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Ephemeral Work Group Formation of Jenu Kuruba Honey Collectors and Late 19th Century Coloado Silver Prospectors

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Summary

Humans frequently form short-lived cooperative groups to accomplish subsistence and economic tasks. We explore the ecological and cultural factors behind ephemeral work-group formation in two disparate cultural contexts: groups foraging for wild honey in present day South India and groups prospecting for silver ore in the Elk Mountain Mining District of Colorado in the late 19th Century. Contrary to traditional economic foraging predictions, we find little evidence that per capita yields are the most important factor in determining size and composition of ephemeral work groups. We explore factors in each of these cultures that may be of importance in group formation such as kinship, reputation, and pleasure. Models that only incorporate economic parameters will make poor predictions of how humans interact with their environments.

Keywords: Human Behavioral Ecology, Foraging theory, Group formation, Resource extraction

Introduction

Cooperative foraging has the potential to optimize per capita yields and aid in social bonding among group members. These interests are not always complementary; group members must often balance foraging returns and social benefits. It is likely that individuals will alter their strategies based on the social, economic, and ecological contexts. As a hyper-social species, humans provide an interesting case to explore predictions about group foraging behavior including factors affecting foraging group size, composition, and constraints on the ability to manage competing interests.

Ample empirical evidence has provided support for the hypothesis that many social species cooperatively forage to increase per capita yields (Finches: Cody, 1971; Antelopes: Jarman, 1974; Hyaenas: Kruuk, 1975; Wolves: Nudds, 1978; Juncos: Caraco, 1979; Bats: Howell, 1979; Lions: Clark, 1987; African Wild Dogs: Creel & Creel, 1995; Whales: Baird & Dill, 1996; Spiders: Yip et al., 2008; Dolphins: Benoit-Bird & Au, 2009). Foraging groups are frequently somewhat larger than the predicted optimal group size because of the need to maintain large enough groups for effective reproduction (Rasmussen et al., 2008), for providing care for young (Caraco & Wolf, 1975; Packer et al., 1990; Baird & Dill, 1996; Schmidt & Mech, 1997), for defense against predators and competitors (Clark & Mangel, 1984; Vucetich et al., 2004), and because lone individuals, who have very low foraging success, put pressure on group members to be allowed to join (Sibly, 1983; Kramer, 1985; Giraldeau, 1988; Giraldeau & Caraco, 1993; Higashi & Yamamura, 1993).

When there is conflict between group members and potential joiners, actual group size will depend on the specific individual characteristics of group members. This conflict might be mitigated by a high degree of relatedness between members and joiners, which allows for a larger group size than for groups without kinship (Figure 1) (Rodman, 1981; Smith, 1981; Smith, 1985; Giraldeau & Caraco, 1993; Higashi & Yamamura, 1993; Mathot & Giraldeau, 2010). Groups may also allow additional members beyond the typical group size if the potential joiner

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has special skills or access to resources. Stander (1992) and Stander & Albon (1993) show that lionesses in Etosha National Park, Namibia had preferred hunting roles (those that herd prey, those that lie in wait for the prey to be chased their direction). Hunting success increased with group size, particularly when groups included individuals in their preferred stalking or chasing roles. Groups including more competitive individuals, whose skills and motivation can increase yields, should be larger than groups with less competitive individuals (Ranta 1993). Competitive individuals expand optimal group size by elevating overall yields (Ranta, 1993).

(Fig. 1 here)

Group members may also prefer to cooperate with individuals of good reputation, those with a long history of repeat interactions and well-known skills. Individuals with characteristics that negatively impact per capita yields will be excluded from groups. A group of producers may only tolerate scroungers (Boesch, 1994; Vucetich et al., 2004), if the scroungers are kin (Mathot & Giraldeau, 2010). Thus even for non-humans, social interactions are important factors for group formation.

Among humans, who have elaborate social relationships, there is some evidence that foraging decisions are based on foraging economics and social relationships. There are two studies that provide the best evidence of purely economic foraging. First, Beckerman (1983) investigated cooperative spear fishing among the Bari of the Maracaibo Basin, Venezuala. His model predicts an optimally sized group similar to the average number of adult men residing in a Bari longhouse. Second, the Kalahari San forage in groups that are larger for larger patches of concentrated resources which are distant from the village; groups are smaller for dispersed resources near the village (Imamura-Hayaki, 1996).

There are two studies that question the model that foragers are driven only by optimizing economic yields. The foragers in these two societies forage in groups close to the size that optimizes per capita yields, but group size is increased by social pressures. Groups may experience social pressure to add extra individuals (e.g. a mother insists her son bring his little brother along, or someone with political access has requested to join the group). First, traditional whalers in Lamalera, Indonesia achieve high per capita yields by coordinating group search and pursuit of whales but groups are often larger than would be expected to maximize per capita returns (Alvard & Nolin 2002). Social kinship via clan affinity is the strongest predictor of inclusion on a boat crew (Alvard 2003). Second, Smith (1981, 1985) investigated parties of Canadian Inuit hunters and found that humans forage in groups to optimize per capita yields for certain prey types, but he postulates that they are likely highly constrained by social factors (member-joiner rule, dominance, communal sharing beyond the foraging group).

The previous four studies and the animal literature discussed above all assume that economics is a primary factor in group formation. However, two studies question this traditional assumption. Aché foraging group composition varies greatly within and between prey types, and has very little correlation with mean foraging success (Hawkes et al. 1982, Janssen & Hill 2013). For Martu hunters in Australia's Western desert, foraging in groups did not significantly increase per capita return rates across a variety of hunted and gathered prey (Bliege Bird et al. 2012). The authors hypothesize that better hunters may instead receive increased social capital that might translate into other material benefits. These studies demonstrate the need to examine economic optimality models more closely in a variety of cultural contexts.

A survey of the available animal behavior and ethnographic literature indicates that the conventional model of group formation is one where economics is the prime motivator and social factors may tweak actual group sizes to be somewhat larger. Here we investigate the role economics and social interactions have in foraging group formation by focusing on ephemeral foraging groups by examining two distinct case studies: 1) Jenu Kuruba honey collectors in Southwest India - where social groups in a small-scale society periodically collect honey in addition to other economic activities, and do so repeatedly over their lifetimes, and 2) Prospectors for silver ore in late 19th century Colorado - where social groups exist in a highly delimited time and space in a little known environment. Silver miners in Colorado prospected in a dry, mountainous environment where terrain and the potential wealth of resource patches were predominantly unknown. Honey collectors make excursions into the dry-deciduous tropical forest surrounding their village where honey caches can be found worth several days wage-labor.

We first compare group size to foraging returns to see if individuals in these societies are foraging in groups that optimize per capita yields and can be explained by economic models. If this is the case, we predict the modal group

size will be slightly larger than optimal. We then examine the composition of foraging groups to see if those with kin or members with special skills are larger than average. Where results deviate from purely economic predictions, we investigate the assumptions of optimal group foraging models and then examine the local social, economic, and ecological factors affecting social foraging in human groups.

Study Areas

Honey Collectors

The Jenu Kuruba are an indigenous *adivasi* ("first dweller") Scheduled Tribe living primarily in the dry deciduous tropical forests of Kodagu, a district of Karnataka in Southwest India. They number about 30,000 (Census of India, 2001) and complement income from wage labor on local coffee estates with household cultivation and seasonal foraging for wild honey. KD worked in a cluster of five villages in Kodagu from Jan-Dec. 2009, with a population of ~500 people. All the villages were located 1-3km inside a Reserve Forest in which individuals were allowed to reside and collect minor forest products for consumption or sale.

Foragers are most active in May and November when honey production peaks just before the two annual monsoons. Four honeybee species live in the forests of Kodagu, but only the two biggest produce honey in quantities large enough for sale. These two species are known as *hejjenu* (*Apis dorsata*, the giant Asian honey bee) and *thuduvejenu* (*Apis cerana*, similar to the Western honey bee). *Hejjenu* honeycombs hang from sturdy branches in big trees, requiring collectors to climb the trees, cut the combs and lower them down while subduing the bees with smoke. Groups of men will usually go out in sizes of 3 -7 individuals to coordinate labor across these tasks. Hives can produce up to 30 kg of a pale, dilute honey that can be sold at 60-80 Rs/kg[1]. *Thuduvejenu* honeycombs are generally located in the cavities of tree trunks and males prefer to collect alone or in small groups because there is less labor to coordinate and, though *thuduvejenu* honey is thicker, it produces only 1-10kg of honey. *Thuduvejenu* honey can be sold for ~100 Rs/kg. A day's wages for labor on the coffee estates is 125 Rs in comparison. Honey collecting trips usually last from a few hours during the day to overnight trips for *hejjenu* (when the bees are more subdued).

Silver Prospectors

In the late 19th century, prospectors enthusiastically searched for silver ore in the Elk Mountain mining district of Gunnison County, Colorado. Settlers flocked to the Gunnison area after the Jennings brothers discovered rich deposits of wire silver at the Sylvanite lode in late May of 1879 in the high Elk Mountains (Vandenbusche, 1980; Strahorn, 1881; Haase, 1971). The town of Gothic was incorporated (July 17th, 1879: Gunnison County Records) on the confluence of the East River and Copper Creek as the main supply center for the region (Haase, 1971; Vandenbusche, 1980: Figure 1).

Gothic boomed. W.W. McKee remembers the bustling town of Gothic in 1879 as full of dust, traffic, the smell of dead mule, sexy dancing girls, and the sound of sawmills (Wolle, 1949). At its peak, Gothic supported 30-48 businesses (Colorado Business Directory 1881; Haase, 1971), and boasted at least 1225 people as town residents (1880 U.S. Census). Prospectors were quick to form small cooperative groups and search for silver ore, registering about a thousand claims during the first two summers (1880-1881, Gunnison County Mining Claim Records).

Optimistic newspaper articles, and likely other more informal sources of information, vastly overestimated the value of silver in Gothic, misleading many local prospectors (Glover, 2009). In reality, there was simply not enough high quality ore to sustain a town (Haase, 1971). Edgar Warren (1924) notes that, "Many of these men who were at Gothic my first year [1882] did not return, or if so, only for a few days. The mines, or prospects- most of them, failed to come up to the expectations of their owners and they abandoned them." Indeed, by 1885 the town was all but deserted (Colorado business Directory, 1885).

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[1] In 2009, 50 Indian National Rupees ≈ 1 United States Dollar

Predictions and Methods

To explore the relationship between group size, group composition and per capita success, KD surveyed the Jenu Kuruba honey collectors about recent honey collecting trips and SGK searched the Gunnison historical record to learn more about silver prospecting claims. We gathered information about the size of the group, measures of foraging success, if the group included kin, and if the group included individuals with special skills.

Honey Collectors

KD spent the first nine months of field research in ethnographic and participant observation of honey collecting. Using qualitative observations of honey collecting during the prime season, she built a multi-dimensional interview to elicit demographic information and information about the most recent honey-collecting trip a man had taken to complement the observational data[2]. This interview was administered by KD, a research assistant, and two trained translators during the minor honey season Nov-December. All items were pretested on an independent sample for clarity. We report data from 42 trips with a known per capita profit for the sale of the honey collected. No trips were double-reported by different group members. Any reported trips that had taken place more than five years ago were dropped from the data set due to memory biases. We understand memory biases may remain for more distant events, although few foraged items are sold among the Jenu Kuruba and expect responses to be fairly accurate and accept this trade-off for increasing sample size. The value of the Indian National Rupee remained fairly stable (1 USD = 40-50 INR) between 2000-2010 (Times of India 2013).

Group size and per capita yields: If honey collectors are foraging to maximize returns, we expect to observe a negative quadratic relationship between group size and per capita returns. We report group size as the number of individuals present at a collecting event including the focal individual. Because honey is split equally between all adult group members present at a collection event, we use personal profit in Rupees as reported by the informant as per capita returns for all group members reported on that trip. The smaller the bee species, the less honey it produces, so we predict the returns to additional group members will vary by bee species. We use a generalized linear regression to compare profits with group size for the two honey types.

Group composition and group size: We predict that conflicts between members and joiners will lead to the creation of sub-optimally large groups containing a greater number of kin. We recorded the collector's relationship to the others that accompanied him. Kin were recorded as any affinal or consanguinal relative as reported by the informant. We used a Poisson generalized linear model to see if larger groups contain a higher proportion of kin for the profitable honey types, *hejjenu* and *thuduvejenu*.

We report only data from adults - anyone 16 years of age and older. Juveniles do not accompany men who collect *hejjenu* or receive a share of the profits from collecting *thuduvejenu*. The smaller, safer honeybees that young children collect from provide a delicious snack but no monetary profit. For this reason, we do not report juvenile collecting trips because they are motivated by practice and socialization, and not to maximize economic returns.

Silver Prospectors

Gunnison County has kept records of mining claims since before its incorporation in 1879. Since the only legal right a miner/prospector had to a claim was if they registered at the county offices, there is little reason to think that many attempted to falsify information or neglect to file records. These records contain information on all legal proceedings regarding the claim, including the names of those who located the claim (including if a claim was made by a company), date of claim, type of claim (placer or hard rock), if a claim was ever officially worked (affadavit of labor), price paid for the claim if it was ever sold, and the last date any legal proceedings involved this claim. SGK collected these pieces of information for all (2,568) claims made in the Elk Mountain Mining District.

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[2] We sampled only men, since women collect honey extremely rarely and only opportunistically.

Around 4% of all claims were missing and were excluded from analysis. These claims were usually missing because of indexing mistakes made in the 1980s. Since the indexing was done a hundred years after Gothic's mining boom, it can be safely assumed that indexing mistakes were not patterned by the type of claim, date of record, or individual. Thus, we assume the data to be missing at random and should not affect this study.

For the purposes of this paper, we restricted our analysis to hardrock claims made by small groups (2,080). Certainly placer mines and large company mines are also part of the mining history of the Elk Mountain district, but the majority of the story of how prospectors searched for ore can be told through an investigation of hard rock claims. The data population was winnowed further by only considering hardrock claims made before 1894 (1,326). The year 1894 makes a natural stopping point for collecting data because the value of silver ore crashed in 1893. It is not appropriate to lump groups from before and after the crash because they are under very different economic pressures.

Group size and per capita yields: If prospectors are foraging to maximize returns, we predict a negative quadratic relationship between group size and per capita profits. The historic data set does not contain the success an individual gains from a particular claim since claims were most often sold as a package with many other claims. So while the sale price for a package of claims is recorded, the value of a particular claim cannot be resolved. If the claims were all of the same group size, then a good estimate of the success of that size group is to divide by the number of prospectors. However, it is rare that all the prospecting groups that made each claim in a package were the same size. Thus, the following proxies of success have to be used: if the claim was ever sold, if an affidavit of labor was ever filed for a claim, and the length of time that people legally took interest in that claim. If group size affects per capita success then it should also affect these proxies. SGK collected information for a random subsample of hardrock mining claims made before 1894 (n=435).

Group composition and group size: We hypothesize that, because of inclusive fitness and trusting relationships, groups with kin will be on average larger than groups without kin. We also hypothesize that groups will preferentially add individuals with access to special skills or information to increase per capita yields. Since prospecting groups are often short on cash, the presence of a capitalist, with the necessary start-up money for food, explosives, mule rental, simple assay kits, and excavation tools, enhances the chances of success. Thus, we hypothesize that groups with capitalists can afford to be larger than groups without capitalists. To test these hypotheses, we apply a generalized linear model to estimate effect sizes for the parameters of presence/absence of kin and presence/absence of a capitalist.

All pre-1894 hardrock claims (n=1,326) were coded as "kin" or "non kin". Claims were coded "kin" if two or more locators of a claim had the same surname and "non kin" if there were no locators that shared surnames. In an area of all new immigrants, it is likely that two people with the same last name are close kin. This intuition is supported by the fact that according to the 1880 U.S. Census, there are very few repeats of surnames in males over the age of 15 (79% of surnames are found only once in the records, 97% of surnames are repeated 5 or fewer times).

An intrinsic property of groups with kin in them is they must have at least two members. To ensure that any effect size for presence/absence of kin predicted by the generalized linear model would not be entirely due to groups of loners, we also ran a model where all groups of 1 were excluded. This assumption provides the most conservative test if groups with kin are larger than groups without.

Claims were coded as "capitalist" or "non capitalist". A list was compiled of the cohort of locators of hard rock claims registered in 1879, 1880, and 1881 (730 claims, 1,882 men). These individuals were cross-referenced with 1880 US Census records to find their occupations (ancestry.com's database). Claims with individuals found in the 1880 census were coded as "capitalist" if they contained at least one capitalist (merchants, lawyers, doctors, capitalists, mine speculators), and "non capitalist" if they had all members identified as non-capitalists (prospectors, miners, laborers, clerks).

Unsurprisingly, there were many claims for which information was incomplete. Since, all members had to be matched to securely identify the claims as "non-capitalist" whereas only one member had to be matched as a capitalist to code the claim as "capitalist", the larger groups of non-capitalists would hardly ever make it into analysis. This would make it artificially appear that groups with capitalists were larger than those without one. A more conservative test to see if capitalist groups are indeed larger, we coded all claims with incomplete information

as "non-capitalist". This is a quite reasonable assumption as many non-capitalists were poor and transient and could easily be accidentally skipped by U.S. Census takers, whereas capitalists, being relatively rich, permanent residents, business owners, and socially prominent were not likely to be skipped in a small town.

Results

Honey Collectors

Does group size predict per capita yields? We found no relationship between group size and per capita success for either *hejjenu* (*Apis dorsata*) or *thuduvejenu* (*Apis cerana*) honey. Success is similar regardless of group size within each honey type (Figure 2). An information criterion analysis of both a linear and quadratic model show that the linear model better explains the data without overfitting the data ($AIC_{linear} = 301.81$; $AIC_{quadratic} = 303.47$) (Akaike, 1975). A generalized linear model produces estimates of an intercept and slope for group size (β), where estimates of 0 support the hypothesis of no effect of group size. The estimated β for per capita profits for *Hejjenu* was 90.05 +/- 90.54 (n = 19). The estimated β for *Thuduvejenu* profits was -26.75 +/- 80.44 (n = 33). Since standard errors are similar to or exceed parameter estimates, sizes of groups on success can be effectively interpreted as having no effect size.

(Fig. 2 here)

Does group composition predict group size? A Poisson generalized linear model predicts no relationship between proportion of kin in a group and group size for either *hejjenu* (β= -0.4 +/- 0.27, p= 0.14; n = 19) or *thuduvejenu* (β= 0.13 +/- 0.28, p= 0.63; n = 33). Table 1 displays the most common relationships between informants and group members, which vary by the type of honey collected. *Hejjenu* collecting trips generally include more friends, as well as close kin. *Thuduvejenu* collecting trips tend to include more distantly related kin. Brothers-in-law are traditionally a category of relative who is important for risky honey collecting (he trusts you since your sister is the one who will suffer if you let him down). Across all honey types, we found no correlation between the proportion of friends included in a honey-collecting group and group size.

Ethnographic observations of honey collecting trips reveal that individuals join groups for many purposes and joiners are rarely rejected. *Hejjenu* collecting trips are often also pleasure excursions - time away from the workplace and home with close friends and relatives. *Thuduvejenu* is sometimes taken opportunistically, on the way to or from work on a coffee estate, or seen while walking through the forest between villages. Collecting trips can also be educational - in our survey we documented one trip where a man was teaching his two sons to collect honey, and one with the purpose of teaching KD about honey collecting.

Table 1
Frequency of relationship types included on honey collecting trips.

Relationship	Frequency of inclusion (*hejjenu*; n = 66)	Frequency of inclusion (*thuduvejenu*; n = 75)
Friend	44%	29%
Brother	14%	23%
Cousin	20%	11%
Relative	4%	12%
Brother-in-law	11%	4%
Other	7%	21%[3]

Silver prospectors

Does group size predict per capita yields? We find no evidence that group size is related to per capita yields. Logistic regression models produce estimates of an intercept and estimates of slopes for group size (β) and a quadratic term for group size (γ), where estimates 0 supporting the hypothesis of no effect of group size. For claims that were ever sold, the estimated β for if our random subset of pre-1894 hardrock (n=435) was -0.10 +/- 0.11 and the estimated γ was 0.03 +/- 0.03. For the same sample of claims with an affidavit of labor filed, the estimated β was -0.19 +/- 0.11 and an estimated γ of 0.04 +/0 0.03. Since standard errors are similar to parameter estimates, the effects sizes of group sizes on these proxies of success can be effectively interpreted as nil. For the same subsample of claims (n=435), there is no visible effect of group size on the length of interest in the claim. Figure 3 demonstrates that there is no apparent effect of group size on the length of time a claim was of legal interest.

(Fig. 3 here)

Does group composition predict group size? We found evidence supporting our hypotheses that kin and people with special skill would allow for larger groups. A generalized linear model predicts a positive and significant parameter estimate for both presence/absence of kin (β= 1.10 +/- 0.17, p< 0.0001) and presence/absence of a capitalist (β=0.47 +/- 0.22, p= 0.0319). The effect size for presence/absence of kin is not driven entirely by groups of one individual. When groups of 1 are excluded from analysis the presence of kin is also positively and significantly correlated with group size (β= 0.63+/- 0.16, p= 0.0001).

Discussion

Studies from the animal behavior and ethnographic literature produced a conventional model that stressed the importance of profitable foraging for determining the size of foraging groups. The conventional model also incorporated the pressures of social relationships (kinship, reputation, etc.) and its potential to increase group size. Two recent studies on the Martu and the Aché directly challenge this model (Bliege Bird et al. 2012; Janssen & Hill 2013). Our research also challenges the conventional model; we observe that social interactions can be a primary factor in shaping group size and composition.

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[3] The other category for *thuduvejenu* consists primarily of uncles and nephews, accounting for 8% of relationships in collecting groups.

Social foraging can optimize per capita returns when group size maximizes the benefits of labor sharing but is not outweighed by the costs of within-group competition (Schoener, 1971; Cody, 1974; Brown, 1982). Human groups have been observed to coordinate labor to effectively increase returns above solitary foraging when possible or profitable (Beckerman 1983, Imamura-Hayaki 1996). Humans also appear to expand group size because of social constrains like kinship and reputation (Smith 1981, 1985; Alvard & Nolin 2002; Alvard 2003). This research produces a conventional model where economics and social relationship both play a role in shaping foraging group size. This conventional model generally appeals to our understanding of how foragers must make flexible decisions contingent on local circumstances.

However, this conventional model does not seem to make good predictions for all humans. At least for the Martu (Bliege Bird et al. 2012) and the Aché (Bliege Bird et al 2012, Janssen & Hill 2013), there is little relationship between returns from cooperative foraging and group size (Bliege Bird et al. 2012, Hawkes et al. 1982, Janssen & Hill 2013). We too observe no demonstrated difference in the success of groups of varying size for honey collectors or silver prospectors. We provide two explanations for these results from our ethnographic and historic experience with these groups.

Honey collectors are experienced foragers who match group size to *continuously varying patch quality*. As seen in Figure 1, we expect group size to vary with prey type. Thus, honey-collecting groups foraging for *hejjenu* tend to be larger than groups collecting from the smaller *thuduvejenu* hives. This pattern follows the model assumption that different prey types will have different optimally sized groups. However, significant variation in size of prey exists within types of honey, since hives vary widely in quantity and quality. *Hejjenu* hives can be observed hanging from trees; collectors claim they can guess the amount of honey inside a *thuduvejenu* hives by listening to bee activity inside the tree trunk. Honey collectors keep private internal maps of hive locations and may choose among them when setting out for a collecting event depending on group size, composition, distance, weather, and other factors. Since the Jenu Kuruba are experienced foragers with a great deal of local ecological knowledge, they can plan ahead for potential hive size and titrate group size accordingly or, depending on the number of participants, they can choose an appropriate hive to exploit since there are many hives in the forest. Because the size of prey varies continually, so we would expect group size to vary as well. Since the amount of honey in beehives varies continuously, each hive will have a different optimal group size and we will not observe a relationship between group size and per capital returns across collecting events.

Because hive size can be reconnoitered ahead of time, honey collectors can take advantage of size differences to flexibly include group members for learning or socialization opportunities. For many collectors, we observed that inclusion on a honey-collecting trip was to spend time in the forest with friends – also the most common relationship reported in honey collecting groups. Collectors specifically remarked that they bring juveniles on honey-collecting trips (or at least tolerate their presence) so that the youngsters might watch and learn. Kin within the same generation are included in a majority of groups, although there is no correlation between proportion of kin and group size. We observe proximate motivations to be the most important factor affecting group composition for honey collectors where they may select between variable patches.

Silver prospectors are neophyte foragers with *poor information about the quality and distribution of resources* making foraging decisions based entirely on group composition. Similar to the Jenu Kuruba, we observed no difference in the success of groups of varying size in 19th century silver prospectors. However, the reason why no one optimal group size was found is different from the Jenu Kuruba; silver prospectors were not titrating group size to available resources. They could not because 19th C. silver prospectors in Gothic violate theoretical assumptions of near-perfect information about the local environment (Smith & Winterhalder, 1992). The majority of Gothic prospectors came from Midwestern farms, and were neophyte mineral prospectors (Glover & Towner, 2009). While they may have picked up some local information in saloons and newspapers, these sources tended to inflate potential foraging prospects in the region in order to attract more migrants (Glover, 2009). Thus, prospectors would not have really known the locations or quality of ore before forming a prospecting group.

The lack of local knowledge is a serious problem for silver prospectors. Alvard and Nolin (2002) and Sosis (2002) demonstrate the importance of local knowledge for foraging success. When Lamalerans observed an unusually small number of successful hunts early on during the 1999 whaling season, fewer and fewer boats left the beach each morning and hunters instead pursued other tasks as the season continued (Alvard and Nolin 2002). Bad

 weather and poor returns to cooperative fishers on Ifaluk atoll lead to greater amounts of individual fishing the following day (Sosis 2002). The fishermen explained that they had expected to do better on these cooperative fishing trips with low success (Sosis 2002).

Prospectors lacking reliable information could not form economically optimal groups, so they built groups that would function socially. In fact, given the lack of knowledge prospectors had about their environment, social predictors where the almost the only information they had to work with. In essence, they made the best of a bad situation. Kin and the presence of a capitalist investor are important predictors for larger prospecting groups among silver miners. Kin were most likely preferred group members because of increased levels of trust and inclusive fitness, as has been demonstrated in other contexts (Rodman, 1981; Smith, 1981; Smith 1985; Giraldeau & Caraco, 1993; Higashi & Yamamura, 1993; Mathot & Giraldeau, 2010). With minimal law enforcement and a potential for group members to abscond with profits, trustworthiness would have been valued in these cooperative ventures. Likewise, it has been observed in other species that individuals with special skills are preferentially included in groups (Stander, 1992; Stander & Albon, 1993; Ranta, 1993). Access to funds for food, mules and other mining supplies lead prospectors to preferentially include capitalist investors in their groups.

Previous animal behavior and ethnographic research has primarily focused on the importance of maximizing per capita yields, with the caveat that social constraints are of importance as well. It is interesting and vital to test out our simple models in order to build better ones (Winterhalder 2002). There are now four documented case studies for which this model falls apart (Martu, Aché, 19th C. silver prospectors in the U.S., Jenu Kuruba). Our research demonstrates the importance of accurate information and social relationships for how humans can form foraging groups. For knowledgeable foragers, like the Jenu Kuruba, they can match each foraging patch to group size, making any attempt at resolving aggregate optimality curves impossible. However, we can investigate how they adjust group size and composition to maintain social bonds. Neophyte foragers, like silver prospectors must make the best decision they can with little good information about patch quality or location. Thus, there is no way to resolve optimality curves from a population like this one. Instead, we can study how they were forced to compose groups based almost entirely on social factors like kinship and reputation. These findings fit into the larger theoretical discussions that behavioral ecologists are currently having about how local cultural and ecological contexts shape human behavioral decision-making (Glover, 2009; Lopez et. al, 2011). Future foraging models of group formation must take local context into account and allow for situations in which economics or social relationships have primacy.

Acknowledgements

References

Akaike, H. (1975). Markovian representation of stochastic processes by canonical variables. -SIAM Journal on Control 13: 162-173.

Alvard, M. (2003). Kin preference and partner choice: Patrilineal descent and biogical kinship in Lamaleran cooperative relationships. Hum. Nat. 22:156-176.

Alvard, M., & Nolin, D. (2002). Rousseau's whale hunt? Coordination among big game hunters. –Curr. Anth. 43(4): 533-539.

Baird, R.W. & Dill, L.M. (1996). Ecological and social determinants of group size in transient killer whales. -Beh. Eco. 7(4): 408-416.

Beckerman, S. (1983). Optimal foraging group size for a human population: The case of Bari fishing. -Amer. Zool. 23: 283.

Benoit-Bird, K.J., & Au, W.W.L. (2009). Cooperative prey herding by the pelagic dolphin, *Stenella longirostris*. –J. Accost. Soc. Am. 125(1): 125-137.

Boesch, C. (1994). Cooperative hunting in wild chimpanzees. –Anim. Behav. 48: 653-667.

Boyd R., Richerson P., & Henrich J. (2011). Rapid cultural adaptation can facilitate the evolution of large-scale cooperation. -Behav. Ecol. & Sociob. 65 (3): 431-444.

Brown, J.L. (1982). Optimal group size in territorial animals. -J. Theor. Bio. 95(4): 793-810.

Caraco, T. (1979). Time budgeting and group size: A test of theory. - Ecol. 60(3): 618-627.

Caraco, T., & Wolf, L.L. (1975). Ecological determinants of group sizes of foraging lions. - Amer. Nat. 109(967): 343-352.

Census of India (2001). http://www.censusindia.gov.in/Tables_Published/SCST/STRC_29.pdf

Clark, C.W. (1987). The lazy, adaptable lions: a Markovian model of group foraging. -Anim. Behav. 35: 361.

Clark, C.W., Mangel, M. (1984). Foraging and flocking strategies: Information in an uncertain environment. -Amer. Nat. 123(5): 626-641.

Cody, M.L. (1971). Finch flocks in the Mohave desert. -Theor. Pop. Bio. 2: 142.

Colorado Historical Society. Denver, Colorado: Colorado State Business Directories (1880-1885).

Creel, S., & Creel, N.M. (1995). Communal hunting and pack size in African wild dogs, *Lycaon pictus*. -Anim. Behav. 50: 1325-1339.

Giraldeau, L.A. (1988). The stable group and the determinants of foraging group size. -In: The ecology of social behavior (Slobodchikoff, C.N., ed.). Academic Press, San Diego, p. 33-53.

Giraldeau, L.A., & Caraco, T. (1993). Genetic relatedness and group size in an agregation economy. -Evo. Ecol. 7:429-438.

Gjolberg, O., & Nardhaug, O. (1996). Optimal Investment Committee Sizes. -J. Portfolio Manag. 22(2): 87-93.

Glover, S.M. (2009). Propaganda, public information, and prospecting: explaining the irrational exuberance of central place foragers during a late nineteenth century Colorado silver rush. -Hum. Ecol. 37(5): 519-531.

Glover, S.M. & Towner, M.C. (2009). Long-distance dispersal to the mining frontier in late 19th century Colorado. -Behav. 146: 677-700.

Goñi, R., Adlerstein, S., Alvarez-Berastegui, D., , Forcada, A., Reñones, O., Criquet, G., Polti, S., Cadiou, G., Valle, C., Lenfant, P., Bonhomme, p., Pérez-Ruzafa, A., Sánchez-Lizaso, J. L., García-Charton, J. A., Bernard, G., Stelzenmüller, V., & Planes, S. (2008). Spillover from six western Mediterranean marine protected areas: evidence from artisanal fisheries. -Marine Ecology Press Series 366: 159-174.

Gunnison County Recorder's Office. Gunnison, Colorado.; Judge's Notes on Criminal and Civil Court Cases (1880-1884); Mining Claim Records 1879-2002.

Haase, C.L. (1971). Gothic, CO City of Silver Wires. Western College. Master's Dissertation, Western State College, Gunnison.

Hammel, E.A. (2005). Kin-based politics and the optimal size of kin groups. -PNAS 102(33): 11951-11956.

Hawkes, K. Hill, K., O'Connell, J. F. (1982). Why hunters gather: Optimal foraging and the Ache of Eastern Paraguay. Amer. Ethnologist 9(2): 379-398.

Higashi, M., & Yamamura, N. (1993). What determines animal group size? Insider-outsider conflict and its resolution. -Amer. Nat.142(3): 553-563.

Howell, D.J. (1979). Flock foraging in nectar-feeding bats: Advantages to the bats and to the host plants. -Amer. Nat. 114(1): 23-49.

Imamura-Hayaki, K. (1996). Gathering activity among the Central Kalahari San. -African Study Monographs 22: 47-66.

Janssen, M. A., Hill, K. (2012). Benefits of grouping and cooperative hunting among Ache hunter-gatherers: Insights from an agent-based foraging model. CSID Working Paper Series.

Jarman, P.J. (1974). The social organization of antelope in relations to their ecology. -Behav. 58: 215-267.

Kramer, D.L. (1985). Are colonies supraoptimal groups? -Anim. Behav. 33(3): 1031-1032.

Kruuk, H. (1975). Functional aspects of social hunting by carnivores. -In: Function, evolution, and behavior. (Baerends, G., Beer, C. & Manning, A, eds.). Carendon Press, Oxford, p. 119-141.

Leslie J. Savage Library at Western College. Gunnison, Colorado: Elk Mountain Bonanza (July 1880- March 1881).

Lopez, P.F.M., Clauzet, M., Hanazaki, N., Ramires, M., Silvano, R., & Begossi, A. (2011). Foraging behavior of Brazilian riverine and coastal fishers: How much is explained by the optimal foraging theory? -Conservation and Society 9(3): 236-246.

Mathot, K.J., & Giraldeau, L. (2010). Within-group relatedness can lead to higher levels of exploitation: a model and empirical test. -Behav. Ecol. 21(4): 843-850.

Nudds, T.D. (1978). Convergence of group size strategies by mammalian social carnivores. -Amer. Nat. 112(978): 957-960.

Packer, C., Scheel, D., & Pusey, A.E. (1990). Why lions form groups: Food is not enough. -Amer. Nat. 136(1): 1-19.

Ranta, E. (1993). There is no optimal foraging group size. -Anim. Behav. 46: 1032-1035.

Rasmussen, G.S., Gusset, M., Courchamp, F., & Macdonald, D.W. (2008). Achilles' heel of sociality revealed by energetic poverty trap in cursorial hunters. –Amer. Nat 172(4), 508-518.

Rodman, P.S. (1981). Inclusive fitness and group size with a reconsideration of group sizes in lions and wolves. -Amer. Nat. 118(2): 275-283.

Schmidt, P.A. & Mech, L.D. (1997). Wolf pack size and food acquisition. -Amer. Nat. 150: 513-517.

Schoener, T.W. (1971). Theory of feeding strategies. -Ann. Rev. in Ecol. and System. 2: 369-340.

Sibly, R.M. (1983). Optimal group size is unstable. -Anim. Behav. 31(3): 947-948.

Smith, E.A. (1981). The application of optimal foraging theory to the analysis of hunter-gatherer group size. -In: Hunter gatherer foraging Strategies. (Winterhalder, B., & Smith, E.A., eds.). University of Chicago Press, Chicago, p. 35-65.

Smith, E.A. (1985). Inuit foraging groups: some simple models incorporating conflicts of interest, relatedness, and central-place sharing. -Ethol. & Sociob. 6: 27-47.

Smith, E.A., & Winterhalder, B., eds. (1992). Evolutionary ecology and human behavior. -Aldine de Gruyter, New York.

Sosis, R. (2002). Patch choice decisions among Ifaluk fishers. -Amer. Anth. 104(2): 583-598.

Stander, P.E. (1992). Cooperative hunting in lions: the role of the individual. -Behav. Ecol. and Sociob. 29: 445-454.

Stander, P.E., & Albon, S.D. (1993). Hunting success of lions in a semi-arid environment. -Symposium zoological society of London 65: 127-143.

Strahorn, R.E. (1881). Gunnison and San Juan. A late and reliable description of the wonderful gold and silver belts and iron and coal fields of that newest and best land for prospector and capitalist, southwestern Colorado ... as presented in a series of letters written to the "New York world" by its special correspondent, "R. E.S." Also, containing a valuable appendix on mining laws. The New West, Omaha.

Times of India (July 15, 2013). Journey of Indian rupee since independence.

U.S. Census Bureau. Gunnison County, Colorado 1880 Census. Retrieved May 4, 2005 from http://www.ancestry.com.

Vandenbusche, D. (1980). The Gunnison Country. B&B Publishers, Gunnison.

Vucetich, J.A., Peterson, R.O., & Waite, T.A. (2004). Raven scavenging favours group foraging in wolves. -Anim. Behav. 67: 1117-1126.

Warren, E. (1924). Diary of Edgar Warren, Written in 1924 Recalling the Old Days, May 1882–Fall 1896. Rocky Mountain Biological Laboratory Archives, Gothic.

Winterhalder, B. (2002) Models. –In: Darwin and Archaeology: A handbook of key concepts (Hart, J., & Terrel, J., eds.). Greenwood Publishing Group, New York, p. 201-233.

Wolle, M.S. (1949). Stampede to Timberline: The Ghost Towns and Mining Camps of Colorado; C. L. Haase, Gothic, CO City of Silver Wires.

Yip, E.C., Powers, K.S., & Aviles, L. (2008). Cooperative capture of large prey solves scaling challenge faced by spider societies. -PNAS 105(33): 11818-11822.

Figure 1: Graphical model of group formation depending on group composition. If group members have no control over group membership, then individuals will join the group until the rewards of joining a group are the same as foraging alone (nS: Sibly size). Typically group members do have control over group membership. Point nA is where the cooperative benefits are outweighed by the costs of competition over the resources gained or "optimal group size". If potential joiners are related to group members, group members may allow the relative to join the group past nA and to nB because of inclusive fitness and increased trust. All individuals do not have equal competitive abilities. Those individuals that are particularly competitive will be more productive than other individuals. Groups with highly competitive members will be generally larger than groups without because the group foraging yield can be potentially larger. Also, a group of less competitive individuals may try to pick up a competitive member to increase total group product. Generally, the optimal size for these groups will be larger than groups without competitive members (nC).

Figure 2: Box plots representing per capita profits in Rupees by group size for a) *Hejjenu* honey (A. dorsata, n = 19), and b) *Thuduvejenu* honey (A. cerana, n = 33). Groups are larger, on average, for collecting *Hejjenu*, but there is no apparent correlation between group size and foraging success.

Figure 3: Box plots representing the length of time a claim was of active legal interest (years) by group size (n=435). There is no apparent change in the median length of interest by group size. Note that few large groups are actually formed, which might indicate that these groups were actively avoided by prospectors.