# EXPLORING COOPERATIVE BEHAVIORS AMONG THE SENA OF GORONGOSA NATIONAL PARK, MOZAMBIQUE AND THE DOLGAN/NGANASAN OF UST'-AVAM, SIBERIA

by

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# ABSTRACT

Why do humans cooperate? Mechanisms including inclusive fitness, reciprocal altruism, indirect reciprocity, and costly signaling provide explanations for human cooperation and partner choice. Using data from the Sena people of Gorongosa National Park, Mozambique and the Dolgan/Nganasan of Ust'-Avam Siberia, I examine several questions relating to cooperation. During a preliminary study, interview and observational data was collected that provide insight on the day-to-day activities of 33 households in Gorongosa National Park. Cooperative activities include cooperative socializing, play, cooperative breeding, and household labor. It was found that most daily activities observed were done solitarily and men were most likely to be participating in the cooperative activities. A social network analysis of cooperative hunts among the Dolgan and Nganasan allowed me to test the influence of relationship type, reciprocity, and centrality on partner choice and hunting returns. Hunters were more likely to choose kin and friends as partners, and these relationships had greater reciprocity than neighbors and acquaintances. Hunters with high outdegree centrality and betweenness centrality had greater production per capita hunting returns. These outcomes are consistent with inclusive fitness and reciprocal altruism, and the benefits associated with cooperation.

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| | |
|---|---|
| CST | Costly signaling theory |
| GNP | Gorongosa National Park |
| KG | Kilograms |
| MRQAP | Multiple regression quadradic assignment procedure |

# CHAPTER ONE: INTRODUCTION

## Evolution of Cooperation

Cooperation involves two or more individuals acting together, sharing a common goal, and receiving benefits that increase survival and reproductive success (Bailey, Myatt, and Wilson 2013). In evolutionary studies, the emergence and stability of large-scale cooperation among unrelated individuals is a prominent research problem, especially when the risk of being exploited by one's cooperative partner is non-zero (Axelrod and Hamilton 1981; Sosis 2000b; Bshary and Bergmüller 2008; Nowak 2006; Boyd and Richerson 2009). Examining such risks and benefits in a variety of socio-environmental contexts is important to understanding the social behavior of humans. Cooperation among social mammals tends to occur mainly between related individuals (Nowak 2006). My broader research question is why would human individuals behave in a way that increases the fitness of another if selection favors behavior that maximizes one's own fitness (Bshary and Bergmüller 2008)?

For the emergence and stability of cooperative behaviors to occur, the benefits of cooperating must outweigh the costs. If the alternative to cooperative behaviors is working alone, then we would expect that cooperative benefits (minus possible costs) would have to outweigh the benefits of solitary behaviors (minus their costs) (Sosis 2000b). Sosis (2000b) examines this prediction, comparing cooperative and solitary behavior by calculating the mean per capita net return rate of *n* (foraging group size) and the mean per capita net solitary return rate to find which one yielded a higher return rate.

Sosis (2000b) argued that the stability of cooperative foraging over solitary foraging depends on the net return rates of cooperative foraging being consistently greater than those from solitary foraging. Sosis' (2000b) hypothesis that the mean per capita net cooperative sail-fishing production would be higher than the mean per capita net solitary production was supported. This finding reflects why the emergence of cooperative behaviors occurs. For stability to occur, the net benefits of cooperative foraging have to be greater than the net benefits of solitary foraging (Sosis 2000b). The stability of cooperative fishing on Ifaluk occurred through five types of distribution patterns which consisted of canoe-owner, village-level *ilet*, atoll-level *ilet*, fishermen distribution, and men's feast. Of these distribution patterns, canoe-owner, village-level, and atoll level are the primary types of distribution since they never co-occur, but nearly all recorded sharing events includes one of these types (Sosis 2000b). Solitary fishing typically occurred from the compound since using a boat typically required more than one person, but it also limited the fish available and some of the fish caught this way were taboo for the women (Sosis 2000b). Cooperative fishing allowed greater access to resources for Ifaluk both in quantity and for distribution purposes (Sosis 2000b).

Cooperation involves investing in individuals and having that behavior returned by the individual(s) invested in (Bshary and Bergmüller 2008). If the behavior is not returned, then the initial cooperator now has provided a resource without receiving anything in return (Bshary and Bergmüller 2008). The possibility of being 'cheated' is a risk that makes cooperation hard to maintain and may explain why we see low levels of cooperation among non-kin in many non-human species. In species such as humans where non-kin cooperation may be important in some contexts and no other we would expect to see the evolution of conditional cooperative strategies, where an individual is able to assess the expected risks and payoffs of working alone or with others (Bshary and Bergmüller 2008).

A large impetus in evolutionary studies of cooperative behavior is examining the evolutionary mechanisms supporting the maintenance of cooperative behaviors (Patton 2005; Gurven 2006; Jaeggi and Gurven 2013; Ziker, Rasmussen, and Nolin 2016). Mechanisms commonly discussed are inclusive fitness or kin selection, reciprocal altruism, indirect reciprocity, and costly signaling (Hamilton 1964; Trivers 1971). Kin selection explains altruism (a behavior that benefits the recipient and is costly to the actor) in terms of inclusive fitness, where the benefits that extend to the recipient improve the actor's indirect fitness, resulting in cooperation instead of altruism (Hamilton 1964; Trivers 1971; Bshary and Bergmüller 2008). In fact, reciprocity is seen as the main driving force for cooperation in humans (Jaeggi and Gurven 2014). Comparatively, reciprocal altruism involves two or more non-kin and reciprocity is typically delayed (Trivers 1971).

### Inclusive Fitness

As previously stated, kin selection has been viewed as the primary form of cooperative interaction between social mammals (Hamilton 1964; Nowak 2006; Hames 2015). Primates such as baboons, vervets, and gorillas rely heavily on kinship for social networks, grooming practices, aid in combat, and dominance relationships or hierarchies (Trivers 1971; Hames 2015). The costs for cooperating can be offset by the benefits to kin discounted by the coefficient of relatedness (Hamilton 1964; Axelrod and Hamilton 1981). According to Hamilton's rule, as the relatedness gets closer to zero, the likelihood of nepotistic behavior also approaches zero (Hamilton 1964; Alvard 2009). In other words, nepotistic behavior should occur more often as genealogical relatedness increases (Alvard 2009). As an example, Alvard (2009) studied whale hunting by people in Lamalera, Indonesia, and compared his findings to a reanalysis of Napoleon Chagnon's axe fight among the Yanomamo of Venezuela to determine to what degree did kinship play a role in the organization of cooperative groups in these two diverse societies. Among the Yanomamo, genealogical kinship was the main organizing factor for the coalitions that formed in the axe fight. Alvard (2009) acknowledged that relatedness does not account for all aspects of the social behavior exhibited among the Yanomamo, who were predominantly forager-horiculturalists. The results showed that members within their own faction were more closely related to each other than the members of the opposing faction (Alvard 2009). On the other hand, Alvard (2009) found that lineage (i.e., group descent) affiliation played the largest role in the organization of whale hunting groups in Lamalera lineage. Lamalerans are predominantly complex marine foragers who rely on cooperative hunting for large game such as sperm whales and rays in large quantities. Hunters who participate as well as lineage members are guaranteed their shares from the hunt through a complex and mutually agreed upon set of food distribution norms (Alvard 2009). The larger the group is, the less likely they are to be closely related to one another (Alvard 2009). Foraging and hunting in certain areas and/or for specific prey require larger group sizes and the optimal size for a group is difficult to achieve with high degrees of relatedness (Alvard 2009).

In Paraguay, foraging bands among the Ache typically consist of seven to nine individuals (Janssen and Hill 2014). Out of these seven to nine individuals, more than half are unrelated. However, based on agent-based modeling, seven individuals in a group were found to be the optimal group size since there was a balance between average daily harvest and risk of a shortfall (Janssen and Hill 2014).

Patton (2005) studied the formation of coalition groups and transfer of meat among members in Conambo, an indigenous community in Ecuador living in the Amazon. Patton (2005) tested six evolutionary explanation for meat sharing which included kin selection, reciprocity, tolerated theft, coalition support, costly signaling, and show off-hypothesis. Nepotism was found to be a prominent influence in meat transfers. He stated this was due to the lack of generalized sharing norms which discourages targeted meat transfers to kin, reciprocators, and allies (Patton 2005).

Inclusive fitness theory has been used to explain cooperative behaviors such as food sharing and distribution (Betzig and Turke 1986; Ziker 2003, 2007; Ziker and Schnegg 2005). Relatedness has been found to be a strong indicator between food sharing households (Betzig and Turke 1986). In the same study, it was found that if food sharing households were a greater distance apart, the relatedness between households would increase to compensate for the cost of transporting the food as predicted using Hamilton's Rule.

In sum, inclusive fitness has been shown to be a prominent explanation for cooperative behavior including food sharing and organization of coalition across multiple groups (Betzig and Turke 1986; Ziker 2003, 2007; Ziker and Schnegg 2005; Patton 2005). However, genealogical relatedness may not be the strongest explanatory variable in explaining the organization of larger groups which are needed for procuring larger resource packages and usually decrease in relatedness (Alvard 2009). In addition, where costs and benefits are low, or do not help to ameliorate risks in the environment, inclusive fitness is not sufficient to organize human cooperation (Trivers 1971; Alvard 2009).

### Reciprocal Altruism

Reciprocal altruism refers to two or more individuals who choose to work with one another if the costs at the time of the cooperative interaction are lower than the expected benefits that result (i.e., delayed returns) (Trivers 1971; Hames 2000, 2015; Ziker 2003, 2007; Ziker and Schnegg 2005). The evolution of reciprocal altruism depends on the preconditions of organisms having longevity, low dispersal rate or reduced movement, and mutual dependence (i.e. which can increase the likelihood that individuals are cooperating with close kin) (Trivers 1971, Bshary and Bergmüller 2008). Reciprocal altruism has also been associated with extended periods of parental care, the lack of a “strong linear dominance hierarchy”, and aid in combat (Trivers 1971).

Several studies have examined the role of reciprocity in human food sharing (Ziker and Schnegg 2005, Ziker and Fulk 2018, Hames 2000, Alvard 2009, etc.). Reciprocal altruism among the Yanomamo is described as fairly balanced (Hames 2000). Families share food with other families, and the flows are not necessarily equal, but are based on relative need and productive ability (Hames 2000). Kaplan and Hill (1985) found that individuals who choose to engage in reciprocal food sharing have higher nutritional status among the Ache of Paraguay. Reciprocal food sharing also has the potential to significantly reduce day-to-day variation in individuals’ consumption and serves as a subsistence strategy for family provisioning (Kaplan and Hill 1985; Gurven 2006).

Ziker's analyses (Ziker and Schnegg 2005; Ziker, Nolin, and Rasmussen 2016; Ziker and Fulk 2019) of food sharing in Ust'-Avam, an indigenous community in northern Siberia, found that kinship, reciprocity, as well as an interaction between kinship and reciprocity were the predominant factors structuring food sharing. Ziker and Schnegg (2005) hypothesized that clusters within cooperative networks are created when kinship and reciprocity interact in the care of children of extended households. Ziker, Nolin, and Rasmussen (2016) show an interaction between reciprocity and hunting skill of partners. As reciprocity increases, there is also an increase in the skill of hunting pairs. This finding is consistent with risk buffering as support for reciprocal altruism. Ziker and Fulk (2019) conducted a social network analysis using the diaries of women in Ust'-Avam. They found positive correlations between interhousehold relatedness and food sharing, and food sharing and the interaction of interhousehold relatedness and reciprocal sharing (Ziker and Fulk 2019). In their last model, with kinship and the interaction effect controlled for, there was still a positive relationship with reciprocal sharing.

### Indirect Reciprocity and Tolerated Scrounging/Theft

When one individual aids another despite receiving no direct reciprocal benefits, they may be doing so to receive indirect reciprocal benefits. For example, one hunter may help another hunter because the second hunter will help out someone else who might in turn aid the initial hunter (e.g., Person A to Person B to Person C and back to Person A) (Alexander 1987; Boyd and Richerson 1989).

Boyd and Richerson (1989) tested two models of the evolution of indirect reciprocity including the first model in which the participant helps someone else without knowing if that person will help someone else, and the second model in which the first individual may know that the person they are helping will also help someone else. It was found that indirect reciprocity heavily relied on the information available to the participants (Boyd and Richerson 1989).

Tit-for-tat is typically measured over shorter periods of time (Jaeggi and Gurven 2013). For better representation of helping or cooperative behavior, long-term studies provide more insight since individuals who received helped once before are more likely to reciprocate in the future (Jaeggi and Gurven 2013). There are also social norms in place that discourage what is considered selfish (Ziker, Rasmussen, and Nolin 2016). Ziker, Rasmussen, and Nolin (2016) tested generosity as a reason for why one individual may help another without being related or receiving direct benefits. In Ust’ Avam, it is common practice to “give it, if I have it” which is a prominent aphorism in the community (Ziker, Rasmussen, and Nolin 2016). This is most common between neighbors and other non-relatives. Reinforcing these social norms and signaling can create a risk-buffer. Using a matrix regression on interhousehold food transfer frequency, there was a positive effect when controlling for household relatedness and household skill (Ziker, Rasmussen, and Nolin 2016). A negative relationship occurs when the model is controlled for the interaction between household relatedness and skill (Ziker, Rasmussen, and Nolin 2016). A possible explanation is that transfers between unrelated households with low summed household skills were mostly not reciprocal and generous. Additionally, these transfers were not related with differences in household skill and costs of hunting which further suggests generosity as being the explanation of some of these interhousehold food transfers (Ziker, Rasmussen, and Nolin 2016). The Dolgan and

Nganasan have aphorisms that speak to the negative outcomes for being selfish (Ziker 2014).

Although not a cooperative mechanism, there are instances of tolerated theft or scrounging meaning an individual does not receive direct benefits (Kaplan and Hill 1985). When there is competition over resources that are divisible and more valuable to selected contestants (Blurton-Jones 1984; Kaplan and Hill 1985). The contestant who values the resources the most should win (Kaplan and Hill 1985). Depending on the other contestants, the costs of fighting over the resources are greater than the benefits of keeping the resources. The resources become less valuable (Kaplan and Hill 1985).

Among the Ache, food sharing was not found to be the outcome of these contests (Kaplan and Hill 1985). However, Kaplan and Hill (1985) argue that this does not necessarily mean that it did not feel like theft to those who lost the resources. The purposed explanation is that there could be social obligation or pressure to allow the theft. For example, the cost of fighting would be great, but the benefits may include increased nutritional status related with reciprocity (Kaplan and Hill 1985).

### Costly Signaling

Costly signaling theory (CST) proposes that “inefficient” or “wasteful” behaviors are a means of transmitting honest information that benefit both signalers and observers (Zahavi 1975; Sosis 2000; Smith and Bird 2000). The handicap principle is defined as a stable honest signal that is too costly to produce and imitate (Zahavi 1975, Sosis 2000a). The handicap principle has been used to explain the evolution of an honest signal in situations when, among organisms with similar signaling costs, the costs are high enough that only those sending the honest signal can benefit (Smith and Bird 2000).

An example of application of CST in research on human food sharing is torch fishing of dogtoothed tuna on Ifaluk atoll (Sosis 2000a,b). Sosis (2000 a,b) found torch fishing of dogtooth tuna to be an inefficient foraging strategy if the goal is to maximize the rate at which a fisher acquires resources. On average, yellowfin tuna is more profitable than dogtoothed tuna which include days of the ritualized torch-fishing displays. The production rates of trolled yellowfin tuna are also significantly higher than torched dogtoothed tuna (Sosis 2000a). Sosis (2000a) argues that torch fishing is a handicap because it is a reliable way to show a man’s work ethic and provides reliable information for women to assess the productivity of a man for potential marriage. Sosis (2000a) found that nearly half the men participating in torched fishing were already married, but they explained their participation as a display the hardworking traits of their matriline on behalf of the unmarried men of the matrilineage.

CST is an evolutionary mechanism for cooperative behavior that has the potential for explaining an interesting characteristic of a lot of human cooperation: participants do not have to be directly receiving resources in return for their efforts (Smith and Bird 2000; Gintis, Smith, and Bowles 2001).CST can explain certain cooperative behaviors such as individuals sharing a capture with a large group or investing time and energy in costly activities since individuals may benefit from the signaling by being favored as mates or have more allies (Sosis 2000a; Smith and Bird 2000).

## Research Question and Hypotheses

Prior studies on cooperative behaviors, such as group hunting or food sharing, have examined individual decisions to participate in group versus solitary activities, and have attempted to identify the trade-offs associated with the different strategies (Alvard et al. 2002; Sosis 2000a,b). Benefits related to cooperation include improved resource extraction efficiency, hunting large game, access to previously unattainable resources, and decreasing variation in prey capture rate (Bailey, Myatt, and Wilson 2013). Other benefits associated with cooperation include decreasing risks of injury and energy costs (Bailey, Myatt, and Wilson 2013) or potential benefits in terms of mating effort (Sosis 2000a; Smith, Bird, and Bird 2003). On the other hand, costs of cooperation can include investing too much time and energy without receiving sufficient payoffs. For example, group sizes that are too large often have the problem of having to share with more individuals so it is possible to reach a point when it is more costly to the individual to participate in a group hunt (Smith 1991; Janssen and Hill 2014). Individuals are also more likely to cooperate when they can predict future benefit of the interaction or are working with other known cooperators (Axelrod and Hamilton 1981; Alvard et al. 2002; Bshary and Bergmüller 2008).

Individuals are expected to choose cooperative strategies when the benefits of cooperating outweigh the benefits of completing a task alone and are not too costly to the individual (Axelrod and Hamilton 1981). For example, research on whaling activities among the Lamalera found only marginal differences between cooperative whaling return rates and solitary fishing return rates (Alvard et al. 2002). The researchers did acknowledge that could be the result of an “off season” for whaling (Alvard et al. 2002). Nonetheless, if there is no significant difference between group and solitary activities, individuals may choose to work alone to directly increase their fitness (Axelrod and Hamilton 1981).

This thesis will examine questions of cooperation by analyzing data from two larger projects. The first includes a preliminary study in Gorongosa National Park (GNP) examining the daily activities of the Sena people living within the park boundaries and in the buffer zone of one of Africa's greatest wildlife restoration projects. With this data, I explore the following questions:

1. Is there a significant difference in time invested in group versus individual activities?
2. What cooperative activities are more frequently observed?
3. Is there a significant difference in cooperative and solitary activities based on gender?

If the benefit for cooperative activities is a savings in time and energy, resulting in increased per capita production, then it is hypothesized that cooperative production would be preferred over individual production. Certain activities may also be dependent on cooperation since they may include tasks that would be either difficult or impossible to complete alone (cf. Alvard et al. 2002). Across several societies, males and females from the same household have been shown to have different roles and different subsistence strategies. Gender differences in productive activities might be advantageous to the household if men and women are provisioning different types of resources with differing risk or cost profiles (Bird 1999). The data from GNP speaks to the questions of individual and cooperative activities and differences in activities of men and women.

The second part of this project includes data from the larger project titled, "The Behavioral Ecology of Food Sharing among North Siberian Foragers," funded by the Max Plank Institute for Social Anthropology and the L.S.B. Leakey Foundation. As part of this study, John Ziker collected data on 77 hunts in Ust'-Avam in 2001 and 2003. Ziker, Nolin and Rasmussen (2016) and Ziker (2007) focused on the hunters' distribution of meat and fish in the community once the hunters returned from the hunt and Ziker and Fulk (2019) focused on subsequent distributions. For this thesis, I will use the data on the division of meat and fish among the hunters at the conclusion of the hunts (i.e. the primary distribution) which had not been analyzed until this thesis. Using social network analysis techniques, I examine the hunters who participated in cooperative hunts (i.e., groups consisting of 2 or more individual hunters). The meat and fish produced, divided, and taken by each of the hunters provides empirical data on the productivity of cooperative hunting.

Ethnographic data on the Dolgan and Nganasan reported that cultural norms encourage cooperation and sharing in food production, distribution, and land use (Ziker 2002; Ziker and Schnegg 2005). For this study, the focus is on the primary distribution. The primary or 'first' distribution is one of the three identified phases of food sharing for hunter-gatherers and is defined as the obligatory sharing at the end of a hunt to those who participated either directly or indirectly (Ichigawa 2005). As previously stated, food sharing patterns among the hunters provide insight to the costs and/or benefits associated when multiple hunters are involved (Smith 1991; Ziker and Schnegg 2005). If individuals are hunting with members of their kin, they are working to increase their fitness. Similarly, individuals identified as "friend" or "neighbor" may also receive benefits of hunting in a group (i.e. greater resource acquisition, access to unobtainable resources when hunting individually) and possible future interactions (i.e. being invited to a future hunt).

This dataset has the benefit of including social network data, so information about a per capita production means and relationship to other hunters allows for an examination of how relative involvement in cooperative production activities relates to productivity. Social network models have two important measures: degree centrality and betweenness centrality. Centrality is defined as the importance of a node in a network (Borgatti et al. 2018). How 'importance' is defined can vary depending on the centrality measure. In other words, it can be based on position in the network, number of ties connected to a node, or any other property or attribute of a node in a network (Borgatti et al. 2018). Degree centrality is defined by the number of ties a node has (Borgatti et al. 2018). In this case, it would be the number of identified relationships one hunter has to other hunters in the network. High degree centrality (see Chapter 3 for further explanation) has been associated with 'important' members of the network which could indicate 'better' hunters (Borgatti et al. 2018; Bird and Power 2015). Betweenness centrality is defined as the number of times a single node is on the shortest path between two other nodes (Borgatti et al. 2018). This would be the hunters that connect two other hunters in this network. High betweenness centrality (see Chapter 3 for further explanation) can indicate a level of 'importance' in the network since this individual has the "potential to control the flows of the network" (Borgatti et al. 2018, p. 201).

Based on a previous study conducted by Bird and Power (2015), if high degree centrality is important to success in cooperative hunting, then I would expect greater production to correlate positively with degree centrality. Having more ties in the network can be an indicator of someone who is highly cooperative in the network and thus has access to greater resources or is invited along to more hunts. Although, it was observed that the Martu hunters would cook their catch, then do an initial division between the participating hunters, or each participating hunter distributes prey to other consumers (Bird and Power 2015). It is difficult to see all primary distributions, since this stage of food sharing is typically done before hunters return to camp whereas the secondary distributions (i.e. hunter to consumer) are more public (Bird and Power 2015).

High betweenness centrality should also be positively correlated with greater production since these individuals potentially have significant influence on the flow of resources and connection between other nodes (i.e. hunters) in the network (Borgatti et al. 2018). Using the preexisting data set on the Siberian hunters, I will answer the following questions:

1. Which relationships are significant for hunter cooperation?
2. What is the reciprocity of these relationships? Are there any interactions between reciprocity and these relationship types?
3. Is there a correlation between resource production and degree centrality?
4. Is there a correlation between resource production and betweenness centrality?

Chapter 2 of this thesis will consist of an ethnographic study of the Sena people of GNP followed up by analyses of observed cooperative and/or solitary behaviors. In chapter 3, data from John Ziker on the Dolgan and Nganasan of Ust'-Avam will be used in a social network analysis to examine patterns in the primary distribution of meat among hunters. The conclusion, Chapter 4, will discuss results, limitations, and future research possibilities.

# CHAPTER TWO: COOPERATIVE BEHAVIOR AND SOLITARY BEHAVIOR AMONG THE SENA PEOPLE OF GORONGOSA NATIONAL PARK (GNP), MOZAMBIQUE

## Field Research

Gorongosa National Park (GNP) is located in the northern Sofala Province in Mozambique. The park's main objective is to conserve ecosystems and biodiversity (Lynam, Cunliffe, and Mapaure 2004; Walker 2017). The park also has an extensive science department with labs and other facilities, science personnel, and cooperative research agreements with a number of universities internationally, including Boise State University.

The field visit in which the data for this thesis was collected took place in June of 2018 during the early dry season and in the middle of the harvest. In the initial proposal, the goal was to visit four communities. Based on the recommendations of park professionals, who are familiar with communities living in and around the park, three communities were selected, and each inhabiting a distinct social-ecological micro-region. Community A was a small community located along a small watercourse in foothills of the East plateau. Community B was located in savannah woodlands at the floor of a rift valley. Finally, Community C was a large, dispersed community located on the Western plateau and closest to a town, Villa Gorongosa. John P. Ziker, Nicole Herzog, and I spent three days in each community conducting interviews and collecting observational data. Mateus Dapitaia, a translator and interpreter, was present for all interviews.

We collected data through semi-structured interviews (Appendix A), instantaneous sampling, and focal follows. Semi-structured interviews allowed us to collect demographic data, along with detailed information on subsistence strategies and cooperative behavior. The interview questions included demographic information (e.g., gender, age, marital status), number and type of domestic animals and plants on the compound, use of fire, and subsistence decisions, including those related to foraging, farming, and hunting. Since the interviews were semi-structured, occasional follow-up questions were asked.

Once consent was granted from the individual, behavioral data was collected through a combination of instantaneous scan sampling and focal follows (Altmann 1974; Paolisso and Hames 2010). Scan sampling was done in time intervals of 10 minutes with an observational window of 3 minutes. Focal follows were conducted if an individual agreed, and any behavior and/or movement was recorded during the follow. Follow times varied depending on the individual.

All behavioral scans and focal follows were recorded using a combination of a customized CyberTracker template and handwritten notes. With CyberTracker (http://www.cybertracker.org), it was possible to record data more efficiently by downloading the software onto a smartphone or mobile device, and then exporting that data to statistical software for analysis. Observed behaviors were coded as: active land management (plowing, land tillage, cutting vegetation), foraging (hunting, gathering, harvesting), travel, and other (meal preparation, resting, socialization).

Using SPSS 24, I examined the frequency of daily behaviors and ran statistical analyses on the amount of time engaged in different behaviors. Doing a time allocation study provided a better understanding of daily activities - including the frequency and duration of certain behaviors. Specifically, we coded what the behaviors were (i.e., foraging, travel, and other) and whether that behavior was done with others or done alone. It was possible for a person to engage in multiple activities simultaneously, but we defined their behavior based on what seemed to be the primary purpose. For instance, a mother may be observed cooking as well as caring for a child. Even though these behaviors were occurring simultaneously, we would select the behavior that was the primary purpose or which one the individual was visibly putting more energy into. This potentially provides information as to what behaviors are more time consuming based on what the behavior was, and which ones required more than one person to accomplish.

I examined whether women tended to cooperate more in their daily activities than men do. I also was interested in whether differences in cooperative behavior were related to the type of activity (e.g. household labor, cooperative breeding, cooperative play, etc.). I expected more cooperative behaviors to be exhibited by women, since both women and men seem to participate in subsistence maintenance, but women in this community seem to also have the additional responsibility of childcare.

## Descriptive Statistics of the Sena People

We visited a total of thirty-eight compounds/households. The average number of individuals living on a compound is ten. The average number of children living on a compound is eight. These households typically consisted of parents and children. Some outliers to these included compounds consisting of one individual who was in the process of moving so his family already lived on a different compound and one man with six wives and had approximately forty individuals living on the same compound. Polygyny was not unheard of in these communities, but some individuals expressed that is expensive to have more than one wife currently. Of the thirty-eight households, twelve reported to be polygynous. Seven of the men had two wives, two men had three wives, two men had four wives, and one man had six wives.

The average number of huts on a given compound was between five and six. The maximum number of huts on a compound was thirteen and the minimum was one. However, different huts served different purposes. Some were designated kitchens, silos, living quarters, or meeting huts. Huts were constructed using mud or concrete. Materials for the roofs included grass and metal.

## Ethnography of the Sena People

The Sena people are horticulturalists. During interviews, we learned that hunting was prohibited by the park at present, though it had been a common subsistence activity in the past. Most individuals relied on their domesticated food and foraging for wild plant food (e.g. fruits, roots) for sustenance. Some of the more common domesticated plants included maize and sorghum, as well as sesame. Some of these foods were grown as cash crops rather than for direct consumption. People also grew a wide range of vegetables and fruits that varied depending on the community and household. Domesticated animals mainly consisted of chickens, pigs, ducks, and goats. Other domestic animals included dogs, cats, guinea fowl, guinea pigs, pigeons and two households reported that they farmed fish. Although dogs and cats were commonly found on compounds, they were often not included in their answers when asked, “What animals do you raise?” This could be because they did not see dogs and cats as valuable since they did not directly profit from them and were mainly used as security or to clean the compound of scraps.

We were also interested in collective or cooperative behaviors around fire use, since in many places' horticulturalists use fire as a landscape management tool. However, most of the indigenous people living in the communities within the park boundaries and in the buffer zone reported that starting fires was discouraged by the park and were reluctant to share information regarding these practices. It is not unheard of for fire policies and regulations to be in place to prevent fires for conservation purposes (Laris 2002). A prevalent view is that too much burning occurs and, as a result, anthropogenic burning in indigenous communities is seen as harmful for the environment and conservation efforts (Laris 2002). Individuals living in these communities stated the nearby park rangers prohibited burning of any kind and anything related to burning (e.g., collecting firewood). There were only a few households that did report using fire to keep wildfires away from their homes and/or to clear fields.

This restriction was a great concern to them since this meant that they could not create fire barriers. Most of their huts were made of grass and easily burned from other fires that occurred, especially in the dry season. The emphasis on this concern aligns with the most reported reasons for burning previously stated by communities located in West Africa (Laris 2002).

The fire practices that were said to occur, and what was observed, were those mainly used to provide warmth and for cooking purposes. Based on our observations, there was little to no evidence of burning fields or starting fires in the bush around these areas. It is possible that burning was occurring in other areas and that they were reluctant to share this information with us, but, as we were walking around in the community and between compounds, there seemed to be very little evidence of burning.

Once this information regarding the restrictions arose, we inquired about past burning and hunting practices. Respondents expressed that these practices were previously widespread. Burning had been used for hunting and to keep larger wildfires away from their homes. One household mentioned that past hunting practices typically included four to five men from the same community participating in a hunt and sharing the acquired meat.

For everyday activities, we asked questions, such as, did they share resources, who helped with activities, did they hire workers, among other questions that would indicate if daily activities were typically done alone or in groups to address cooperative practices in the community. We observed a pattern of individuals either doing the work alone or limiting it to the family living on the compound. Some of the households reported that they used to hire workers or would hire workers if they could afford it. Certain activities also seemed to be done in groups. For example, one head of household mentioned that his wife would go forage for roots with her family/friends as a group. Since this behavior was not directly observed by us, it is unclear if this qualifies as cooperative activity since we cannot determine how frequently this type of group foraging occurs. Most of the foraging behavior observed was done alone. Perceptions such as these contradict some of our observations. As another example, we witnessed neighbors coming to the aid of one another in processing maize (e.g. shucking, grinding) as well as general aid in other chores. It is difficult to say if this behavior is an everyday occurrence or as a result of our presence. Regardless, it was apparent through interviews and observations that most cooperative activities were done with other members of their own compound, as opposed to other members of the community or hired workers.

# Results

First, I coded behaviors as either solitary or cooperative. This being defined by whether the activity was completed by one person, or by two or more people. There are some limitations for defining behavior this way (for further explanation see Chapter 4). Once behaviors were coded, cooperative behavior was characterized into smaller categories which included cooperative play, cooperative socializing, and household labor (e.g. cooking, cleaning, and fixing/building huts/fences).

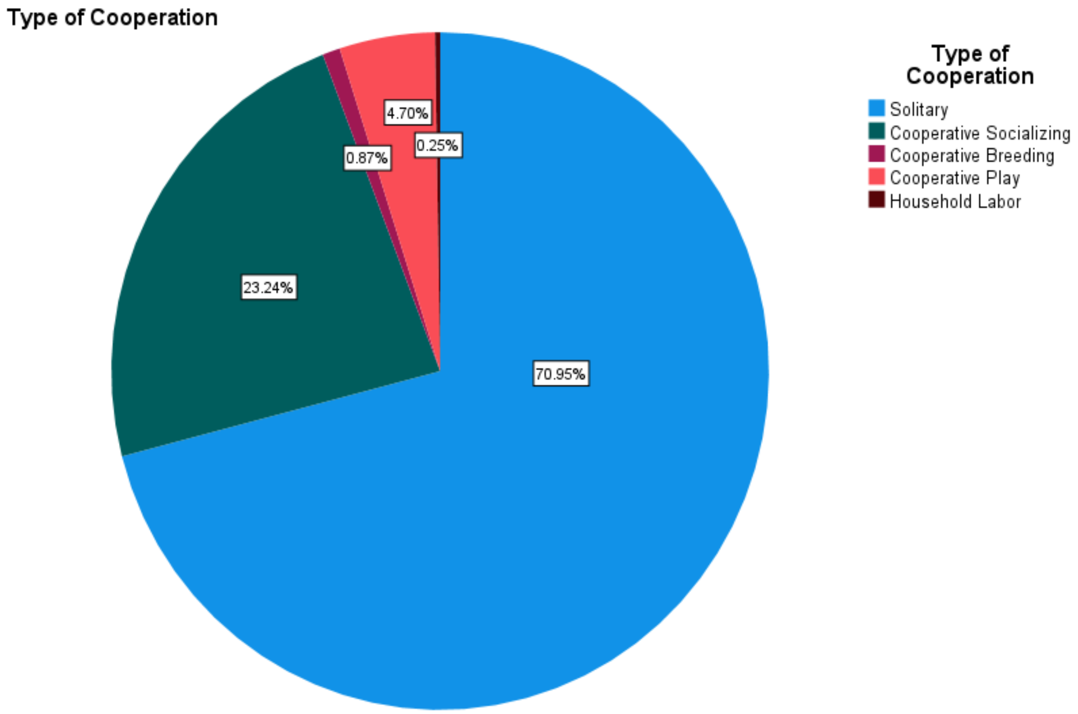

**Figure 1** **Time-allocation pie chart of cooperative and solitary behaviors based on observational scan data across all recorded households.**

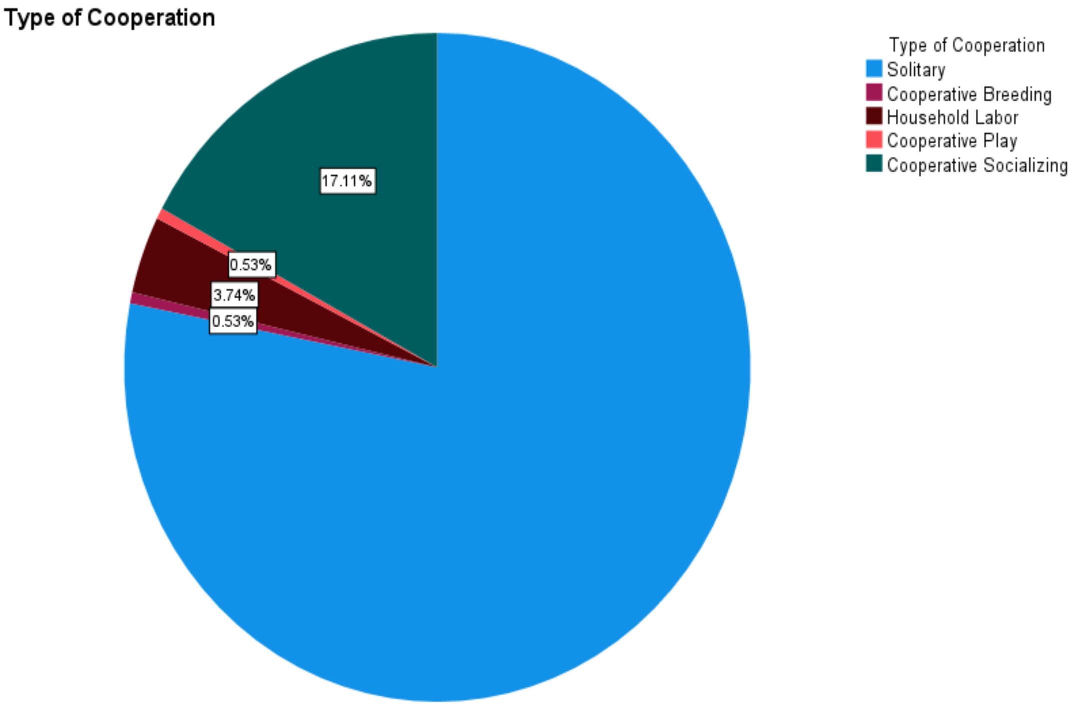

**Figure 2 Time-allocation pie chart of cooperative and solitary behaviors based on focal follow data of selected individuals.**

For frequency of solitary and cooperative behavior, I found that most activities were done alone (See Figures 1 and 2). The second most prominent behavior was cooperative socializing which potentially includes the exchange of information or future planning. Cooperative socializing was recorded any time an individual's primary behavior included communicating with one or more individuals. When looking specifically at the cooperative data collected, there are observational differences between men and women in the bar charts Figures 3 and 4. However, a chi-square test provided a better indication of which gender is more likely to engage in cooperative behavior.

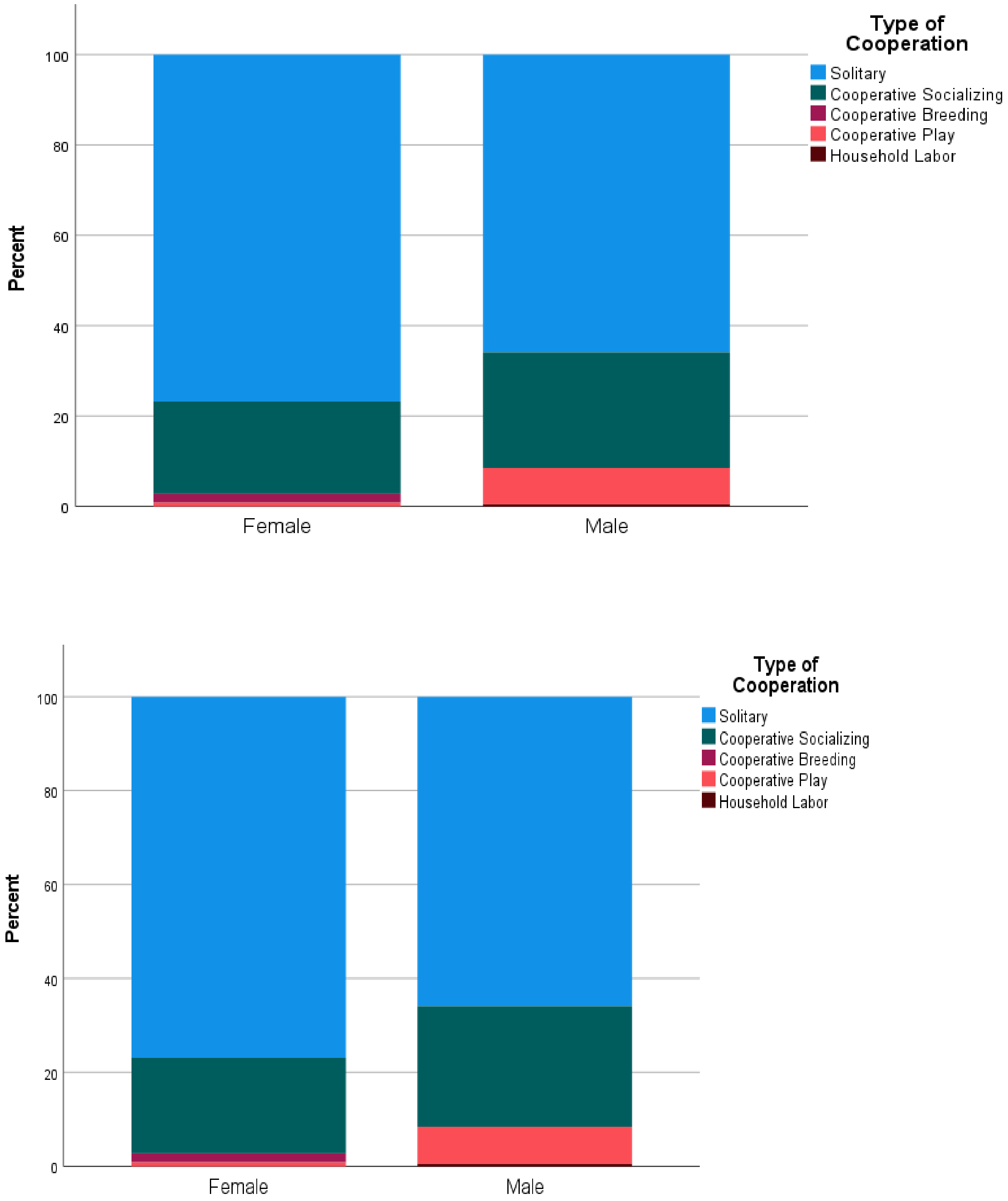

**Figure 3 Cooperative behavior based on observational scan data from all recorded households.**

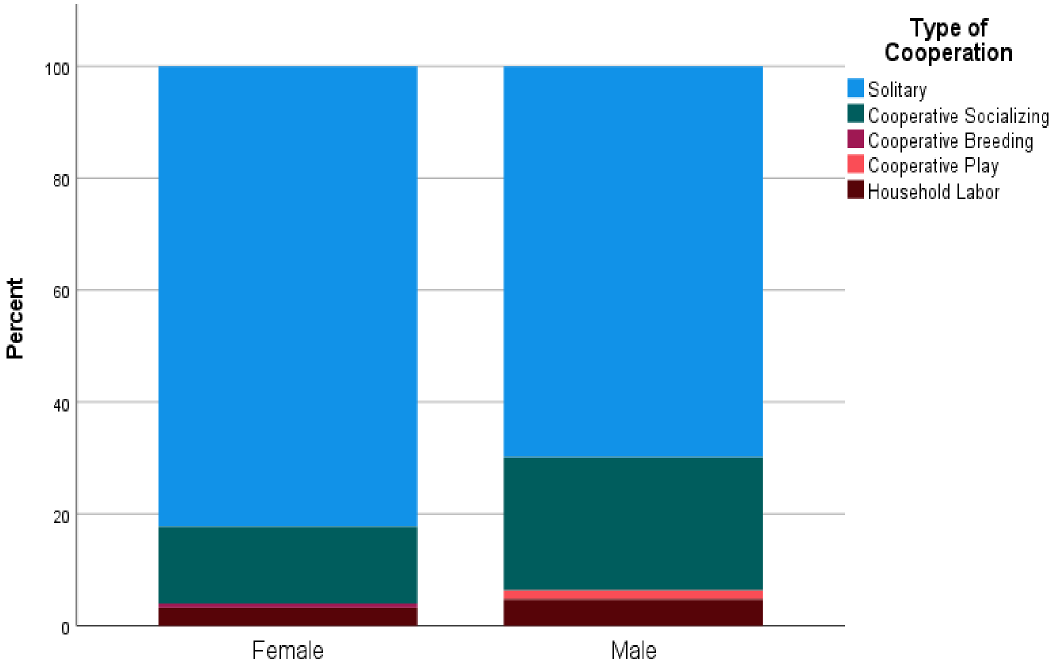

**Figure 4 Recorded cooperative behavior based on focal follow data from selected individuals across all communities.**

I examined quantitative differences between men and women in the community for these cooperative behaviors. During interviews, some individuals mentioned that women typically do certain activities such as gathering roots and we also recorded several women processing food (e.g. shelling and grinding) while the men mainly worked in the fields. However, these roles did not seem to be strict. Women also owned and worked their own plots of land. The more frequently recorded cooperative behaviors include cooperative play, cooperative breeding, cooperative socializing, and household labor (e.g. cooking, cleaning).

**Table 1 Crosstabulations of behavior and gender using observational scan data.**

| | | | Solitary | Cooperative | Total |
|---|---|---|---|---|---|
| **Gender** | **Female** | Count | 286 | 86 | 372 |
| | | Expected Count | 263.9 | 108.1 | 372.0 |
| | | % within Gender | 76.90% | 23.10% | 100.00% |
| | | % Within Cooperation | 49.80% | 36.60% | 46.00% |
| | | Standardized Residual | 1.4 | -2.1 | |
| | **Male** | Count | 288 | 149 | 437 |
| | | Expected Count | 310.1 | 126.9 | 437.0 |
| | | % within Gender | 65.90 | 34.10% | 100.00% |
| | | % within Cooperation | 50.20 | 63.40% | 54.00% |
| | | Standardized Residual | -1.3 | 2 | |
| **Total** | | Count | 574 | 235 | 809 |
| | | Expected Count | 574 | 235 | 809.0 |
| | | % within Gender | 71.00% | 29.00% | 100.00% |
| | | % within Cooperation | 100.00% | 100.00% | 100.00% |

**Table 2 Chi-square test results of behavioral differences based on gender from observational scan data.**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| **Pearson Chi-square** | 11.750 | 1 | 0.001 | | |
| **Continuity Correction** | 11.223 | 1 | 0.001 | | |
| **Likelihood Ratio** | 11.877 | 1 | 0.001 | | |
| **Fisher's Exact Test** | | | | 0.001 | 0.000 |
| **N of Valid Cases** | 809 | | | | |

**Table 3 Phi and Cramer’s V test on observation scan data**

| | | **Value** | **Approximate Significance** |
|---|---|---|---|
| **Nominal by Nominal** | Phi | 0.121 | 0.001 |
| | Cramer's V | 0.121 | 0.001 |
| **N of Valid Cases** | 809 | | |

From the observational scan data, there is a significant association between behavior and gender (see Tables 1 and 2) $X^2(1) = 11.75$, $p = 0.001$. Based on the odds ratio, men are 1.72 times more likely to participate in cooperative behavior than women. However, the Phi and Cramer’s V is 0.121 which is a low association between gender and cooperative behavior. The focal follow data showed a marginal significant association between behavior and gender (See Tables 3 and 4) $X^2 (1) = 3.76$, $p = 0.052$. Based on the odds ratio, men are 2 times more likely to participate in cooperative behavior than women. Similar to the output for the observation scan data, the Phi and Cramer’s V is low (0.142), so it is a weak association as well (see Chapter 4 for limitations).

**Table 4 Crosstabulations of behavior and gender using focal follow data.**

| | | | Solitary | Cooperative | Total |
|---|---|---|---|---|---|
| **Gender** | **Female** | Count | 102 | 22 | 124 |
| | | Expected Count | 96.8 | 27.2 | 124 |
| | | % within Gender | 82.30% | 17.70% | 100.00% |
| | | % Within Cooperation | 69.90% | 53.70% | 66.30% |
| | | Standardized Residual | 0.5 | -1 | |
| | **Male** | Count | 44 | 19 | 63 |
| | | Expected Count | 49.2 | 13.8 | 63 |
| | | % within Gender | 69.80% | 30.20% | 100.00% |
| | | % within Cooperation | 30.10% | 46.30% | 33.70% |
| | | Standardized Residual | -0.7 | 1.4 | |
| **Total** | | Count | 146 | 41 | 187 |
| | | Expected Count | 146 | 41 | 187 |
| | | % within Gender | 78.10% | 21.90% | 100.00% |
| | | % within Cooperation | 100.00% | 100.00% | 100.00% |

**Table 5 Chi-square test results of behavioral differences based on gender from focal follow data.**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| **Pearson Chi-square** | 3.763 | 1 | 0.052 | | |
| **Continuity Correction** | 3.072 | 1 | 0.08 | | |
| **Likelihood Ratio** | 3.641 | 1 | 0.056 | | |
| **Fisher's Exact Test** | | | | 0.062 | 0.041 |
| **N of Valid Cases** | 187 | | | | |

**Table 6 Phi and Cramer's V test on focal follow data**

| | | Value | Approximate Significance |
|---|---|---|---|
| **Nominal by Nominal** | Phi | 0.142 | 0.052 |
| | Cramer's V | 0.142 | 0.052 |
| **N of Valid Cases** | 187 | | |

In this chapter, solitary behaviors were more frequently recorded than cooperative behaviors. Within cooperative activities, there were significant differences based on gender using the observational scan data. Specifically, it was found that men were more likely to complete or be engaged in activities with others than women. Chapter 4 will discuss possible explanations, and propose further research to address limitations and inconsistencies in these results.

# CHAPTER THREE: SIBERIAN HUNTERS

## Introduction

The data for this analysis was collected in 2001 and 2003 by John Ziker as part of a larger project studying the food sharing behaviors of the Dolgan and Nganasan. These two indigenous groups live in the Taimyr Autonomous Region located in the Russian Arctic (Ziker 2002, 2003, 2007). Previous analyses done by Ziker (Ziker, Nolin, Rasmussen 2016; Ziker and Fulk 2019) focused on food distributions following the hunts. The focus for this chapter is the composition of hunting parties and food distributions among members of the hunting party, which has not been previously analyzed. Using a dataset of 77 hunts documented by Ziker in 2001 and 2003, my research questions were how connected were participating hunters across these hunts, what was the role of different types of relationships in structuring partner choice (i.e., relative, friend, neighbor, or acquaintance), and to what extent were these relationships reciprocated. Furthermore, in order to examine my research question about the benefits for cooperative foraging, I examined the association between the total weight of meat and fish acquired by each hunter and centrality indices derived from the network of hunt participants. Finally, I checked for correlations between centrality indicators and the total weight of the acquired resources taken by each hunter, the total weight from the hunt, the ratio of total weight of acquired resources by a hunter.

Degree centrality is measured by the number of ties a node has in a network (Borgatti et al. 2018). For this analysis, I analyzed both indegree and outdegree. Indegree is the number of ties received by a node, whereas outdegree is the number of ties put out by a node (Borgatti et al. 2018). Indegree is typically more indicative of an influential node, since it is actively sought after by other nodes and is considered a standard measure of influence in complete networks (Borgatti et al. 2018). Since this dataset is an observational sample of 77 hunts and not a complete network, outdegree represents the number of hunting partners that were nominated by the hunter interviewed. Outdegree represents the hunting partners that active hunters nominated during interviews.

Betweenness centrality is defined as "the number of times a given node falls along the shortest paths between two other nodes" (Borgatti et al. 2018). In this analysis, I was interested in looking at betweenness centrality since it provides an additional measure of the influence or significance of a hunter has in that network. Betweenness represents the degree to which each hunter bridges different sets of hunting partners across the network.

### Ethnography

The Dolgan population consists of approximately six thousand and approximately one thousand Nganasan live alongside them in three permanent settlements. One of these settlements is Ust'-Avam (Ziker 2007; Ziker, Rasmussen, and Nolin 2016).

The Dolgan were traditionally reindeer pastoralists, big game hunters, and fishers and trappers (Ziker 2007). Some Dolgan used dog teams for travel, but the majority used domesticated reindeer for travel relating to subsistence and household migrations (Ziker 2014). The Nganasan were traditionally hunter gatherers who used dog teams to fish and trap. The Nganasan traditionally kept domesticated reindeer which were often used as decoys during their hunts for wild reindeer (Ziker 2007, 2014; Ziker, Rasmussen, and

Nolin 2016). For both groups, these traditional practices lasted until the 1970s (Ziker 2014). As the Soviet Union advanced development in the north, the indigenous groups including Dolgan and Nganasan were moved to larger, permanent settlements (Ziker 2014). Many communities across the Taimyr lost their domesticated reindeer in the 1960s and 70s. At that time snowmobiles and other combustion-powered vehicles started to be used to travel and hunt. In addition, hunting was done on-foot, depending on season, distance, and household wealth (Ziker 2007).

Distribution of resources from hunts completed on-foot are typically completed with kin (Ziker 2014). Hunts done with vehicles, such as snowmobiles, usually involved more participants and produced more, and thus, resulted in a wider distribution of food across the community. Most cooperative hunts observed were completed using mechanical transportation (Ziker 2014). This means that when more resources are procured and hunting partners are included, the more likely the distribution is going to include non-kin (Ziker 2014). The reverse is also true. So, the less that is gathered, the more likely the distribution is going to remain among kin (Ziker 2014). Rather than focus on distribution of resources following hunts, this research focused on hunter partner choice and splitting of resources by participating hunters at the conclusion of a hunt.

## Methods

My hypotheses for the social network analysis are that kin are the most significant predictor of cooperation in this network and based on the ethnographic research, I also expect friends to be significant predictors as well. In predicting cooperation, I expect reciprocity, and the interaction with reciprocity and each of the four relationship types to be significant predictors. For the centrality correlations, I expect all of my independent variables (i.e., Hunter KG, Total Hunt Weight, and the ratio of Hunter KG and Total Hunt Weight) to be significant and positively correlated with indegree, outdegree, and betweenness centrality.

The data was collected using an interview form that was initiated when hunters returned to the settlement following a hunt (Ziker 2003; 2007). The information includes the names and relationships of the hunter interviewed and other hunt participants, resource description (e.g., taxon, weight), equipment used (e.g., snowmobile, boat), hunt duration, distance travelled, and how resources were divided (Ziker 2002, 2003, 2007).

I calculated by the total weight (kg) of fish and meat acquired by each hunter in every hunt they participated in and reported during this study (hunter kg). Total hunt weight is the sum of everything acquired in a hunt before distribution to each hunter. I also calculated a ratio between these two variables as rough representation of the amount “taken away” for each hunt. However, this is a very rough representation since this data includes cases when the hunter did not take any meat from the hunt (i.e., the resource was left in a cache in the tundra), cases when a hunter reported to give it all away, and cases where a hunter split everything with participants.

I examined information from each hunt record. In order to construct the social network of hunters I used the hunter identification number (i.e., name and number associated with hunter for identification purposes) for participants in each hunt. I only examined cooperative hunts.  what was acquired and how much, and how much was divided among the hunters (i.e., primary distribution). Cooperative hunts were defined by hunts that were reported to have more than one individual go with the main hunter or the hunter interviewed. The relationship defined was based on reported data from the hunter interviewed. Consanguine and affinal relatives were combined into the category “kin.” “Friends” were defined as individuals who were identified as friends (*druz’ia*) on the survey, as well as those identified as old school mates (*odnoklassniki*). “Neighbors” were any hunters identified as *sosedy* -- people who lived in close proximity to one another and did not have a closer relationship. A final category, “acquaintances,” included individuals who were identified as acquaintances (*znakomie*) or were not otherwise specified. A few individuals were reported as joining a hunt because they needed food or were headed someplace else and asked to join—they were coded as acquaintances.

The UCINET program was used to transform a nodelist of each hunter interviewed and their partners across all 77 hunts into a full matrix of each hunter with their participants. The hunter partner matrix was valued and directional. This means that if a someone appeared more than once as a hunting partner across the 77 hunts, then the matrix indicated the sum of those participation events. The directionality indicates the hunter interviewed (who in most cases was the hunt organizer) sending ties to their partners (i.e., the other people who participated in the hunt).

UCINET was used to generate general statistics about the network, as well as node-level statistics, including the centrality measures used in my analysis of hunting returns. UCINET was used to generate a transpose of the hunter partner matrix to represent reciprocal hunting party organization (i.e., participants in hunts who in turn organized their own hunts). As mentioned above, each hunter-partner dyad was coded with one of the four relationship types. Four separate matrices were generated using UCINET to represent hunter-partner relationships characterized as kin, friends, neighbors, and acquaintances. The MRQAP function (multiple regression quadradic assignment procedure) in UCINET was used to test the relative importance of the reciprocity and the four relationship types in explaining the pattern of partner choice. In addition, I used UCINET to create interaction effects between reciprocal hunting party organization and each relationship type in order to understand which kinds of relationships were more reciprocal.

## Results

### Descriptive Statistics

This is a small network made up of 64 nodes (i.e., hunters) and 79 ties (i.e., relationships). As this is an observational sample as opposed to complete community social network survey, there are clear core and periphery nodes. Core nodes are nodes that are well-connected to other nodes, especially other core nodes, in a network (Borgatti et al., 2018). Periphery nodes are not as well connected and are not likely to connect with other periphery nodes. The core/periphery fit or correlation is 0.2774 which is a relatively low fit. This is expected since the network has a low density, as well. The density of the network is 0.020 which means that out of the entire network, only 2% of the possible ties are present. The average degree of each node is 1.234. In other words, each hunter is, on average, connected to one other hunter.

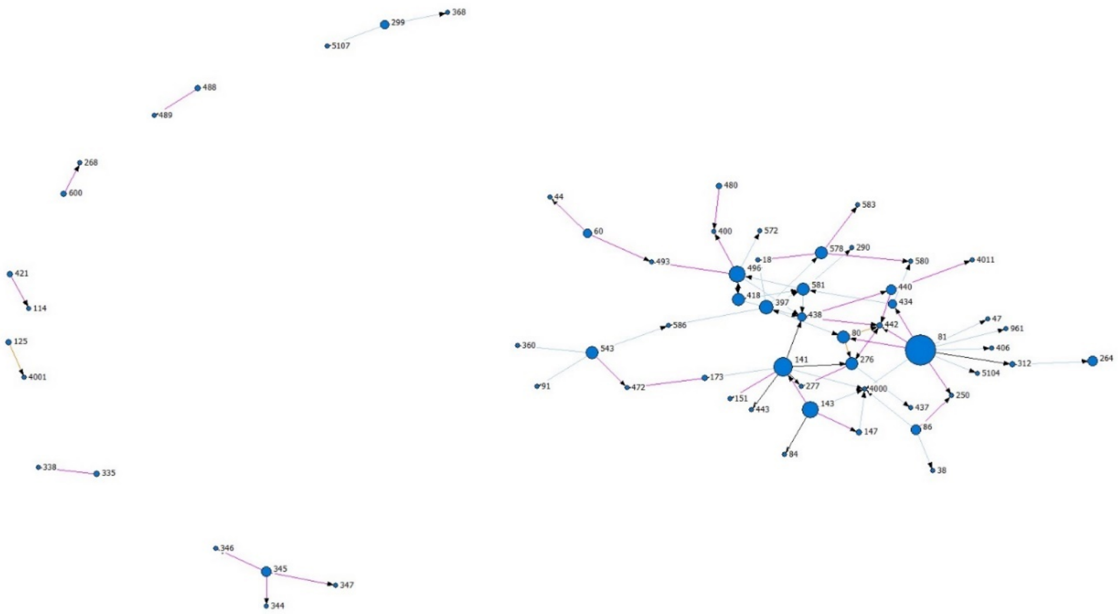

**Figure 5 The hunting partner choice network. Nodes (blue circles) are weighted by outdegree. The thickness of the line indicates the number of times each was observed participating in a hunt. The color of the line indicates the relationship type where: Pink = *Kin*, Blue = *Friend*, Black = *Neighbor*, and Acquaintance = *Orange.***

Visual inspection of Figure 5 indicates that most of the relationships in the network are characterized as kin and friends. Interestingly, one node, hunter 81, had the largest number of hunting partners (n = 10) comprised of kin, friends, and neighbors. Hunter 81 did not participate in any other hunter's parties during the observation period, which is why the arrows all point to the other hunters. Figure 6 shows the same network with the nodes weighted using the betweenness centrality statistic. Note that hunter 81 has low betweenness. Hunter 581 and 438 have the highest betweenness because they lie on the shortest paths of a large number of participants. There is an identifiable cluster of hunters, and then several smaller sets of two to four hunters that are not connected to the main group of hunters (in these data).

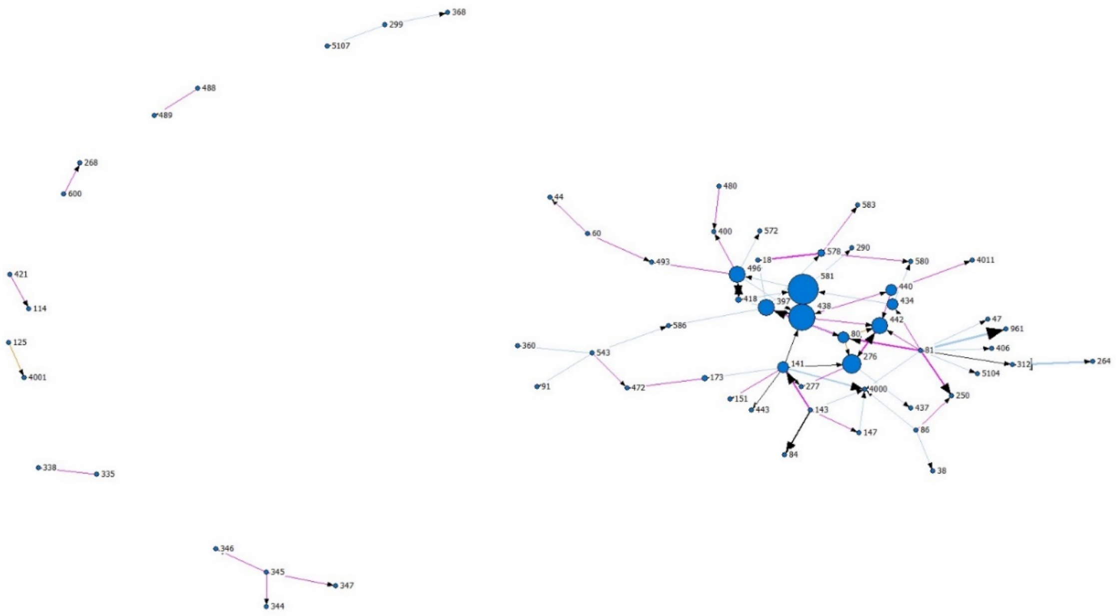

**Figure 6** **The hunting partner choice network with nodes weighted by betweenness centrality.**

<u>Relationship Types and Cooperation</u>

Initially, I tested to see if there was a significant correlation between each relationship type and cooperation which is not surprising since each relationship type is a subset of the hunting partners matrix. The correlation between the kin matrix and hunting partners is 0.609. The correlation between the friend matrix and hunting partners is 0.637, and the correlation between the neighbor matrix and hunting partners is 0.253. Finally, the correlation between the acquaintances matrix and hunting partners is 0.153. These results indicate varying levels of autocorrelation with the friend category being strongest, closely followed by kin, and acquaintance being least important.

**Table 7 Relationships types and hunter partner matrix correlation. **Correlation significant at the 0.01 level (2-tailed).**

| Independent Variables | Observed Value | Significance | Standard Deviation | Min | Max |
|---|---|---|---|---|---|
| Kin | 0.609 | 0.0002** | 0.016 | -0.012 | 0.128 |
| Friend | 0.637 | 0.0002** | 0.016 | -0.013 | 0.108 |
| Neighbor | 0.253 | 0.0002** | 0.016 | -0.002 | 0.216 |
| Acquaintance | 0.153 | 0.0024** | 0.016 | -0.004 | 0.153 |

## Reciprocity

In order to test reciprocity within the network, transposing the matrix (i.e., interchanging the rows and columns of the matrix) allows us to see the direction of partner choice and if these choices are reciprocated (Borgatti et al., 2018). As an example, if Hunter A selected Hunter B to participate in a hunt and then at a later time Hunter B selected Hunter A to participate in a hunt then this would count as reciprocity. The analysis of reciprocity in hunting partner choice is similar to Gurven's (2006) sharing rule of "give to those who give more frequently to you." Reciprocity is hypothesized to be relevant to reducing risk by sharing resources (Gurven 2006). The average observations of contingency in ethnographic research are associated with social perceptions of propriety among relationships (Gurven 2006). This aligns with the ethnographic of the Dolgan and Nganasan, and their beliefs of sharing and giving away food (Ziker 2002). Contingency is measured here as the correlation coefficient between the hunting partners matrix and the transpose of the hunting partners matrix. The correlation is 0.194 with a $p = 0.002$. Based on Gurven (2006), this outcome is within the range of reported contingency statistic, but is on the weak side. Since this is an observational sample of 77 hunts over several months, it is not surprising that we found some but not strong contingency.

### Relationship Types, Reciprocity, and Cooperation

Who do hunters choose as partners, and what can relationship type say further about reciprocity in this network? In order to investigate this question, I conducted a series of matrix regressions on the hunter partners matrix with the hunter partners transpose matrix, the relationship matrices, and interaction effects of those relationships with the hunter partners transpose as independent variable. First, I examined the main effects and I then added interactions. I summarize my results and what these outcomes suggest for hunter cooperation and partner choice. Further discussion on these results will be in Chapter 4.

Model 1 consisted of the four relationship types to predict hunter cooperation. All relationship types were found to be significant predictors with all p values less than 0.01. This model also had a R-square of 0.875 with a close adjusted R-square of 0.874. This was a strong model fit which was expected as the main effects of relationship type are subsets of the hunter partner matrix.

For Model 2, reciprocity was added as an independent variable. All independent variables were found to be significant predictors ($p < 0.01$). The model fit did improve very minimally with an R-square and adjusted R-square of 0.876. This is expected with the relatively week contingency in the network and the very strong effects of the relationship types. Since my hypothesis and previous research suggested kin and friend as preferred partner choices, I removed neighbor and acquaintance for the next model.

In Models 3 through 5 I investigated the interaction of the relationship types with reciprocity. In Model 3, it is interesting to note that the reciprocity main effect dropped out of significance in this model, but both interaction effects of reciprocity with kin and friends relationship types were significant. In other words, all the variation contained in the reciprocity main effect was explained in the interaction effects. The model fit ultimately decreased (R-square = 0.790) with the removal of the other two relationship types.

Neighbors and acquaintances were added back into Model 4, but with only the relationship types, and the main effects of kin and friends. In Model 4, all the relationship types were significant as before, and the interaction effects of reciprocity with kin and friends relationship types were still significant. With the inclusion of neighbors and acquaintances, the fit of this model increased and is one of the better fit models (R-square and adjusted R-square = 0.881).

For the next model, I added interaction effects of neighbors with reciprocity, and acquaintances with reciprocity. Model 5 had all independent variables in the regression. All relationship types main effects, reciprocity, and all four interaction effects. Reciprocity and the main effects for neighbors and acquaintances were not significant. What this means is that there is no reciprocity in organizing hunting parties between hunting partners who were classified as neighbors and acquaintances. All the reciprocity in hunt organization occurred between partners who were classified as kin and friends. Models 4 and 5 had equally good fits (R-square and adjusted R-square = 0.881). However, as Model 4 explains the same variance as Model 5 with fewer variables, I take Model 4 to be the best model.

**Table 8 Matrix regressions with independent variables including the main effects of the relationship type and reciprocity to predict hunter cooperation. ** *p* < 0.01.**

| Independent Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Kin | 0.616** | 0.613** | 0.602** | 0.604** | 0.604** |
| Friends | 0.644** | 0.637** | 0.609** | 0.611** | 0.611** |
| Neighbors | 0.258** | 0.258** |  | 0.258** | 0.258** |
| Acquaintances | 0.156** | 0.156** |  | 0.156** | 0.156** |
| Reciprocity |  | 0.039** | -0.002 | 0 | 0 |
| Kin*Reciprocity |  |  | 0.035** | 0.035** | 0.035** |
| Friends*Reciprocity |  |  | 0.082** | 0.081** | 0.081** |
| Neighbors*Reciprocity |  |  |  |  | 0 |
| Acquaintances*Reciprocity |  |  |  |  | 0 |
| R-squared | 0.875 | 0.876 | 0.790 | 0.881 | 0.881 |
| Adjusted R-squared | 0.874 | 0.876 | 0.790 | 0.881 | 0.881 |

To summarize, all four relationship types, the interaction effect of kin and reciprocity, and the interaction effect of friend and reciprocity were found to be the most significant predictors of hunter partner choice. These finding are consistent with the ethnographic research showed that most reciprocity occurred between kin and friends as well as the previous network analyses conducted by Ziker and others. Neighbors and acquaintances were not found to choose hunting partners reciprocally (see Chapter 4 for further explanation as to why they may be chosen as hunting partners despite the lack of evidence of reciprocity).

### Centrality

In this analysis, I was interested in the relationship between a hunter's centrality, the amount of weight they got from a hunt, total weight of resources from hunt, and what they did not take from their hunts. Before testing for centrality, I created histograms for indegree, outdegree, and betweenness centrality. Next, I tested the correlations between hunters' centralities, hunter kg, total weight, and the ratio of what they took and what the total hunt weight. After running correlation tests, I explain my results and what it means for hunters in this network.

The histogram of indegree (Figure 7) and the histogram of outdegree (Figure 8) show Poisson-like distributions of this statistic (i.e, the mode is zero or close). Since the assumptions for correlations are not met, I used the parametric correlation, Kendall’s tau, to see the relationship between hunter’s centralities, the quantity of resources acquired from the hunts they participated in, and the ratio of total weight each hunter took, and total weight from the hunt.

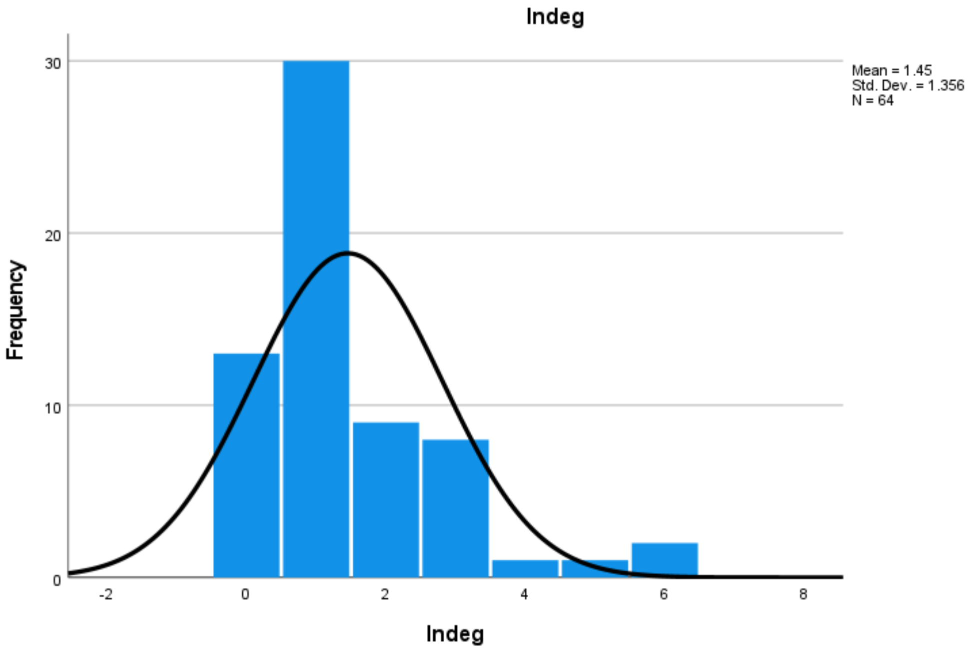

**Figure 7 Histogram of Indegree Centrality.**

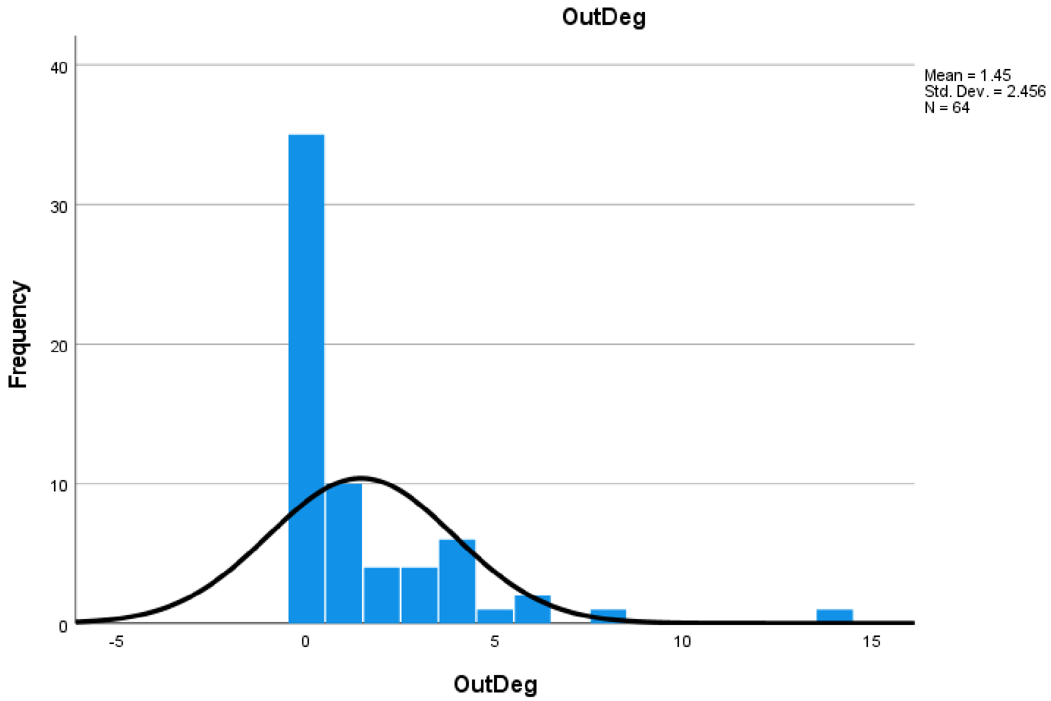

**Figure 8** **Histogram of Outdegree Centrality.**

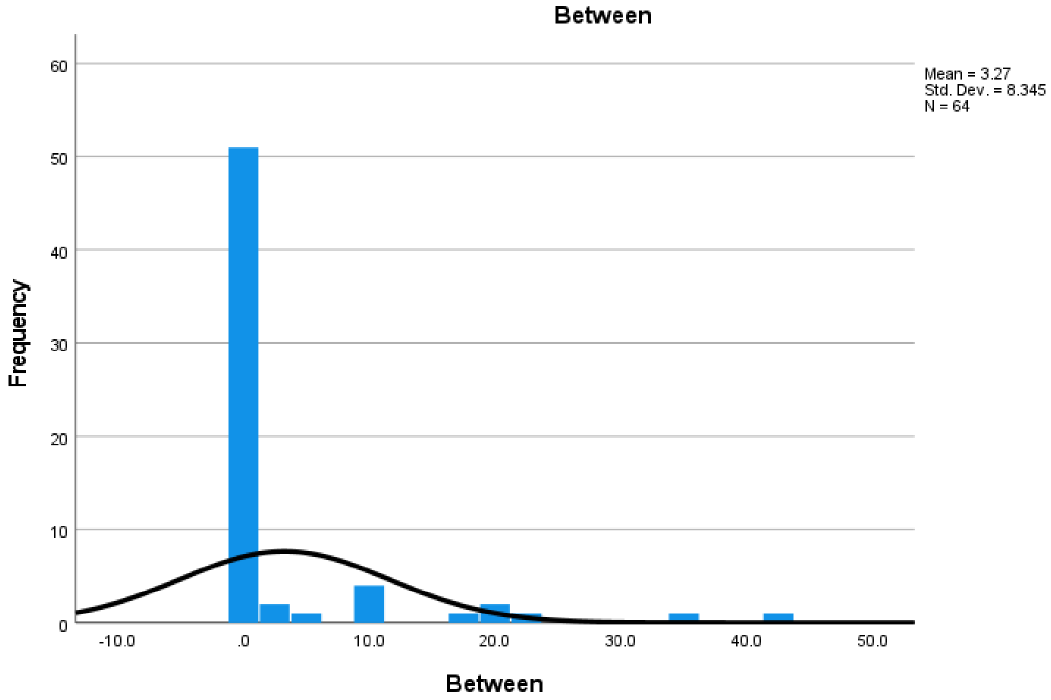

**Figure 9** **Histogram of Betweenness Centrality.**

There were 4 positive significant correlations. Hunter kg and outdegree had a correlation of 0.255 with *p* = 0.008, and Hunter kg and betweenness had a correlation of 0.264 with *p* = .008. Total Hunt Weight and outdegree had a correlation of 0.285 with *p* = 0.003, and Total Hunt Weight and betweenness had a correlation of 0.273 with *p* = 0.006. The ratio of Hunter(kg) and Total Hunt Weight was not significant with any centrality measure.

**Table 9 Correlations between total hunt weight, ratio hunter kg and total hunt weight, and centralities. **Correlation significant at the 0.01 level (2 tailed).**

| Type | | Statistics | Outdegree | Indegree | Betweenness |
|---|---|---|---|---|---|
| Kendall's tau_b | Hunter kg | Correlation Coefficient | .255** | 0.129 | .264** |
| | | Sig. (2-tailed) | 0.008 | 0.176 | 0.008 |
| | | N | 64 | 64 | 64 |
| | Total Hunt Weight | Correlation Coefficient | .285** | 0.113 | .273** |
| | | Sig. (2-tailed) | 0.003 | 0.236 | 0.006 |
| | | N | 64 | 64 | 64 |
| | Hunter kg/Total Hunt Weight | Correlation Coefficient | 0.086 | 0.073 | 0.087 |
| | | Sig. (2-tailed) | 0.376 | 0.452 | 0.39 |
| | | N | 63 | 63 | 63 |

Most of my hypotheses for the correlation between centralities and resource gain were supported. The correlations between outdegree centrality, and total hunt weight and hunter kg were shown to be significant and positive. Similarly, the correlation of betweenness centrality, and total hunt weight and hunter kg were also shown to be significant and positive. The ratio variable of hunter kg and total hunt weight was not shown to be significant with any of the centralities. Indegree centrality was not correlated with hunter kg, total hunt weight, or the ratio of the two. What this means is that hunters who are more central in the network have greater per capita hunting returns than those who are not as central. While this correlation cannot speak to causation, it does speak to the benefits of cooperative foraging. In Chapter 4, I explain possible reasons for these outcomes, limitations of this research, and potential future research.

# CHAPTER FOUR: DISCUSSION

## Cooperative Activities: GNP

Do the Sena people of GNP prefer to work cooperatively or individually? Based on the time allocation results (see Figures 1 and 2 in Chapter 2) and the ethnographic data, more time was dedicated to working individually. Some factors that could have influenced these decisions include economic and ecological factors. In the interviews, many people expressed that it was difficult to make money at that time. In order to compensate, they may not have been able to invest as much in others. Redefining cooperation may provide a better understanding for what is actually occurring as well. When cooperative behavior was being recorded, it was based strictly on the observation of individuals working together to complete the same or similar task. However, it is possible that some solitary behavior observed could have been considered cooperative, if the activity was contributing to the same household's well-being. For instance, although women and men owned and worked their own fields, they might share most of their produce with other individuals on the compound. This is similar to the observations of Bird (1999).

Of the cooperative activities defined, those that most frequently occurred included cooperative breeding, play, socializing, and household labor. There were some observational differences based on sex, but a more long-term study would provide further insight into how frequently these behaviors occur (Figures 3 and 4 in Chapter 2). Based on our limited time in the field, it was difficult to assess the extent to which our presence skewed any of the behavioral data as many individuals in a compound would stop what they were doing during the interview process, despite the fact that only one household member was being interviewed.

The results of the chi-square test found significant and marginally significant results for an association between behavior (solitary or cooperative) and sex (see Tables 1-4 in Chapter 2). Women were found to be more likely to participate in solitary behaviors than men.

### Limitations

For the GNP project, there were several limitations that could have potentially affected our results. While we did work with a translator who is indigenous to the area, it is possible there was a loss or confusion in meaning from the Sena to Portuguese to English, and the other way around as well. An example of confusion with meaning was the way questions were translated that led people to answer in ways that downplayed the casual types of help that we observed. The reason for this concern was the result of some inconsistencies with the observed data and reported data. It was reported that most of the work was done alone or stayed within the family on the compound, while most of the observed data reported solitary behaviors. However, based on the answers to the interview questions, there was not a lot of work being shared nor sharing of resources occurring between compounds. During the field visits, occasional help between members of the same community would be observed. In one case, we observed two neighbors work together to grind corn. Initially, the woman was doing this alone, but the neighbor soon joined her in the activity. It is unknown as to how often these casual interactions occur.

As previously stated, it is unclear how much of our presence skewed behavioral observations. Since we were in each community for three days, this may have not provided enough time for participants to be accustomed to our presence. Many individuals would stop working and choose to sit close to the member of the household being interviewed, and not go back to working until we left during the scan sampling. Occasionally, members of other compounds/families would follow us to other compounds. The Sena are also very hospitable, and many insisted on preparing meals and provided better seating (on chairs, logs, or bamboo mats). Unfortunately, this type of behavior did draw a lot of attention and many seemed distracted from their household chores. A long-term study with repeated visits would, ideally, make it so that our presence would not affect their day nearly as much and give us a better indication of what an average day consists.

### Future Studies

The GNP preliminary study did provide a sense of the communities and how to improve a research protocol if visited again in the future. We have a sense of how communities in and close to the park are influenced by the park's presence. Ideally, future visits would expand to other areas of the park and last for longer periods of time. Future collection of more quantitative data (i.e. how much food they are producing, wealth, etc.) can allow for future analyses involving cost and benefits associated with cooperative or solitary behaviors. Overall, further analysis is critical to understanding why cooperation occurs under certain conditions rather than others to fully grasp the evolution of human sociality.

As previously stated, the research conducted in GNP was part of a preliminary study and as a result, a limited amount of information was acquired. Future research within and around the park should expand to other communities and include varying ecologies. It would also be beneficial to stay in each community for an extended period of time in order to establish a greater understanding of time allocation. If an extended stay is granted, collecting other information such as quantity of food provisioned and foraged, how long each foraging trip is, who joins for each trip, how is the acquired food divided, among any other variables that would contribute to a more in-depth understanding of the costs and benefits associated with the cooperative behavior. As a result of for three-day limit in each community, it was difficult to collect a larger amount of qualitative data along with the quantitative information. The interviews conducted were mainly used to get a sense of the everyday activities of the individual(s).

Referring to the misunderstandings that we may have encountered in our study, future interview questions could include what role the park plays in these activities (e.g. burning and farming). On the website of Gorongosa National Park, it is apparent that the park is involved with agricultural activities,such as providing seeds for high value crops (e.g. maize, sorghum, sesame seeds, beans, and peanuts). They have also introduced beekeeping by training and providing supplies for community members, so that the honey can provide an additional source of income.

Additionally, it would be interesting to conduct a social network analysis on these adopted agricultural interventions from the park and how information is spread within the communities. Bandiera and Rasul (2006) were interested in how social learning influences a farmer’s initial decision to adopt a new crop (i.e. in this case, the crop being introduced was sunflower) can be related to the decisions of other farmers in their social network. They found that a farmer is more likely to adopt the new technology/crop when there are other individuals in their social network who use that new technology/crop, but if there are too many individuals in their social network using that new technology/crop, they may delay the decision to adopt the new technology/crop. Similarly, it may be interesting to see how this may have occurred since many individuals were reported growing the crops that the park mentioned introducing, and some individuals reported that they had the beehives. This type of network analysis can also be done with burning practices information. For example, understanding how/where one individual heard that burning the field damages the soil. A social network analysis could also potentially explain why individuals are so afraid of starting fires (outside of the practices mentioned).

## Cooperative Activities: Ust'-Avam

Hunting partner choice among the Dolgan and Nganasan in Ust'-Avamwas biased most strongly toward a hunter's kin and friends. Secondarily, partners were chosen from neighbors and acquaintances. In addition, we found that hunting party organization had a marginal degree of reciprocity for kin and friends, but not for neighbors and acquaintances.   All off the reciprocity in this data set analyzed is in interactions with kin and friends (see Table 8).

This outcome means that reciprocity in kin and friends is significant in predicting hunter cooperation. For partner choice, working with kin and friends is ideal since they are reciprocal partners in this hunter network. These findings are consistent with inclusive fitness and reciprocal altruism theory, and support most of my hypothesis. I had hypothesized that all relationships and reciprocity would be predictors for cooperation. Why were neighbors and acquaintances not reciprocal yet still selected as partners?

There are a few possible explanations as to why neighbors and acquaintances were selected as partners, even though they were not reciprocal. It is possible that this finding could suggest indirect reciprocity or tolerated scrounging are driving these partner choices. Ethnographic data stressed the importance of sharing in the community and it is possible that since sharing among everyone is to be expected, this is a form of indirect reciprocity. Going on a hunt with a neighbor or acquaintance may benefit the hunt organizer again in the future through attitudinal reciprocity, generosity signaling, or tolerated scrounging. Tolerated scrounging could drive partner choice if the cost of not including these individuals in hunts outweigh the cost of including them. However, a cost/benefit analysis and additional variables would need to be incorporated to see if this is the case.

Measures of betweenness and outdegree centrality in this network indicate positive correlations with per capita hunting returns. This finding did mostly support my hypotheses. However, indegree was not found to be significant with production. The ratio variable of hunter kg and total hunt weight was also not found to be significant with any of the centralities.

Degree centrality having a positive correlation with production could be an indicator of signaling (Bird and Power 2015). If the ratio variable of hunter kg and total hunt weight had been positively correlated with indegree or even outdegree centrality, I thought it could have potentially a type of signaling (e.g., costly or generosity), but this variable is not a strong representation of generosity or food being ‘given away’. As previously stated, I believe this outcome shows the benefits of cooperative hunting and being a central cooperative hunter in this network since is associated with greater production. A hunter with high outdegree centrality brings more partners into the activity which increases their access to resources.

A hunter with high betweenness centrality could control the flow of resources. A hunter with high betweenness centrality is who connects two other hunters in the shortest or ‘fastest’ way. This position could be crucial for partner choice since hunters on the periphery of the network may not have an immediate way to be invited on a hunt. The hunter with high betweenness centrality can influence the connection of other hunters, flow of goods or information, among other benefits.

### Limitations

With this social network analysis, one limitation was sample size. This data consisted of an observational sample of 77 hunts that occurred during several months in 2001 and 2003 that included a limited number of people. A different sampling strategy, such as social network interviews of all hunters in the community would have created a more robust network. However, I do not think sample size invalidates these findings, since they were consistent with findings on other phases of food distribution, other social network samples, and the ethnography in this community.

As stated previously, another limitation included the ratio variable. This variable is not the more representative way of knowing how generous a hunter is or even if they are giving away resources. As mentioned earlier, a number of hunters not take resources following the hunt, preferring to store these at their hunting camp, which is different than consciously giving away goods. It is likely these resources were being stored for distributions throughout the winter. The data pulled from the hunt records included how much was acquired from each hunt and how much each hunter got. Information was not systematically collected on how they decided to go about the splitting of products from the hunt. Some hunters did provide rationales and these were noted in the hunt records, , but a larger portion of the records did not have information on how or why the distribution occurred the way it did for the primary distribution. The focus of the data collection was on subsequent sharing events.

Another limitation of this analysis is that variables representing the cost of these cooperative hunts such as hunt time and distance were not included.

### Future Research

Future research could benefit from having a larger sample size and getting more information on the decision-making behind the primary distribution. Alternatively, a complete community sample using network interviews would generate information on partner choice but not provide information on specific costs and benefits of cooperative hunts. It would be beneficial to know why some hunts ended with the splitting of the resources obtained while in other hunts resources were left in the tundra. Incorporating a cost/benefit analysis would provide more insight to cooperation and partner choice.

This research could benefit by developing an agent-based model. This would be beneficial because parameters can be set on the model that could potentially influence relationships and reciprocity in the network. These parameters can include season, mode of transportation, distance, geological landscape, number of hunting days, group size, prey migration and other variables that could influence cooperation along with reciprocity and relationship type as Janssen and Hill (2014).

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# APPENDIX A

## Interview Questions

1. What is your name?
2. In what year were you born? When did you move here?
3. How many people do you live with?
4. What are their names? How old are they? What is their relation to you?
5. Can you tell us the story about this village? Who was the first person to come to this village? What kind of activities did he do?
6. Are you doing the same kind of activities?
7. What plants do you grow in your garden? Do you have a labor group that helps you? Are they hired? Family?
8. What animals do you raise?
9. Are there plants or animals from the bush, or fish, that you like to eat?
10. If yes, what time of year do you harvest these plants? Do you go by yourself to do this, or with others? Who joins you? Why do you go with them? How often? Do you share your collected plants with anyone?
11. If yes, what time of year do you harvest these animals? Do you go by yourself to do this, or with others? Who joins you? Why do you go with them? How often? Do you share your meat with anyone?
12. [If they fish] what time of year do you fish? Do you go by yourself to do this, or with others? Who joins you? Why do you go with them? How often? Do you share your fish with anyone?
13. Do you start small fires around your home? Why do you do that? When? How do you start these fires?
14. Do you start small fires in the bush? Why do you do that? When? How do you start these fires?

15. What about your current activities (gardening/farming, gathering plants, hunting, and burning) did you learn from your ancestors? What has changed?