more likely to increase fitness gains across generations by having fewer children and enhancing their quality. In order to gain optimal fitness, the men were more inclined to have more children, and were more interested in investing in reproductive efforts.

Several explanations have been summarized by Smith (2004) for the correlation between an individual’s hunting success and reproductive success. Direct provisioning of wives and children enhances offspring survivorship and spousal fertility. This is an example of the reproductive-versus-parenting tradeoff. Rather than invest the meat they catch in gaining potential access to additional mates by sharing the food with individuals outside of the household, they choose instead to provision their current spouse. Another explanation for this correlation is dyadic reciprocity, where hunter's exchange meat for direct access for mates. Indirect reciprocity is delayed and comes from multiple individuals, usually in the form of reputation building. Costly signaling acts on the hunter using his hunting skill to broadcast the signal that he is a superior mate.

Food Sharing

Food sharing occurs universally among hunter-gatherers and the study of this behavioral trait opens a window for researchers to understand the evolution of cooperation. Although primate species do participate in food sharing outside of provisioning of offspring (Jaeggi and Van Schaick, 2011), hinting at a primate origin for the behavior, humans are unique in the extent of their food sharing activities. Jaeggi and Gurven (2013) document fifteen species of primates with male-to-female food transfers, and conduct a meta-analysis of primate and human food sharing. A similar degree of contingency was found across primates and humans controlling for a number of other variables (Jaeggi and Gurven, 2013). Explaining the evolution of cooperative behaviors is difficult, and often raises more questions regarding the role and mechanisms of natural selection. Cooperative behaviors such as food sharing may help to increase the fitness of the recipients, but at a possible risk of lowered fitness to the donor. So how would such traits be selected for? Multiple models have been proposed to explain the evolution of food sharing among humans. The four discussed here are kin selection, reciprocal altruism, costly signaling and tolerated scrounging. These four have been subject to much debate in the last two decades in human behavioral ecology.

Kin Selection

Kin selection is often proposed as an explanation for altruistic or cooperative behavior. Natural selection supports strategies that favor the success of kin, and possibly at the cost of the individual's own reproductive success. Individuals are expected to share with kin above non-kin. Hamilton's rule (1964) states that only when the benefit (B) gained and relatedness factor (r) between the two individuals combined outweigh the cost (C) of the action will a transfer occur ($C < B*r$). The general premise of kin selection is that because kin share some genes, fitness might be gained by an individual when its kin reproduce, even if the individual does not. Therefore, altruistic acts benefiting one's kin might indirectly benefit oneself, in terms of fitness. Two related individuals, for example, siblings. have the probability of sharing 50% of their alleles. If one individual incurs a cost that might inhibit their reproductive success, but benefits their siblings' reproductive success, there is a likelihood the trait that prompted the first sibling would also exist in, and be passed down through, the second individual. In other words, altruistic traits may be selected through the benefit to kin. Kin selection in food-sharing proposes that individuals will be more willing to share with those who are more closely related by Wright's coefficient of relatedness r (Kaplan and Gurven, 2001).

Reciprocal Altruism

An individual may choose to perform an altruistic act by imposing a cost to his or her self to benefit another individual. Trivers (1971) first described how altruistic behaviors might evolve among unrelated individuals. He uses the example of a drowning man. There is little incentive to save the man, especially with potentially great cost (such as death, in this case). So why would someone choose to save the man? If an individual is at as much of risk of drowning in the future, and the risks of drowning can be mitigated by being saved by another individual, then altruism might be selected for.

Reciprocal altruism in food sharing requires that the donor bears a cost that benefits another, and that the recipient of the altruistic act receives a benefit that is higher than the costs. Food shared reciprocally should be contingent on previous transfers. Reciprocal altruism is more likely to occur when food procured is in large, asynchronous packages (Kaplan and Hill, 1985), based on the law of diminishing returns. The first portion an individual acquires is of more value than the second portion, which is of more value to the individual than the third, and this continues on for every subsequent portion. A large package is composed of many portions, so when an individual has consumed their third portion of the package, the value of the fourth, unconsumed portion is greater to another individual, because it is their first portion. The portion is of less value to the individual who acquired the packaged than it is to the individual who hasn’t consumed any portions. The individual performing the altruistic behavior must receive a benefit from the original recipient of the altruistic act in order for cooperation to evolve via this evolutionary mechanism.

Axelrod and Hamilton (1981) modeled several strategies submitted by numerous colleagues in a computer tournament of the Prisoner’s Dilemma, and concluded that the tit-for-tat strategy was the best strategy. Subsequent studies of the iterated game have found different strategies serve the individuals playing better than basic tit-for-tat. The basic Prisoner's Dilemma is a game constructed around a two-by-two matrix. Two players may choose to cooperate and receive a benefit, or cheat and secure an even greater benefit while imposing a cost on the other. However, if both individuals cheat, then they both incur a cost. The tit-for-tat strategy involves going into a situation like the Prisoner's Dilemma with good faith by cooperating on the first move, and then copying the other player's behavior for every subsequent move. This strategy is based in reciprocity.

Costly Signaling

Costly signaling (Zahavi, 1975; Grafen, 1990) hypothesized that an individual shares food to broadcast a signal that they are a superior mate or ally. In this respect, cooperative behavior evolved as the cost associated with individual signaling behavior. In order for costly signaling to explain food sharing, four conditions need to be present. The first of these is that the signals must carry honest and reliable information that address variation in the quality of the trait being advertised (Smith and Bliege Bird, 2000). The second is that the signal imposes a cost relative to the quality being advertised on the individual signaling. Finally, the signal must benefit both the signaler and the receiver. The marginal costs of sending the signal relative to the marginal benefit ensure the signal's honest. Recipients of the signal will repay the signaler back, although not in ways similar to reciprocity. Signalers will receive more intangible benefits – they may find increased access to mates and allies, rather than reciprocity in goods or food.

Tolerated Scrounging

Tolerated scrounging has been proposed as an alternative to kin selection and reciprocal altruism. Tolerated scrounging is a simpler theory, and occurs when an individual with food realizes the cost of defending the food is greater than the cost of giving it up to encroachers. Generally, as the marginal value of a food package decreases to the hunter, the more likely they are to give up portions of food to those who ask or demand (Blurton Jones, 1987). Tolerated scrounging is expected to occur with large, asynchronous packages. Again, if the individual who procured the package has consumed the first (or more) portion of the package, the second portion is of less value to that individual, but may be of greater value to another, second individual. If the second individual pressures the first to give up a portion of the package, the value of that portion may be low enough that the first individual decides defending the portion is too great. The second individual may realize the value of the first portion is great enough to initiate conflict/other costs on the first individual. The costs imposed on the hunter can be physical (through violence) or social.

Ethnographic Background

The data used for this research was collected from the village of Ust'-Avam by Dr. John Ziker of the Boise State Department of Anthropology. Ziker visited Siberia over a series of several field trips from the year 1994, with his last trip occurring in 2007, spending a total of 36 months in this community.

Geography

Located in the Taimyr region of central Siberia, Ust’-Avam lies at 71° North latitude. The village is located along the Avam River, at 71° 07’ N and 92° 49’ E, on the Taimyr Peninsula in Central Siberia. The Avam River flows out of the Putoran Plateau north into the Dudypta River, shown on Figure 1, which then flows into the Piasina River. The winters are long and cold, and the summers are short and mild (Ziker, 2002). Ziker writes the area is in close proximity to a forest of Daur’s larch, which extends across the lowlands and surrounds the village. There are multiple lakes in the area.

The growing season is very short – only five or six weeks as recorded by Ziker. Native to the area are caribou and several types of fish, which include sturgeon, burbot, and whitefish, all of which are sought prey items. Geese and rock ptarmigans can also be hunted. Moose are uncommon in the area and rarely hunted, as are musk oxen.

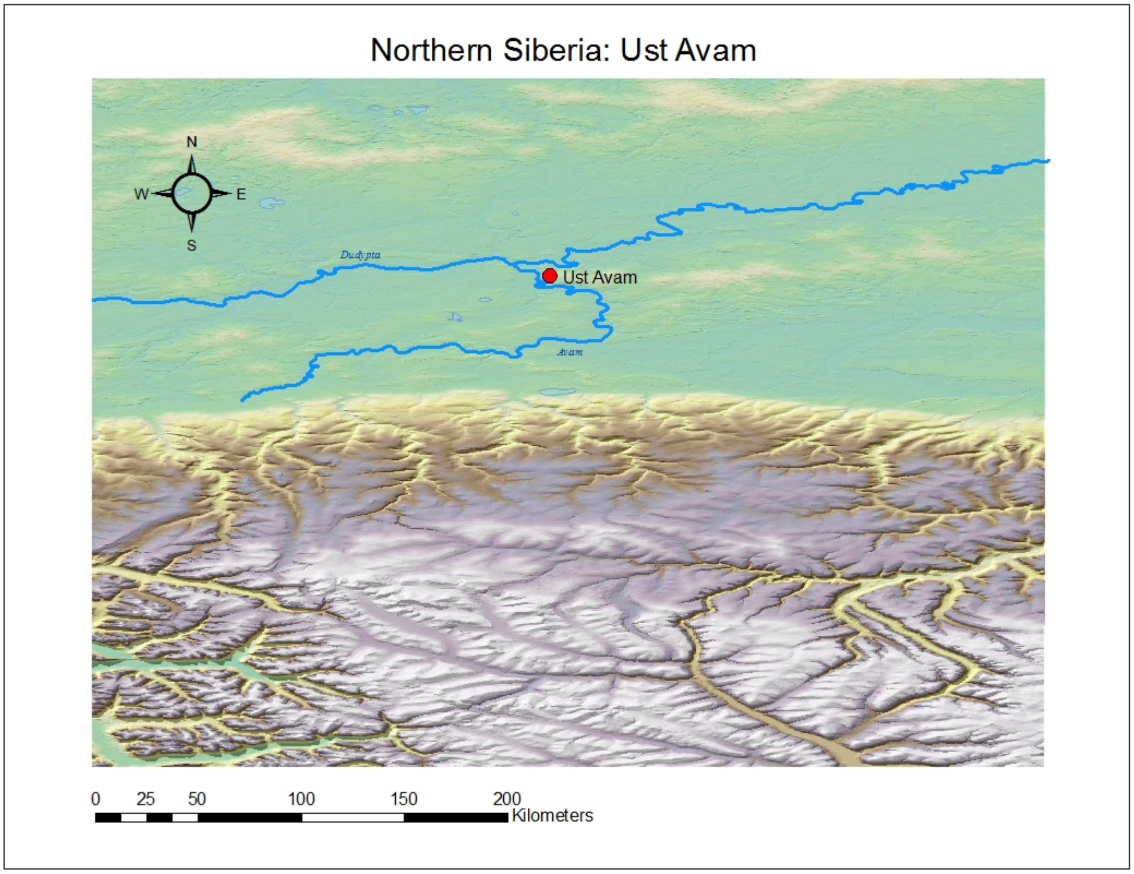

Figure 1. Map of Ust Avam

The village's remoteness inflates travel costs, making it difficult to travel to or from the community. Travel is either by helicopter, boat, or snowmobile. The Dudpyta and Avam Rivers act as the main source of travel in the summer.

<u>History</u>

Before the 17th century, the native peoples of the Taimyr had little contact with outsiders and were left alone to be fairly independent. Over the next few centuries, they experienced increasing exposure to outside powers, especially the Russian empire, which demanded tributes to be paid in furs. After the revolution in 1917, their settlement pattern changed little, but they became more integrated with the greater Soviet economy. By 1938, though, there were five collectives in the Avam area, and the Soviet government had collectivized most of the domestic reindeer. In 1971, the community of Ust'-Avam was created. Ust'-Avam sat on ten million hectares set aside to create a new administrative hunting district, "Taimyrskii," which focused on commercial hunting, trapping, and fishing. At this point, community members became fully integrated in the Soviet planned economy and were paid decent monthly salaries for a variety of jobs including staff hunter, seamstress, stove stoker, janitor, etc. Villagers received wages and pensions like all other workers in the Soviet Union. In addition, all domestic reindeer were slaughtered by 1978 and the community became fully dependent on combustion-powered transportation. Since the Dolgan and Nganasan lost much of their traditional autonomy and became dependent on outside sources of equipment, fuel, and cash, the community was very negatively affected by the collapse of the USSR. The importance of traditional subsistence activities has been emphasized with the decentralization of the Russian government since the fall of the Soviet Union (Ziker, 2002). Since the early 1990s, few jobs are salaried and those are reserved for a select few. The costs of fuel and equipment increased drastically so Ust'-Avam hunters give more emphasis to hunting and fishing for subsistence rather than commercial sales. In addition, traditional modes of hunting and gathering, such as game trapping, became more widespread.

Ust'-Avam

The community consists of 177 households and 670 individuals (Ziker and Schnegg, 2005). The Dolgan and Nganasan are the two largest ethnicities in the village. The Dolgan number close to 6,000 people (Ziker, 2002), and traditionally herded domestic reindeer, hunted caribou, trapped and fished. There are approximately 1,000 Nganasan, and traditionally they hunted caribou and used reindeer for transportation.

They also trapped and fished. Both were traditionally semi-nomadic. After the establishment of the Government Hunting Enterprise Taimyrski alongside the permanent village in 1971, the state provided snowmobiles, rifles, and ammunition for hunting. In the 1990s and early-to-mid 2000s, as such goods became costly and most hunters were no longer receiving a wage, snowmobiles and other equipment were found to be aging and failing. Many hunters were focusing more on local prey as travel costs increased. In 1996, a few hunters were able to sell their game for cash. However, cash income remains rare.

In the growing season, women and children will collect what mushrooms and berries they can gather (Ziker, 2002). Caribou are hunted in late fall and early spring at river crossings, and during the summer, fall, and winter on land. Geese are hunted in the spring and the summer. Fishing occurs year-round, with ice-net fishing in the winter, open-water net-fishing and seine fishing in the summer, and thin-ice fishing in the spring. Arctic fox trapping occurs in the winter, but can be costly due to transportation requirements of checking long trap lines.

CHAPTER TWO: RECIPROCITY, KINSHIP, SKILL, AND GENEROSITY EXPLAIN INTER-HOUSEHOLD FOOD TRANSFERS IN A SIBERIAN HUNTER-GATHERER COMMUNITY

In the community of Ust’-Avam, the fall of the Soviet Union decreased the amount of outside resources available to the people. An increased reliance on traditional modes of subsistence – hunting, trapping and fishing – was noted by Ziker in his visits to the area (Ziker, 2002; Ziker, 2003; Ziker and Schnegg, 2005). Food sharing is pervasive in hunter-gatherer societies, and is seen in Ust’-Avam. Hunters share the meat they hunt in the community with kin, neighbors, friends, and acquaintances. What determines with whom a hunter will share with? This chapter seeks to predict variation in inter-household sharing between donor, hunter households, and recipient households. In order to do so, several variables are examined. Household characteristics of hunting skill and material wealth, previous transfers of meat or other items and services, and inter-household relatedness to kin are all analyzed. In this chapter, I outline the methods used to conduct these analyses and their results. This outline includes descriptions of each variable and the procedures used. Finally, I summarize the conclusions these results point to.

Methods

Foraging excursions were documented in 2001 and 2003. Thirty-six hunters went on 77 excursions, representing 100% of the total foraging excursions during this time as noted by Ziker (M.S. 2013). The variables examined were collected in 1997, 2001, and 2003, and some in 2007.

Dependent Variable

What best predicts food sharing in Ust'-Avam? To answer this question, the frequency of transfers occurring between households was analyzed using several independent variables. These transfers occurred after 77 hunting excursions involving 36 hunters. Ziker recorded the amount of meat and fish acquired, and the amounts consumed or distributed for all 77 excursions. In order to examine dyadic relationships between households, a matrix regression analysis is used. Each variable is entered into a 177x177 matrix. The 177x177 matrix consists of all pairs of households in the community, with donor households represented by row and recipient households represented by column. To create the frequency of transfers matrix, the number of transfers occurring from the donor household to the recipient household is entered as the value of the matrix cell. For this example, please refer to Table 2.1. If household A gave food once to household B, the value in cell 2 would be 1. If household B never reciprocated, the value in cell 2 would be 0. Two hundred and four sharing events were analyzed between 36 donor households and 102 recipient households, though all households participated in the study. Non-hunted food sharing events were not recorded in this study, so the 36 donor households are solely hunters. Cell 1 represents sharing occurring between household A, with household A, and cell 4 represents sharing occurring within household B. Since no inter-household sharing is occurring, the values for these cells remain blank.

Table 2.1 Example of matrix used for frequency of transfers

	A	B
A	[cell 1]	[cell 2] 1
B	[cell 3] 0	[cell 4]

Independent Variables

Maximum Genealogical Relatedness

Does kinship best predict inter-household transfers? In order to analyze the frequency of transfers with kinship, genealogical relatedness needed to be calculated for each household. For a pair of households, the genealogical relatedness for each individual in one household was determined in relation to all other individuals in the other household. The coefficient of relatedness was derived using the DESCENT program (Hagen, 2005). Ziker collected extensive genealogies in the community, reaching several generations into the past. The genealogical data was last updated in 2007. The max r value (coefficient of genealogical relatedness) was used to express the total household relatedness between the pair. For example, if household A had three members, one of whom was the sibling of a member of household B, which had two members, and this was the strongest tie, then the max genealogical relatedness value would be 0.5 as described in Figure 2. The value of the cell conjoining households A and B in the max genealogical relatedness matrix would also be 0.5.

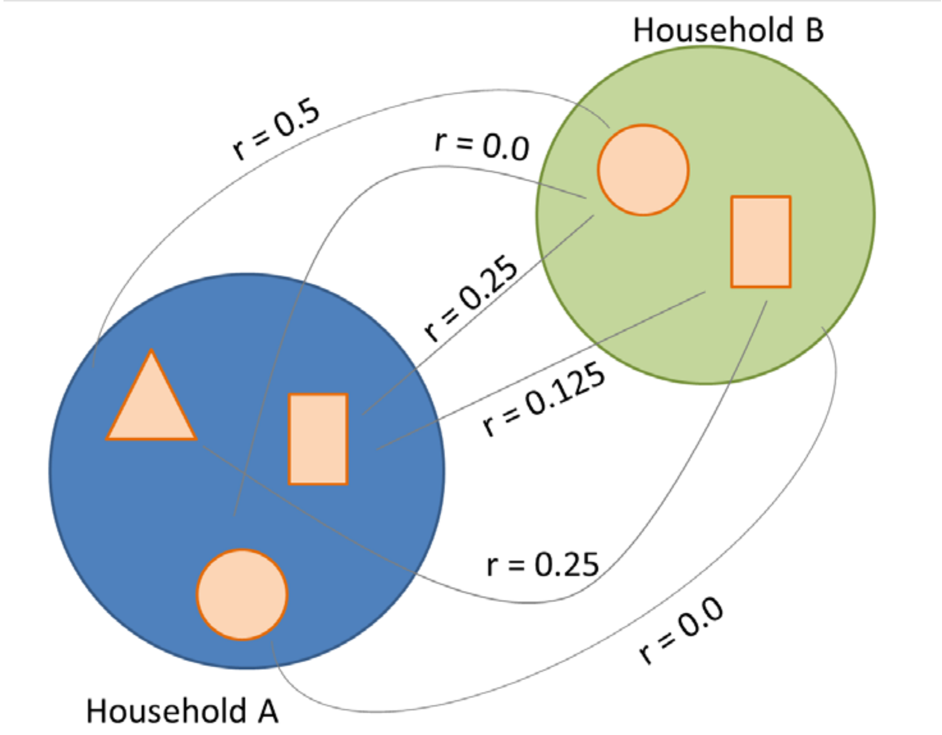

Figure 2. Fictitious diagram illustrating coefficients of relatedness between members of two households. The maximum relatedness is r = 0.5, whereas the average would be r = 0.1875.

Sum of Maximum Hunter Skill

In 2003, Ziker asked nine informants to rate all of the hunters in the community on a 3-point scale by skill level. Five of these informants evaluated 56 men in common. However, not all informants provided ratings for all hunters. These five evaluators provided a sample of rated hunters with which to act as a control for the other hunters with fewer evaluations. A Cronbach's alpha is a coefficient of internal consistency and is used to test the reliability of a scale (Cronbach, 1951). If the separate factors of a scale are correlated together, the Alpha score will be higher (Tavakol and Dennick, 2011). The scale in question here is composed of the scores of these five informants. The Cronbach's alpha coefficient of 0.825 indicates high scale inter-reliability. Missing ratings for hunters were imputed with the average rating provided by the missing evaluator. If an individual evaluator was biased towards rating hunters higher or lower than other evaluators, then the imputed ratings for that evaluator would reflect this bias consistently across all hunters. In order to check that imputing ratings were still valid, the imputed ratings were summed and, along with the summed un-imputed ratings, linearly regressed against age-adjusted reproductive success (See Chapter 3). The results were similar and justify using the larger dataset (imputed hunter skill evaluations: adj. $R^2 = 0.101$, $F_{1,\,140} = 16.824$, $\beta = 0.328$, $t = 4.102$, $p = 0.000$; non-imputed hunter skill evaluations: adj. $R^2 = 0.124$, $F_{1,\,55} = 8.872$, $\beta = 0.374$, $t = 2.963$, $p = 0.005$). The independent variables representing dyadic skill relationships use the maximum hunter skill evaluation for each household in cases where there were two or more hunters in a household. The summed values of the hunter skill evaluations of an inter-household dyad are used to create the sum of max hunter skill matrix.

Sum of Maximum Hunter Wealth

Each hunter was assigned a wealth value on a scale of 0 - 5. This value was determined by the ownership of any of the following four items in the year 2003: snowmobile, boat motor, rifle, and shotgun; and by the occupation of a hunting territory in 1997, 2003, or 2007. A Mokken scaling analysis, performed in R, was used to determine the validity of creating a scale from these five items. A Mokken analysis is similar to a Guttman's scaling analysis, and is used to construct and determine the validity of a scale of dichotomous variables (Van der Ark, 2007). A Loevinger's h greater than 0.5 indicates high scale inter-reliability, and for this scale $h = 0.672$ ($p = 0.048$). These values created a material wealth scale for which all hunters were assigned a value. The maximum material wealth figure for each household was selected in the case of more than one hunter in a household, and these values were summed in a 177x177 matrix – that is, the highest material wealth value was summed for each inter-household dyad.

Difference of Maximum Hunter Skill

The sum of maximum hunter skill evaluations variable is a matrix of the sums of hunter skill in an inter-household dyad, as discussed above. Here, instead of summing the two hunter skill evaluations in a household pair, a matrix was constructed by finding the difference between the skill evaluations of each pair of households. The recipient skill rating was subtracted from the donor skill rating. I plan to capture differences in producer ability with this variable.

Difference of Maximum Hunter Wealth

The sum of maximum hunter wealth variable is a matrix of the sums of the material wealth ratings in an inter-household dyad, as I discussed previously. In order to measure differences in wealth, the differences (as opposed to the sums) of the ratings between households are found and entered into a matrix. The recipient hunter wealth scale was subtracted from the donor hunter wealth scale. I plan to capture differences in hunting reputation with this variable.

Frequency of Transfers Transposed

The frequency of transfers transposed variable represents reciprocal transfers. This matrix is created by flipping the frequency of transfers matrix so that rows no longer represent donor households but rather recipient households, and columns no longer represent recipient households but donor households instead. Recall the example used above with Table 2.1. The value for cell 2 is 1, because household A had given once to household B. If the matrix is transposed, the value for cell 2 is 0, because B never gave to household A. The value for cell 3 becomes 1. The other two cells remain undefined. When frequency of transfers is regressed with frequency of transfers transposed as the independent variable, results indicate the level of reciprocity occurring in inter-household transfers, that is, the correlation of B's giving to A with A's giving to B.

Frequency of Receiving

Each sharing event that occurred from the 77 hunts in field visits by Ziker in 2001 and 2003 was coded into two separate dummy variables, obligatory sharing and voluntary sharing. The interviewee (donor) was asked three questions.

1) Why did you share?
2) What did you get out of sharing?
3) Did the recipient ever give you bush food or anything else?

If the answers indicated that the interviewee felt obligated to give meat or fish in some way, then the obligatory variable was coded with a 1. If the interviewee did not feel obligated to give food, then the obligatory variable was coded with a 0. If the interviewee had voluntarily shared and felt no expectation to share, the voluntary variable was coded with a 1. If the sharing event indicated the interviewee had shared because he felt obligated, or for reasons other than voluntarily sharing, then the voluntary variable was coded with a 0. If no sharing event occurred, then the value was left blank. Sometimes multiple sharing events occurred in a single dyad, in which case the maximum value of the variable was used. A transposed matrix of each of these variables was created, indicating that for the first case, the recipient had given to the hunter something the hunter would feel obligated to reciprocate in meat or fish (for example, the recipient lent him a rifle or boat motor), and for the second case, indicating that the recipient had given to the hunter something the hunter would not feel obligated to reciprocate (for example, tea). These two matrices were summed, indicating any sort of sharing with the hunter prior to the hunt that may have occurred in a different ‘currency.’

Procedure

Multiple-Regression Quadratic Assignment Procedure (MRQAP) performed by UCINET 6.0 was used to analyze these matrices. QAP is used in cases where the data violate the assumption of independence (Krackhardt, 1988). The QAP ‘scrambles’ the dependent matrix by using the same permutation for rows and for columns. Several hundred permutations of the dependent matrix result in a sampling distribution to use as the null hypothesis. The original dependent matrix and the permuted matrix are both regressed with the independent matrix.

If the regression coefficients (or R^2) from the original matrix are in the extreme percentile of the distribution of coefficients (or R^2) produced by the permuted matrices, the null hypothesis can be rejected.

Results

Seven variables were entered individually using the MRQAP routine in UCINET to predict the frequency of transfers between households. Each variable is listed in Table 2.1, along with their results, which include the significance as a variable, the significance of the total model, and the variance (R^2) explained by that model. Max genealogical relatedness ($\beta = 0.33654$, $p = 0.00050$), the sum of max hunter skill ($\beta = 0.09709$, $p = 0.00050$), frequencies transposed ($\beta = 0.44291$, $p = 0.00050$), and frequency of receiving (β = 0.25977, *p* = 0.00050) are significant as variables. The frequency of receiving variable when individually entered is not significant, although it approaches significance. So, while frequency of receiving may have a significant effect on the frequency of transfers, the variance it explains is not large enough to be significant at the model level.

Table 2.2 Individually entered variables predicting frequency of transfers

Variable	Unstandardized coefficient	Standardized coefficient	Variable significance (p)	Model R^2	Model significance (p)
Max genealogical relatedness	1.76707	0.33654	0.00050***	0.113	0.002**
Sum of max hunter wealth	0.01955	0.06432	0.00550**	0.004	0.119
Sum of max hunter skill	0.00738	0.09709	0.00050***	0.009	0.015*
Difference of max hunter wealth	0.00059	0.00360	0.48577	0.000	0.486
Difference of max hunter skill	-0.00120	-0.01498	0.25837	0.000	0.368
Frequencies transposed	0.44291	0.44291	0.00050***	0.196	0.046*
Frequency of receiving	0.92465	0.25977	0.00050***	0.067	0.063†

* = p<0.050
** = p<0.010
*** = p<0.001
† = almost significant

Table 2.2 shows the results of entering the three main effects, determined from the individually entered variables, to predict the frequency of transfers. The three variables acting as main effects are genealogical relatedness, sum of max hunter skill, and frequencies transposed (which represents reciprocity). When entered together, each variable remains significant. The model is significant, and the R^2 is 0.276, resulting in almost 28% of the variance in frequency of transfers explained by these three variables.

Table 2.3 Main effects model predicting frequency of transfers

Variable	Unstandardized coefficient	Standardized coefficient	Variable significance (p)	Model R^2	Model significance (p)
Max genealogical relatedness	2.20274	0.30247	0.00050***	0.276	0.041*
Sum of max hunter skill	0.01269	0.06682	0.00900**		
Frequencies transposed	0.30031	0.30031	0.00050***		

* = p<0.050
** = p<0.010
*** = p<0.001
† = almost significant

Is there any variance that is not explained by these variables individually, but might be explained by some interaction of these variables? In order to answer this question, three interaction terms were created. The first, max genealogical relatedness • sum of max hunter skill, was created by multiplying the corresponding cell values of these two matrices. The second, created in the same way as the first, was max genealogical relatedness • frequencies transposed. The final interaction term was created by multiplying the sum of max hunter skill • frequencies transposed. The main effects need to remain in the model in order to act as controls for the interaction terms. Table 2.3 illustrates the results. The model R^2 has increased to 0.396 ($p = 0.033$). However, max genealogical relatedness, sum of max hunter skill, and max genealogical relatedness •

sum of max hunter skill, are no longer significant. Furthermore, the sign on the coefficient of frequencies transposed has moved from positive to negative (β = -1.33925, *p* = 0.00050), indicating an increase in sharing with households who do not reciprocate, after controlling for a propensity to share with relatives and other skilled hunters who reciprocate. It is important to note that the max genealogical relatedness • sum of max hunter skill variable approaches significance (β = 0.20246, *p* = 0.06697).

Table 2.4 Main effects and interaction terms model predicting frequency of transfers

Variable	Unstandardized coefficient	Standardized coefficient	Variable significance (p)	Model R^2	Model significance (p)
Max genealogical relatedness	0.48986	0.06727	0.26687	0.396	0.033*
Sum of max hunter skill	0.00226	0.01191	0.35032		
Frequencies transposed	-1.33925	-1.33925	0.00050***		
Max genealogical relatedness •Sum of max hunter skill	0.07465	0.20246	0.06697 †		
Max genealogical relatedness • Frequencies transposed	0.31763	0.12287	0.02549*		
Sum of max hunter skill •Frequencies transposed	0.07211	1.57269	0.00050***		
* = p<0.050 ** = p<0.010 *** = p<0.001 † = almost significant					

Is there a more parsimonious model? The decision to remove the interaction term max genealogical relatedness •sum of max hunter skill only slightly affected the overall R^2 of the model, and did not affect its significance. Of some interest is that max genealogical relatedness is again significant in the final model (β = 0.25578, *p* =0.00050). It is important to note here that the sign on the coefficient of frequencies transposed remains negative.

Table 2.5 Final model predicting frequency of transfers

Variable	Unstandardized coefficient	Standardized coefficient	Variable significance (p)	Model R^2	Model significance (p)
Max genealogical relatedness	1.86272	0.25578	0.00050***	0.395	0.033*
Sum of max hunter skill	0.00362	0.01904	0.28486		
Frequencies transposed	-1.43521	-1.43521	0.00050***		
Max genealogical relatedness • Frequencies transposed	0.32785	0.12682	0.01949*		
Sum of max hunter skill •Frequencies transposed	0.07718	1.68334	0.00050***		

* = *p<0.050*
** = *p<0.010*
*** = *p<0.001*
† = *almost significant*

Does reciprocity occur in other currencies? To answer this question, the frequency of receiving variable is included with the other variables of the previous model. Recall that this variable is significant when individually entered to predict the frequency of transfers. The results in Table 2.5 indicate that the frequency of receiving is not a significant predictor of the frequency of transfers in this exploratory model, indicating that most of the variance explained by this variable is also explained by other variables. The model R^2 remains mostly unchanged (though the significance of the model does slightly increase (*p* = 0.037)). When combined with other variables, possibly frequencies transposed, frequency of receiving does not predict frequency of transfers, indicating that reciprocity does not occur in other currencies significantly enough to predict food transfers.

Table 2.6 Model exploring the possible effects of reciprocity in other currencies in predicting frequency of transfers

Variable	Unstandardized coefficient	Standardized coefficient	Variable significance (p)	Model R^2	Model significance (p)
Max genealogical relatedness	1.81726	0.24954	0.00050***	0.396	0.037*
Sum of max hunter skill	0.00340	0.01792	0.29185		
Frequencies transposed	-1.45635	-1.45635	0.00050***		
Max genealogical relatedness •Sum of max hunter skill	0.37359	0.14452	0.01599*		
Max genealogical relatedness • Frequencies transposed	0.07665	1.67159	0.00050***		
Frequency of receiving	0.12498	0.03511	0.10945		

*   = $p<0.050$
**   = $p<0.010$
*** = $p<0.001$
†   = almost significant

Conclusions

The best model to predict variations in food transfer frequencies includes kinship, reciprocity, and household hunting skill. Hunting skill only predicts transfers when included with other variables controlling for the interaction terms, and is not significant. The results from the final model support this conclusion, and also show that this variation is not explained by these three variables alone, but also relies on an amount of interaction between hunter skill and reciprocity, and kinship and reciprocity. This final model, which includes the main effects and these two interaction terms, explains almost 40% of the variance in inter-household food transfers. Aside from the findings of this final model, the results show several other conclusions.

First, the model (Figure 2.5) shows transfers increase in frequency as inter-household relatedness increases, with a standard coefficient (β) of 0.25578 ($p = 0.00050$), controlling for reciprocity, skill, and interaction terms. This result supports the kin provisioning hypothesis discussed in Chapter 1. Second, increases in frequency of transfers, when controlled for kinship and skill and the interaction terms, result in significant decreases in reciprocal transfers, showing a shift from contingency to unidirectional transfers ($\beta = -1.43521$). Unidirectional transfers may indicate distribution of food from those that have to those who are needy. This has been termed “generosity signaling” (Gurven et al, 2000). Lastly, I tested to see if these transfers were truly generous, or if reciprocation was occurring in another currency. Recall the frequency of receiving variable, which was significant when entered individually to predict frequency of transfers. This indicates that reciprocity is occurring in the community in other currencies, but the model was not significant, and the variable was not significant when added to the final model. I conclude that while reciprocity does occur in other currencies, it does not significantly predict the frequency of transfers and that these transfers are truly generous – they are not reciprocated.

Third, reciprocity occurs between highly skilled households, as noted by the significance of the interaction term sum of skills • frequency of transfers ($\beta = 1.68334$, $p = 0.00050$), independent of kinship, generous transfers, and the interaction between kinship and reciprocity. Fourth, reciprocity also occurs between related households ($\beta = 0.03560$, $p = 0.00050$), independent of the interaction of skill and reciprocal transfers, kinship, skill, and generous transfers. Recent studies have also illustrated an interaction with kinship and reciprocity (e.g., Nolin, 2010). I will expand on these in Chapter 4.

Hunters with higher producer capacity do not give more frequently to those with lower capacities, and choose instead to share with those who are more likely to reciprocate, as represented by the strength of the interaction term between sum of skill and frequency of transfers transposed. The variable representing the household differences in hunter skill was not a significant predictor of food sharing frequency individually or in combination with other variables. These findings do not support the costly signaling hypothesis described in Chapter 1. Furthermore, hunters with higher material wealth do not share more frequently with those of lesser wealth. The variable representing the household differences in hunter wealth was also not a significant predictor of food sharing frequency individually or in combination with other variables.

This result does not provide support for the hypothesis of tolerated scrounging. In this community, there are instances where an individual will ask a donor for meat, and can be quite insistent (Ziker, p.c. 2013). These instances were rare enough that they were not significant predictors of food sharing. Food sharing is a very important aspect of life in the community, and not sharing can lead to gossip and a reputation of stinginess (Ziker, 2003). This anecdotal evidence supports the idea that tolerated scrounging may be at work within the community, however it may not be significant enough to explain variation.

CHAPTER THREE: MALE REPRODUCTIVE SUCCESS AND FORMS OF WEALTH IN NORTHERN SIBERIA

Research in the community of Ust'-Avam, following the collapse of the Soviet Union, can provide insight into individuals' decisions in an environment of change. As the members of this community move away from a commercial hunting economy towards a more traditional, subsistence economy, questions central to the HBE field are asked here. What best explains these hunters' reproductive success? How do different types of wealth affect this success, and how well do they predict when a hunter will start his reproductive career? This section looks to answer the broader question of what men do with the resources they choose to keep in light of life-history tradeoffs concerning seeking new mates and potential future offspring, or provisioning current mates and offspring.

This study examines how men invest their resources by their types of wealth as related to hunting and their subsequent reproductive success, in hopes of determining how they make the decision to invest in reproduction or in mating effort. In this chapter, I will outline the methods used to answer these questions. I will then describe the results from these analyses, and finally, I will discuss these results and their implications, and the conclusions I have drawn from them.

Methods

What best predicts variation in men's reproductive success and when they will reproduce? The sample includes all 272 men 15 years of age and over in the Ust'-Avam community. In order to answer this question, age adjusted reproductive success (RS) and age at first birth are regressed against three classes of wealth determined by nine separate variables. These are the same three wealth classes described by Smith et al. (2010) and are material, embodied, and relational wealth. Embodied wealth includes such intangibles as education, skills, and health. Material wealth is the ownership of physical, tangible property, and the most easily measured. The number and quality of social relations determines social capital or, as it's called in this study, relational wealth.

Dependent Variables

What best predicts men's reproductive success? To answer this question, reproductive success needs to be defined and quantified. Here, reproductive success only includes children survived to age 5 at census (2007). Age is controlled for by using the residuals of the number of children survived to age 5 with age and age^2 as predictors. Age is determined by age at census (2007). Age-adjusted RS is used as the dependent variable in linear regressions and using this variable serves to control for the very strong correlation between age and reproductive success, allowing the RS of men of different ages to be compared.

When will men begin to reproduce? Age at first birth is the age of the man at the birth of his first recorded child, had he experienced such an event. If he had not, then his age at census (2007) is included. The event was coded for true or not (1 or 0). Predicting age at first birth requires a hazard-function analysis rather than a linear regression, the Cox regression is a hazard-function analysis provided by SPSS.

Independent Variables

Three classes of wealth are tested in this analysis: embodied, material, and relational. Embodied wealth can often include skills, education, and health statistics such as BMI. Here, I used the education level recorded in the census, and the hunter skill evaluation scale as described in Chapter 2. The variables used to describe material wealth include the material wealth scale also described in Chapter 2, and the amount of cash income recorded in a survey conducted among a sub-sample of hunters in 1997. There are few cases for this variable. Relational wealth is generally defined with variables that act as proxy for the strength of an individual's social network. In this case, I use the count of parents, the count of siblings, the count of parents' siblings, and the count of parents' siblings' offspring. These four variables were provided from Ziker's extensive genealogical data updated in 2007 inputted into the program Descent (Hagen, 2005). I have included an additional measure of relational wealth in the form of a formal hunting status. Each individual was scored on a scale of 1 to 5 (staff hunter, brigade hunter, amateur, etc.) as an indicator of social relations. I have inverted this scale to use in regressions.

Results

Age-Adjusted Reproductive Success

Each of the nine variables was entered individually in both linear and Cox regressions. First, each variable was regressed against age-adjusted reproductive success.

Then, each variable was entered individually in a Cox regression to determine their effect on age at first birth. Each variable representing embodied wealth was individually regressed against age-adjusted reproductive success using SPSS. Bootstrapping was used in order to control for known interdependence in the data, and leads to conservative t-test results. Of the two, only the hunter skill evaluations variable was significant ($\beta = 0.328$, *p* = 0.000). Table 3.1 illustrates these results.

Table 3.1 Age-adjusted RS: Embodied variables - individually entered

Covariate	N	Unstandardized coefficient	Standard error[1]	Standardized coefficient	Significance[2] (p)
Hunter skill evaluations	142	0.193	0.061	0.328	0.000**
Education level	240	0.051	0.044	0.084	0.196

1 Robust bootstrapped standard errors, 2 T-test significance, * Significant at p<0.05, ** Significant at p<0.01, † Approaching significance

Figure 2 illustrates a linear-regression plot with age-adjusted RS as the dependent variable, and hunter skill evaluations as the independent variable. Hunter skill evaluations were the only significant predictor representing embodied wealth of hunter's RS. The blue line indicates the line of best fit and the red lines represent the 95% confidence interval. The R^2 value of 0.107 indicates hunter-skill evaluations explain ten percent of the variation in men's age-adjusted reproductive success. Few of the 142 evaluations fall outside the lines of the confidence interval, and the data points show a definitive, positive trend, though there appears to be a cluster towards lower skill evaluation ratings.

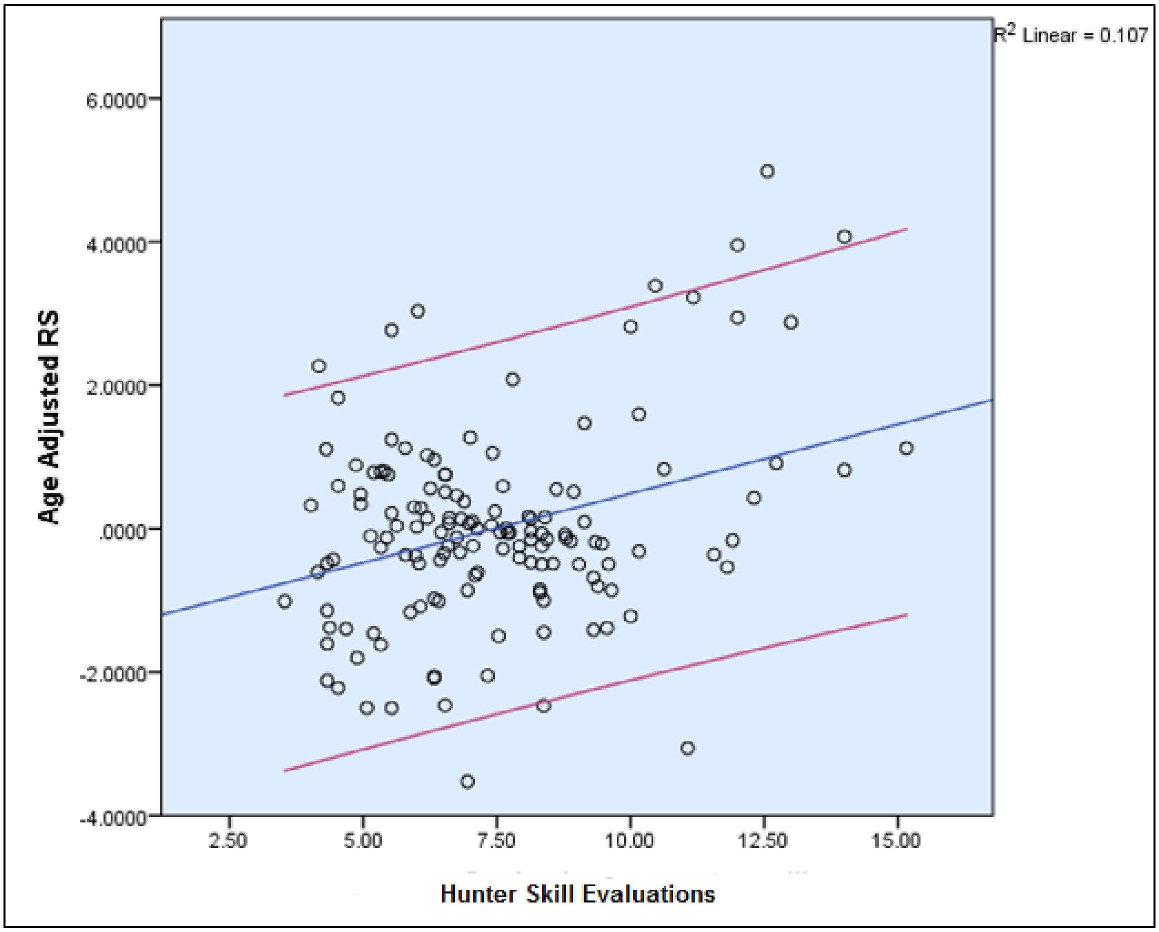

Figure 3. **Linear regression plot: hunter skill evaluations**

Next, the two variables representing material wealth, the material wealth scale and cash income, were individually entered to determine their effect on age-adjusted reproductive success. Only material wealth scale was significant ($\beta = 0.255$, $p = 0.000$) as described in Table 3.2. Income is a poor indicator of individual performance as any effect it has is very insignificant, it has been removed from the model ($\beta = 0.069$, $p = 0.7666$). Income may have such an insignificant effect on determining hunter reproductive success because there are only 21 men in the community who reported a cash income. Such a small ‘*n*’ would alter the results of the final model, further justifying not including this variable.

Table 3.2 Age-adjusted RS: Material variables - individually entered

Covariate	N	Unstandardized coefficient	Standard error[1]	Standardized coefficient	Significance[2] (p)
Material wealth scale	272	0.221	0.064	0.255	0.000**
Cash income	21	3.696E-006	1.9E-005	0.069	0.7666
1 Robust bootstrapped standard errors, 2 T-test significance, * Significant at p<0.05, ** Significant at p<0.01, † Approaching significance					

Figure 3 is a linear regression plot with age-adjusted RS as the dependent variable on the y-axis, and the hunter material wealth scale as the independent variable on the x-axis. This plot shows the effect material wealth has on age-adjusted RS. With an R^2 of 0.065 indicating over 6% of the variance in reproductive success is explained, this effect is significant, recalling Table 3.2. Again, the blue line represents the best fit, and the red lines represent the 95% confidence interval. It is important to remember here that the material wealth scale is composed of the ownership status of five items, and this is why the plot looks striated.

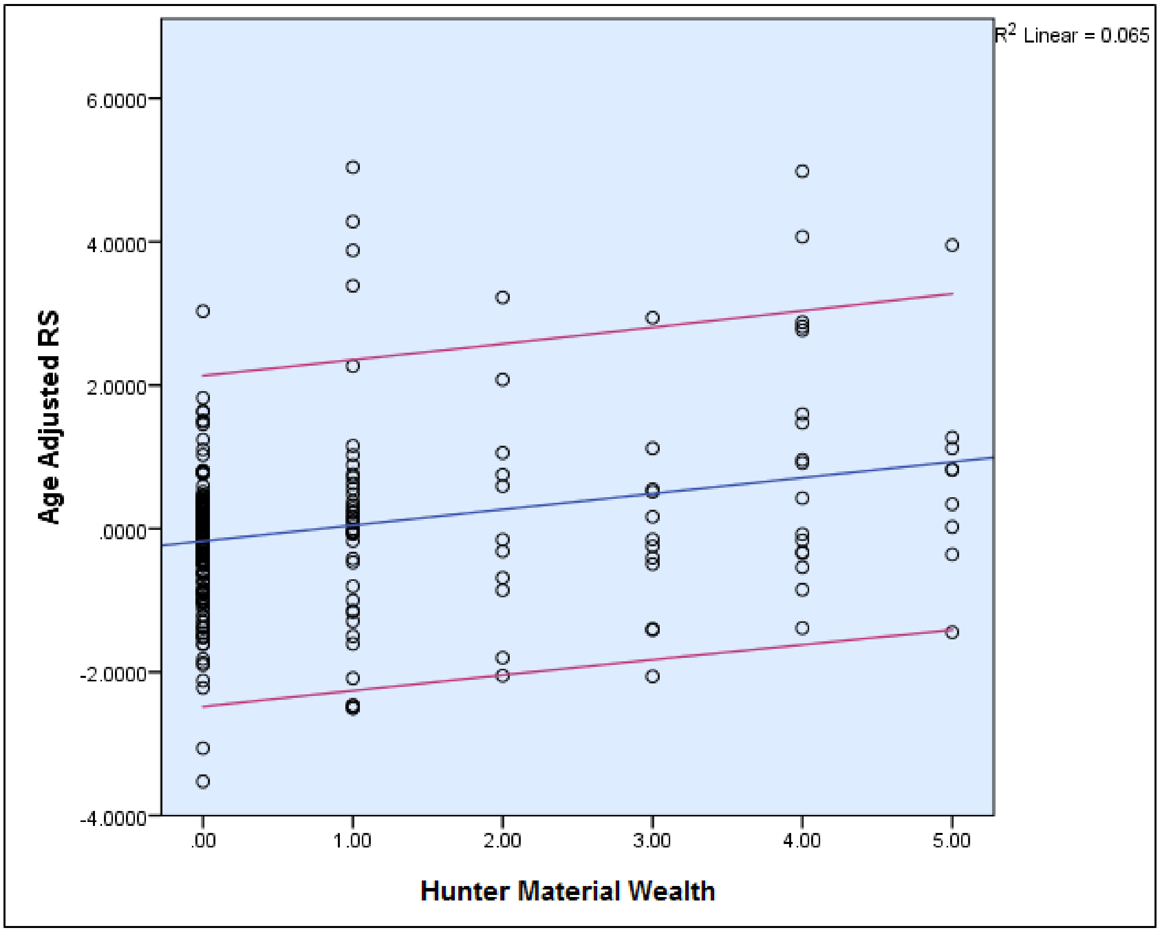

Figure 4. **Linear regression plot: hunter material wealth**

The final set of variables individually entered against age-adjusted RS represented embodied wealth. Again, these five variables are number of living parents, number of living parents' siblings, number of living siblings, number of living parents' siblings' offspring, and formal hunting status as a measure of a hunter's social network access. The results are described in Table 3.3. Only formal hunting status is a significant predictor of age-adjusted RS ($\beta = 0.259$, $p = 0.002$). The number of siblings, number of parents, and number of parents' siblings are not significant in the slightest. It should be noted that the number of parents' siblings' offspring (or the number of the hunter's full cousins), approaches significance (β = -0.115, *p* = 0.058). While the significance of this variable does not meet the threshold set, it does border it, and the number of full cousins a hunter has might have a negative influence on the number of children he has.

Table 3.3 Age-adjusted RS: Relational variables - individually entered

Covariate	N	Unstandardized coefficient	Standard error[1]	Standardized coefficient	Significance[2] (p)
Number of siblings	272	-0.011	0.038	-0.017	0.781
Number of parents	272	-0.012	0.088	-0.007	0.903
Number of parents' siblings	272	-0.021	0.025	-0.031	0.610
Number of parents' siblings' offspring	272	-0.019	0.006	-0.115	0.058†
Formal hunting status	138	0.262	0.103	0.259	0.002**

1 Robust bootstrapped standard errors, 2 T-test significance, * Significant at p<0.05, ** Significant at p<0.01, † Approaching significance

All variables (excepting cash income) were entered into a single model using the SPSS backwards stepwise procedure to create a final model. The backward stepwise procedure begins with all variables, and eliminates variables as the model improves. Table 3.4 illustrates these results. Only hunter skill evaluations and material wealth are found significant ((β = 0.237, *p* = 0.014) and (β = 0.210, *p* = 0.029), respectively). Although formal hunting status is found significant when individually entered, the variation it explains is not significant enough (or unique enough) to be included in the final model; that is, the variation explained by formal hunting status may also be explained by the material wealth scale and hunter skill evaluations.

Table 3.4 Age-adjusted RS: Final model

Covariate	N	Unstandardized coefficient	Standard error[1]	Standardized coefficient	Significance[2] (p)
Hunter skill evaluations	133	0.142	0.057	0.237	0.014*
Material wealth	133	0.175	0.079	0.210	0.029*
Overall Model fit (R^2) = 0.153, F-test significant, p = 0.001					
1 Robust bootstrapped standard errors, 2 T-test significance, * Significant at p<0.05, ** Significant at p<0.01, † Approaching significance					

Age at First Birth

In order to determine when a hunter in the community may expect to experience a first birth, a Cox regression (or Cox proportional hazards analysis) was performed. Each of the nine independent variables was entered individually against the dependent variable of age at first birth. Again, these nine variables are grouped into three categories of wealth: embodied, material, and relational. First, the relational wealth variables were individually entered in a Cox regression. The results are depicted in Table 3.5, and show that again, like in the linear regression predicting reproductive success, only hunter skill evaluations are significant when predicting age at first birth (Exp(B) = 1.091, *p* = 0.045). Of note here, though, is that the education level approaches significance (Exp(B) = 1.106, *p* = 0.056). Where education level did not predict the hunter's reproductive success, it could be said it influences the age at first birth. This is interesting because education level would not be delaying reproduction as generally expected in post-demographic transition societies, but hastening it (note the positive Exp(B) in Table 3.5). Few men leave the community for a secondary education, which may explain why education has a positive influence on men's expected age at first birth: completing 11 years of school in the community may be a general indicator of embodied capital, and thus make these men more attractive as mates. If men left the community for secondary education, they would likely experience a delay in age at first birth. In post-demographic transition economies, individuals delay reproduction to build capital. However, since there are so few employment opportunities that require education (and these are often filled by ethnicities other than Dolgan or Nganasan), education is not as beneficial to an individual in building wealth.

Table 3.5 Age at first birth: Embodied variables - individually entered

Covariate	N	B	Standard error[1]	Exp(B)	Significance[2] (p)
Hunter skill evaluations	142	0.087	0.035	1.091	0.045*
Education level	240	0.101	0.053	1.106	0.056†

1 Robust bootstrapped standard errors, 2 Wald test significance, * Significant at p<0.05, ** Significant at p<0.01, † Approaching significance

Figure 4 plots the probability of survival until a first birth using a Kaplan-Meier plot. The x-axis indicates hunter age minus 15 years (survival of not experiencing a first birth is expected to be 1.0 at 15 years old), and the y-axis represents the cumulative survival of not experiencing a first birth. The youngest father was just under 16 years old. The hunter skill evaluations scale is grouped into three categories; those who scored lower than one standard deviation below the mean are poorly skilled, those that scored between one standard deviation above and below the mean represent moderate skill level, and those that scored higher than one standard deviation above the mean are highly skilled. The plot indicates that highly skilled hunters (the green line) are more likely to experience a first birth by the age of 35 than those who are less skilled. Highly skilled hunters, if they are going to experience a first birth, do so by the time they are 35, whereas moderately skilled hunters will do so by the time they are 55 years old. Interestingly, this plot shows that the least skilled hunters are also the least likely to experience a first birth.

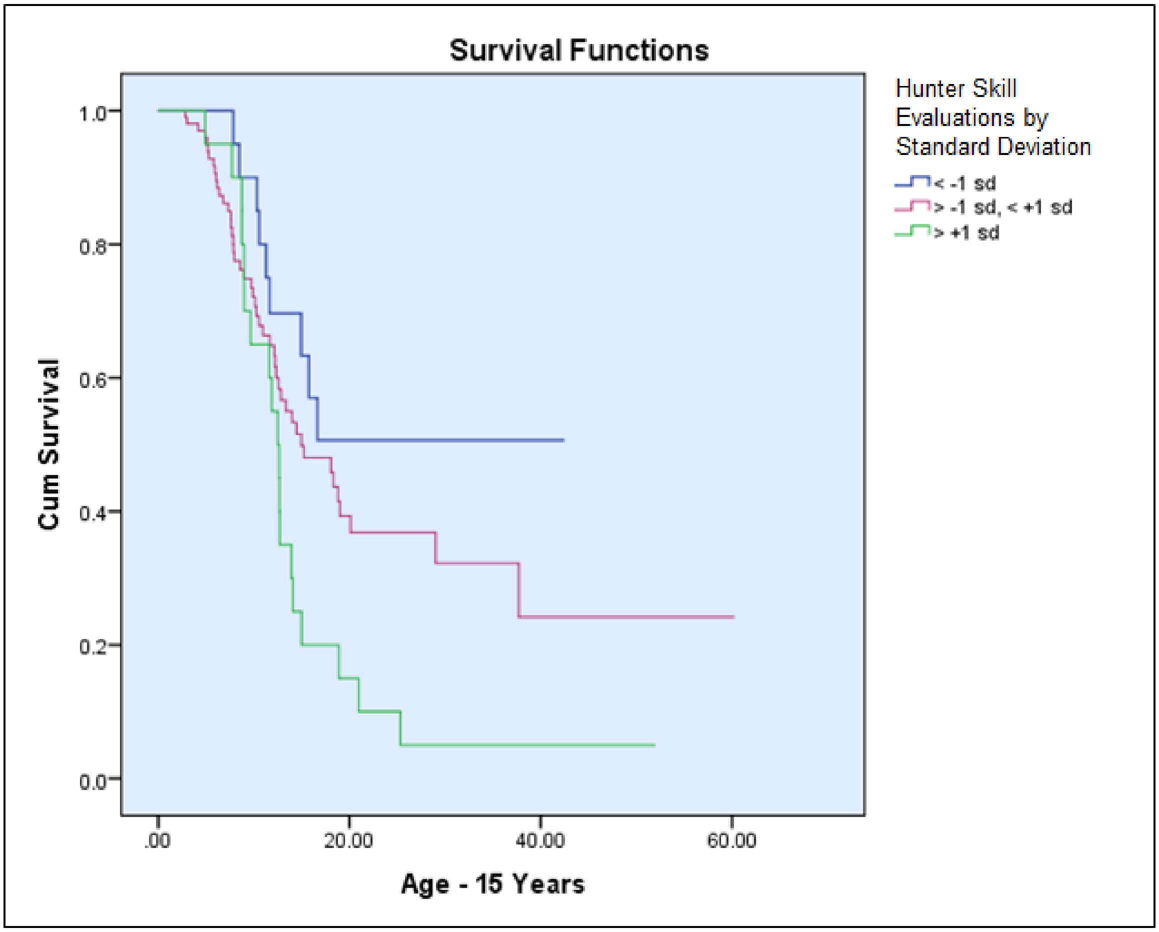

Figure 5. Kaplan-Meier plot of likelihood of age at first birth by hunter skill evaluations

Next, the material wealth variables were entered individually to predict age at first birth. Again, only the wealth scale was significant (Exp(B) = 1.148, *p* = 0.012), and cash income is very much not significant (Exp(B) = 1.000, *p* = 0.695). Since cash income is so insignificant, and again, because its n is so small (21), it is not included in determining the final model.

Table 3.6 Age at first birth: Material variables - individually entered

Covariate	N	B	Standard error^1	Exp(B)	Significance^2 (p)
Material wealth scale	272	0.138	0.046	1.148	0.012*
Cash income	21	0.000	0.000	1.000	0.695
1 Robust bootstrapped standard errors, 2 Wald test significance, * Significant at p<0.05, ** Significant at p<0.01, † Approaching significance					

Figure 5 is also a Kaplan-Meier plot. Age minus 15 years is represented on the x-axis, and cumulative survival to the event (first birth) is plotted along the y-axis. The green line is the wealthiest class of hunters, the red is those with moderate or little wealth, and the blue line represents hunters with no material wealth. Of interest here is that there seems to be little difference between hunters with no wealth and hunters with little wealth. Many hunters with little wealth will experience first births earlier than their wealthier and poorer counterparts. In any case, hunters with high wealth are more likely to experience a first birth, and will do so by the age of 35 or 37.

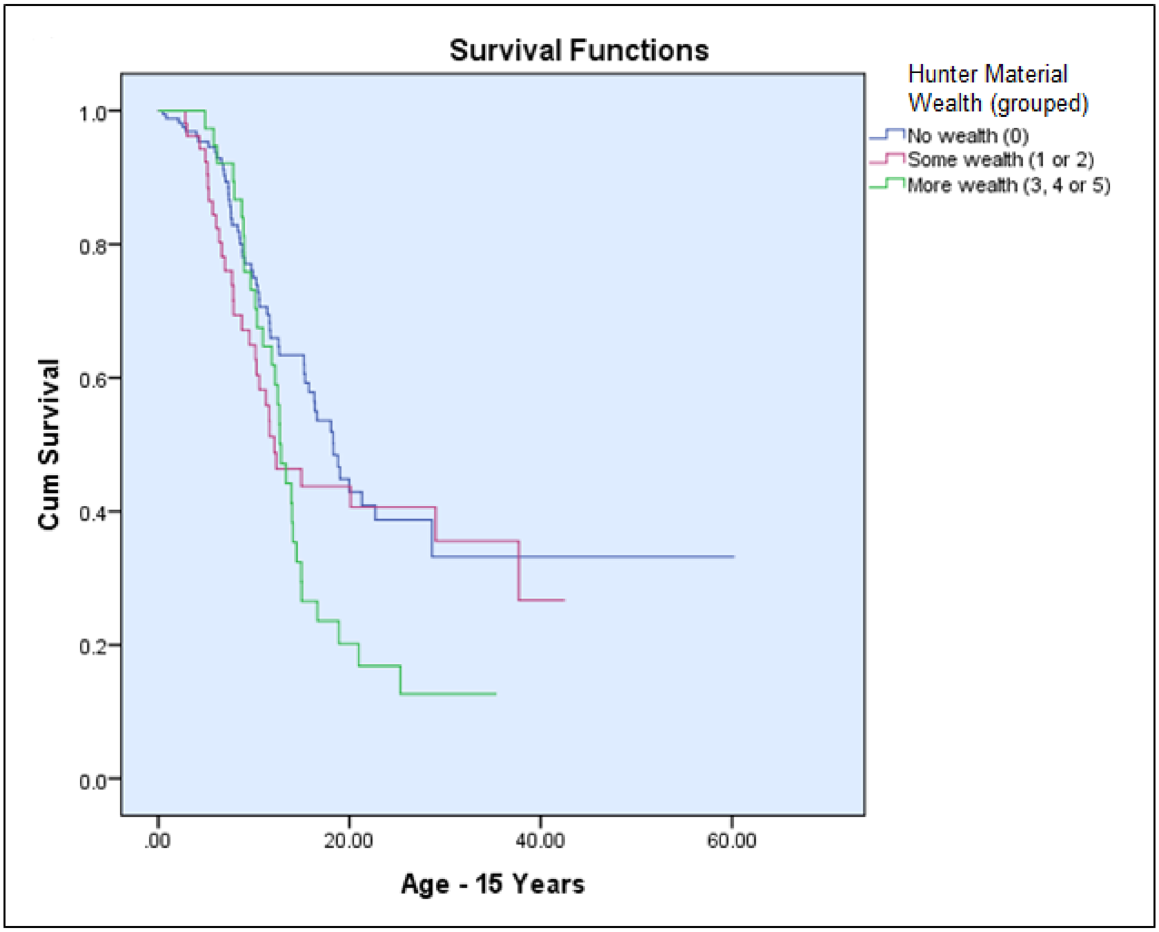

Figure 6. **Kaplan-Meier plot of age at first birth by hunter material wealth**

Variables representing relational wealth were analyzed to predict age at first birth using a Cox regression. These variables were entered individually. Again, these variables include counts in four categories of kin, and the formal hunting status as a measure of social network access representing relational ties. In predicting age at first birth, only formal hunting status is significant (Exp(B) = 1.172, p = 0.043), as described in Table 3.7. No other category, including number of siblings, number of parents, number of parents' siblings, and number of parents' siblings' offspring are significant.

Table 3.7 Age at first birth: Relational variables - individually entered

Covariate	N	B	Standard error[1]	Exp(B)	Significance[2] (p)
Number of siblings	272	-0.089	0.050	0.915	0.106
Number of parents	272	0.059	0.161	1.061	0.704
Number of parents' siblings	272	-0.027	0.080	0.973	0.720
Number of parents' siblings' offspring	272	-0.023	0.021	0.977	0.183
Formal hunting status	138	0.159	0.072	1.172	0.043*

1 Robust bootstrapped standard errors, 2 Wald test significance, * Significant at $p<0.05$, ** Significant at $p<0.01$, † Approaching significance

These nine variables (excluding cash income) were entered into a final model to predict age at first birth using the backwards-stepwise procedure with the Cox regression. Of the eight variables entered, only the material wealth scale, the number of parents' siblings, and the number of parents' siblings' offspring are kept in the final model. Of particular interest here, is that only the material wealth scale is significant (Exp(B) = 1.219, $p = 0.004$), as shown in Table 3.8. The other two relational variables are not significant in the final model, nor were they significant when individually entered. These variables seem to not negatively affect the overall model fit in, and SPSS found that their elimination did not improve the model and the variation they explain, while neither large nor significant, is unique. This may be one possible explanation for why they are included.

Table 3.8 Age at first birth: Final model

Covariate	N	B	Standard error[1]	Exp(B)	Significance[2] (p)
Material wealth scale	272	0.198	0.068	1.219	0.004**
Number of parents' siblings	272	0.250	0.144	1.284	0.083
Number of parents' siblings' offspring	272	-0.057	0.034	0.944	0.094
Chi square-test significant at p=0.016*					
1 Robust bootstrapped standard errors, 2 Wald test significance, * Significant at p<0.05, ** Significant at p<0.01, † Approaching significance					

Conclusions

What predicts a hunter's reproductive success in Ust'-Avam? What predicts when he will first have a child? These are the two questions I sought to answer in this chapter. The results from both the linear regression and Cox regression show that a hunter's material wealth – the ownership status of the five items described earlier – is important in predicting variation in age-adjusted reproductive success and age at first birth. In predicting a hunter's reproductive success, both hunter's material wealth and the hunter's skill were important factors; the model with these two variables predicted 15.3% of the variance. These findings corroborate recent studies into hunter-gatherers in other societies, which I will go into more detail in Chapter 4. The more highly skilled and wealthy a hunter is the more offspring survive to age 5 they are likely to have.

In predicting the age at first birth, the final model included variables that were not significant when individually entered or when entered in the final model using a backwards stepwise procedure. These variables were not eliminated because the variance they explained, though small, was unique. These two variables were the number of parents’ siblings and the number of parents’ siblings’ offspring. The number of parents’ siblings had a positive coefficient (0.250), indicating that the presence of aunts and uncles may slightly increase the age at which a hunter may experience a first birth. The Exp(B) for this variable in the final model is 1.284, meaning that for every one-unit increase in the number of parents’ siblings, the odds of the hunter experiencing a first birth are 1.284 higher than the baseline. Interestingly, the number of parents’ siblings’ offspring (insignificantly) negatively affected when a hunter might start their reproductive career with a coefficient of (-0.057). The Exp(B) for this variable is 0.944, indicating that for every increase in the number of parents’ siblings’ offspring, the odds of the individual experiencing a first birth actually decrease in relation to the baseline at odds of 0.944 to 1. Therefore, the number of aunts and uncles might slightly (though insignificantly) increase the likelihood a hunter will experience a first birth, perhaps by providing the hunter with resources such as childcare or food. When those aunts and uncles have children of their own, they are more likely to invest those resources in their own children, rather than their hunting nephews.

CHAPTER FOUR: DISCUSSION AND CONCLUSION

In this chapter, I consider how these results fit into larger debates about food sharing in hunter-gatherer societies, and how they further this debate. I review the important connections between hunter wealth and skill and social network with their reproductive success in light of the connection between Ust'-Avam hunters' reproductive success and wealth classes.

Food Sharing: Models of Multiplicity

Early studies of food sharing generally looked at testing only one model of food sharing or another. The four models Kaplan and Hill proposed did not include the costly signaling hypothesis, which later researchers often test for (Smith and Bliege Bird, 2000; Gurven, 2004; Ziker and Schnegg, 2005; Allen-Arave, Gurven and Hill, 2008; Nolin, 2012; Koster, 2011; Wood and Marlowe, 2013). However, Kaplan and Hill (1985b) began a trend in HBE that has continued over several decades, with researchers trying to answer the question, "what best explains food sharing?" Kaplan and Hill set out to examine the factors that determine food sharing among the Ache. They list four sets of conditions to account for the evaluation of sharing – kinship, tolerated theft, reciprocity, and cooperative acquisition. Nine foraging trips were recorded, during which investigators accompanied foragers and measured all food procured by weight and count. The researchers found kin selection, as a condition of the evaluation of sharing, was not supported by this data. They found that reciprocity accounted for some 61% of the variance in food sharing (r = .78, 2 = 0.61, *p* < 0.000001, N = 27). Reciprocity was the greatest predictor of variance, and the second greatest predictor was package size.

Betzig and Turke (1986) studied food sharing on the island of Ifaluk. They questioned 10 households about their food intake and distribution patterns, which resulted in 84 food-sharing events captured. The results suggested that sharing occurred largely between kin. The researchers found that kinship and distance did not intersect. Individuals incurred a cost to travel far to bring food to relatives. However, individuals were not as willing to travel to the other islet to give food, indicating there was a cost threshold. Recipient households generally had a greater number of dependent children. Betzig and Turke hoped to contribute their data to the small pool that existed at the time, and the findings of their research supported the kin provisioning model.

Current studies are looking at the possibility of multiple models of food sharing at work in hunter-gatherer societies. Also, current researchers are re-analyzing the predictions and results of previous anthropologists. For example, Wood and Marlowe (2013) are revisiting much of the work done by Hawkes, O’Connell, and Blurton Jones (2001) and Hawkes et al. (2001). In 2001, Hawkes et al. found Hadza men were not minimizing risk and variance of meat acquisition, and were not maximizing their hunting returns. The researchers concluded after a series of games examining Hadza prey-choice, and why Hadza chose to seek large game rather than small, that men acquired benefits to seeking large game that did not benefit their wives or current offspring. Hawkes, O’Connell, and Blurton Jones (2001) in a separate study found that Hadza sharing does not fit the model of risk-reduction reciprocity.

Wood and Marlowe(2013) used data collected from Hadza foraging excursion in the years 2005 through 2009 to examine the causes of food sharing. They found that the best hunters provided 3 - 4 times more food to their families during these excursions. Unlike previous claims, Wood and Marlowe did not find evidence that hunting is merely a status-seeking activity. They also found that large animal hunting benefited the hunter's households during primary distributions, and that the hunter's wives and offspring ate significantly more of what they brought back than other women or children. Hadza men used the foods they brought home to provision their wives and kin. Hadza married men brought food back to camp more frequently than single men, and married men with children brought home the most food the most frequently. Married men with children were also more likely to bring home fruit. These findings show that men, when faced with a tradeoff between investing resources in potential future offspring with other mates, and investing resources in current offspring and mates, Hadza men will choose the latter. This echoes similar findings in these analyses, where better Ust'-Avam hunters have better reproductive success, but fewer opportunities to invest in acquiring other mates.

Allen-Arave, Gurven, and Hill (2008) observed 380 complete household food distributions, and 635 incomplete food distributions among the Ache in Arroyo Bandera. They found that relatedness between households predict food sharing between households, and that this bias was consistent with kin selection theory. They also found that the only significant predictor in the model was the difference in household production ($t_{252} = 4.41$, $p < 0.0001$). Something other than inclusive fitness leads better-off households to share with worse-off households. Allen-Arave et al. (2008) also found a significant, positive correlation between households within the same production class.

They concluded that across all levels of relatedness, households displayed dyadic contingency. Ache households were more likely to share with kin who will reciprocate, rather than kin who will benefit more greatly. These results suggest that contingent reciprocity occurs between close kin. In Ust'-Avam, similar findings suggest a level of contingent reciprocity among kin. There is also a level of contingency occurring between highly skilled households.

Koster (2011) examined 35 households among the Miskito and Mayanga horticulturalists of Nicaragua. His findings noted that kin are likely recipients of exchanged meat, and that households that gave a lot tend to receive less than households that give little. He stated that there is a negative relationship between exchange and distance. There was little relationship between the exchange matrix and differences in household production ratios – that is, households with lower production index did not necessarily receive more. However, there was a relationship between households' production of meat and fish and how much meat and fish they distributed to other households, and households with fewer meat and fish resources receiving more from households with greater resources. Koster summarized that resources flow from households with more meat to those with little. He concluded that many of these transfers occur in mother-offspring dyads. Koster cautioned that researchers need to distinguish between kin provisioning and tolerated theft. He found little evidence of reciprocity among the Mayangna and Miskito. While Koster's analysis found little reciprocity in the community, unlike the analysis of Ust'-Avam inter-household meat transfers, he did stress the importance of model multiplicity.

Ziker and Schnegg (2005) looked at inter-household food sharing at meals in the community of Ust’-Avam. A sample of 50 households, with 84 household dyad combinations, was analyzed. The authors used QAP matrix correlation to examine relationships between relatedness, distance, number of hunters in the households, and difference in age. They concluded that provisioning of kin was the most common form of inter-household meals, and that asymmetrical relationships were more common among kin. Reciprocal hosting occurred between related households, and reciprocity did not occur as commonly between non-related households. Ziker and Schneggs’ findings mirror those in this analysis – multiple models of food sharing are at work, most significantly reciprocity and kin selection. Furthermore, reciprocity often occurs within kin selection.

Nolin (2010) used exponential random graph modeling to test food sharing hypotheses of 317 households in Lamalera, Indonesia. He collected information on households and their sharing partners – those with whom they shared most frequently, resulting in 3,111 ties. Nolin found reciprocity, kinship, and distance predicted whether a household will give food to another household. When included with kinship and distance, reciprocity did not explain much more variance in food-transfers. Reciprocity was correlated with both kinship and distance. Nolin examined distance and its effects on predictions of food sharing, which was not done in this analysis. Families mostly reside in somewhat limited government housing in Ust’-Avam (Ziker, p.c. 2014). Some families occupy very small apartments, and will take what larger housing is available, despite distance from relatives. Also, the village is very compact, which might decrease the effect distance may have on village interactions.

Nolin (2012) again used exponential random graph modeling, but to answer a different question – does sharing-as-signaling predict inter-household food transfer relationships? A sharing network of 317 households was examined along with variables representing their wealth and status. Nolin found wealthy households gave food less frequently to other households, but received food more frequently, after controlling for dyadic reciprocity and differences in household production. Interestingly, higher-status households gave and received more food transfers than households of lower status. Households of men in leadership positions were more likely to reciprocate when given food. Excessive sharing by households with leaders is congruous with the predictions of sharing-as-signaling, but is mitigated by other variables in predicting food-transfers. Much of the sharing explained by sharing-as-signaling may be explained by other factors. Nolin concluded that this analysis provided evidence for multiple adaptive mechanisms of cooperation operating simultaneously.

Kaplan and Hill (1985) tested four models as adaptive mechanisms for food-sharing using data collected from the Northern Ache in Paraguay. These models were kin selection, tit-for-tat reciprocity, tolerated theft, and cooperative acquisition. Observations of Northern Ache foraging trips and consumption were made from October 1981 through May 1982. The results of their tests supported the tit-for-tat reciprocity and tolerated theft models of food sharing, but suggested kin selection as a mechanism for food sharing was not supported. These results are unlike many others summarized here, including my own analysis, in that kin selection appeared to play no role in why Ache hunters shared food.

Smith and Bliege Bird (2000) observed turtle hunting and feasting among the Meriam of Torres Strait. They provided a preliminary framework with which to view instances of sharing as examples of costly signaling. The Meriam hunters provided turtles for feasts, and had little control over the distribution of the turtle meat. Smith and Bliege Bird judged that the sharing is an honest signal of the abilities of the hunter: it is costly; unlikely to be reciprocated; a true signal in that it reaches a broad audience; and seemed to benefit both the signalers and the hunters. These are the four conditions listed that needed to be met in order to consider costly signaling as an avenue of cooperation. After putting for their hypothesis of the feasibility of a costly signaling model, Smith and Bliege Bird suggested future publications provide empirically testable hypotheses, and allow their framework to be tested. Sharing in Ust'-Avam does not necessarily meet the four requirements for costly signaling since the 'signal' is one that can easily be reciprocated, and hunters have much more control over the distribution of their game. Hunting in Ust'-Avam also appears to occur more regularly than the turtle-hunting in Meriam. Gurven et al. (2000) proposed one reason the Ache share food from their hunts is so that they receive food when they are sick or injured. Researchers proposed this sharing occurred to signal cooperative intent, and they received more shares when unable to hunt due to health issues than those who shared less. They analyzed this by looking at 380 food distributions and recording donors, recipients, and package sizes. They also surveyed individuals on the last time they were unable to hunt from sickness or injury. They found that philanthropic and means-well classified individuals received more shares when they were sick than greedy and ne'er-do-well individuals (these classifications were dependent on the amount of food produced in relation to the amount of food shared by the individual). These results led Gurven et al. to argue that long-term payoffs in food sharing may compensate for short-term costs. This generosity is similar to the results I noted earlier in food-sharing: unidirectional food transfers were occurring between households, most likely as generosity signaling.

Gurven (2004) tested models of sharing based on non-tit-for-tat reciprocity as risk reduction, and tolerated scrounging using data collected from the Hiwi and the Ache. Information about package size, amounts given to recipients, number of recipients, and number of successful hunts and hunters on a given day was recorded to test Gurven's predictions. These predictions were designed to test both sharing breadth and depth, and were derived from assumptions of the diminishing marginal value of food packages. He found that variable, large packages were shared more than smaller, more consistently acquired packages. Gurven also reported contingency between donor and recipient individuals. Although he found evidence of reciprocal altruism as a mechanism of food sharing, he stressed its importance not as a single model for explaining variation in food sharing, but rather as an important contribution alongside other models. Gurven stressed the importance of the marginal value of food in testing food sharing models. I did not examine diminishing marginal value of food shared from hunter's food packages.

The results from my analyses, as stated before, support evidence of more than one model of food sharing explaining the variance in transfers. This is an important point that needs to be stressed – multiple models of food sharing may be working as adaptive mechanisms of cooperation in a society at a given time. Multiple models may explain differing amounts of variance in food transfers between individuals and households. However, between societies the importance of kin, reciprocity, generosity, and costly signaling differ greatly. For example, in Ust'-Avam, there was little supported evidence of costly signaling, but there was evidence for this model among the Meriam (Smith and

Bliege Bird, 2000). Not only does the applicability of these models vary across societies, different factors such as distance vary between societies. Distance was an important factor in explaining variance in food transfers in Lamalera (Nolin, 2010), but Ziker has hypothesized it plays no noticeable role in meat and food sharing decisions in Ust'-Avam (Ziker, p.c. 2014). Neighborhood as a proxy for distance did significantly predict reciprocated food sharing at meals (Ziker and Schnegg, 2005), but did not significantly predict unreciprocated food transfers. Societies, communities, and individuals differ in how they share food, and the mechanisms behind that decision also vary.

Reproductive Success and Wealth

The results of the analysis of Ust'-Avam hunters' reproductive success show that men who spend time investing in their own wealth – embodied, material, and relational – are also more likely to reproduce earlier and have more offspring. Men have the choice to either invest in their education or invest in their hunting skill acquisition – men who choose to invest in education are probably more likely to leave the community to find work or continue their education at university in the city. Men are faced with a choice: do they choose to invest their time into acquiring traditional skills such as hunting, trapping, and fishing, or do they seek employment elsewhere?

Irons (1979) was one of the first to test the influence of cultural success on biological success by analyzing the Yomut Turkmen. The numbers of offspring for every adult were counted, and their land and cattle holdings were recorded. He found that wealthier males experienced greater reproductive success, and that variation in male fitness is greater than female fitness. Possible reasons that wealth positively affected reproductive success were that families of wealth males were better fed, and wealthy men were frequently polygynous.

Kaplan, Hill, et al published data on male Ache foragers and reproductive success (1985). Few studies had been conducted that attempted to predict, or even measure, reproductive success in hunter-gatherer societies. Over the course of five years, information about Ache food acquisition, time allocation, and food distribution had been collected. The researchers found that there was no correlation between hunter acquisition amount and the amount his family ate. This led them to ask, how would hunter skill be favored by natural selection? Possible explanations as to why skilled hunters would hunt, and subsequently share, include better alliances, greater access to mates, and bias towards their offspring. Three predictions were made to test these questions: better hunters would have better RS, they would have more extramarital affairs, and they would have more offspring result from these affairs. They found good hunters were reported to have more extramarital affairs and that good hunters had more illegitimate children ($p < 0.05$). The better Ache foragers had better reproductive success. There were a few problems with this preliminary study. The researchers did not control for age, and they had a very small sample size. Older hunters may have had the chance ot have more offspring by virtue of having a longer reproductive career. They did not have complete genealogical information about hunters and their offspring. The Ache were investing resources into future potential reproductive opportunities with other women.

Borgerhoff-Mulder (1987) studied the effects of wealth on reproductive success among the Kipsigis of Kenya. A positive correlation between wealth and reproductive success indicates a connection between the two. Reproductive variance in Kipsigis men was due mostly in part to polygyny and increased access to women. Wealthier men were found to marry at younger ages than poor men. They were also found not to provide abundant resources for their offspring. These findings indicate that the Kipsigis men were not investing in their current offspring, but rather investing in acquiring wealth to gain access to additional wives, and have more children.

Cronk (1991) studied the relationship of wealth and status with reproductive success among the Mukogodo. The society is poorer than their neighbors, and its members have a decreased ability to acquire additional wives. Livestock wealth and male reproductive success are correlated positively, controlling for age. This reproductive success seems to be facilitated by polygyny, and the access to additional wives wealth gives a Mukodogo man. There are no correlations between reproductive success and wages or education. These results are similar to those from Ust'-Avam – education and income were not significant predictors of male RS, but embodied and material wealth were in the forms of hunter skill and the hunter material wealth scale. However, polygyny is not practiced in Ust'-Avam, so another mechanism is most likely facilitating the increase in offspring.

In Ust'-Avam, there are no records of extra-marital affairs. Marriage dates were not collected, and birth of a child is used as a proxy. The community is socially monogamous, and there is little information about extramarital affairs. Among the Mukogodo, Kipsigis, and the Yomut Turkmen, increased reproductive success was facilitated by greater access to women. There is little evidence to indicate that men and women in Ust'-Avam are engaging in greater amounts of extramarital affairs. Better and wealthier hunters are more likely to have greater numbers of children through provisioning.

Conclusion

In the food sharing study, different measures for need could have been included and tested. Many researchers have used different proxies to establish need. For example, counts of children under the age of 5 could have acted as a proxy for need by indicating increased levels of consumption in that particular household.

As is, these studies provide valuable insight into what hunters do with the food they bring back to the village – do they share it or do they keep it? Furthermore, why do they share? The findings of both analyses lend information to the growing bodies of knowledge about these subjects in HBE. While Ust'-Avam men do not share for reasons consistent with hunters in other societies, they are sharing patterns are not wholly unique, either. Instead, these patterns echo what more recent studies are saying – that multiple mechanisms are operating simultaneously in communities and facilitating cooperation. That food sharing often operates within the bounds of kin selection and reciprocal altruism is a common finding, and that reciprocal altruism occurs often between kin is another. I think what is a more unique outcome here is: 1) kinship operating alongside controls for kinship * reciprocity and reciprocity * sum of skill; and 2) generous transfers controlling for kinship, reciprocity, sum of skill and interaction terms, AND frequency of receiving in another currency.

In regard to the second analysis, even in more (not necessarily fully) egalitarian hunter-gatherer societies, wealthier and more skilled men exhibit greater reproductive success. Does this increased fitness result from men having more children with different women, or from men having healthier children with the same woman? Another way of looking at this tradeoff is do wealthier men spread their resources among many different offspring, and women in hopes of gaining increased reproductive access? Or do they focus these resources on providing for their current offspring and ensuring they survive to reproduce? The men in Ust'-Avam tend to invest more in their current offspring. However, as discussed earlier, in some societies men increase their fitness through polygyny, such opportunities are limited in Ust'-Avam. These studies have furthered current academic debates about these subjects, and provided information that can be included in future comparisons.

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