

Kinship, Culture, and an evolutionary perspective on the structure of cooperative big game hunting groups in Indonesia¹

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Abstract

Work was conducted among traditional, subsistence whale hunters in Lamalera, Indonesia in order to test if kinship or lineage membership is more important for explaining the organization of cooperative hunting parties ranging in size from 8-14 men. Crew identifications were collected for all 853 hunts that occurred between May 3 and August 5, 1999. Lineage identity and genetic relatedness were determined for a sample of 189 hunters. Results of matrix regression show that kinship explains little of the hunters' affiliations independent of lineage identity. Crews are much more related amongst themselves than expected by chance. This is due, however, to the correlation between lineage membership and kinship. Lineage members are much more likely to affiliate in crews, but beyond $r = 0.5$ kin are just as likely not to affiliate. The results are discussed vis-à-vis the evolution of cooperation and group identity.

Introduction

People frequently form cooperative groups in order to realize the benefits of collective action. While humans are not the only species that forms social groups, we are unique in the degree to which we regularly rely on the help of conspecifics to satisfy basic needs such as subsistence, defense, and offspring care (Hill 2002). In simple foraging groups, people help one another care for children (Ivey 2000), acquire difficult to obtain resources (Alvard and Nolin 2002), share food (Kaplan and Hill 1985), and fight other groups (Chagnon and Bugos 1979). In complex contemporary society instances are even easier to come by. Examples include unions, political parties, nation states, firms, college fraternities, sports teams, and universities.

Kin selection (Maynard Smith 1964) and inclusive fitness theory (Hamilton 1964a, 1964b) offers good evolutionary explanations for why cooperation among relatives should be common. Kin selection is the process by which traits are favored because of their beneficial effects on the survival of relatives (Grafen 1984). Because kin share genes due to common descent, behaviors that increase the reproductive success of relatives can also increase the future representation of ego's genes. Thus, kin selection theory predicts that, all other things equal, individuals will be more likely to favor kin than non kin, and close kin than more distant kin. Hamilton's well-known rule predicts altruism can evolve if the following equation obtains $rB - C > 0$, where r = the coefficient of relatedness between the actor and the recipient, B = the fitness benefit to the recipient, C = the fitness cost to the actor. The coefficient of relatedness is defined as the probability that two individuals share a copy of an allele through common descent (Wright 1922). For example, between sibs $r = 0.5$, between grandparent and grandchild $r = 0.25$, and between cousins $r = 0.125$. Thus, nepotism will evolve if the recipient of the favor is sufficiently related, the benefit is sufficiently great, or the cost sufficiently low. Kinship has been shown to be an important social organizing principle across a wide variety of taxa (Dugatkin 1997), and especially so in the social insects (Bourke 1997).

For example, Sherman's work on Belding ground squirrel alarms calls is well-known (Sherman 1977). Among humans, some of the best work shows that people are less likely to kill kin than non-kin (Daly and Wilson 1988; Johnson and Johnson 1991). Chagnon and Bugos' (1979) analysis of a Yanomamo axe fight was among the earliest analysis to use kin selection theory to examine human social behavior. As predicted, combatants on each side were more related to one another than expected by chance.

Within fields of study that take an evolutionary approach to human behavior, the role of kinship in explaining cooperative behavior within preindustrial societies is now taken for granted to some extent (Alexander 1987; Chagnon 1979, 1980; Hamilton 1975; see review by Voland 1998:363), although as I shall show, the extent of its importance is ambiguous (Brown 1991; Jones 2000; Richerson and Boyd 1998) Kinship has also long been argued by cultural anthropologists to be the primary organizing principle in tribal societies (Kuper 1982, 1996). In spite of what appears to a common ground, however, there has been little work over the last twenty years to integrate the two approaches. Indeed, kinship within the field has been "denaturalized" by many cultural anthropologists in the late twentieth century (Collier and Yanagisako 1987; Schneider 1984; for a review see Peletz 1995). A standard critique of kin selection theory applied to humans points to the incongruity between kin -- genetically defined, and kin-- culturally defined, to put it simply. This point was made the strongest by Sahlins (1976:58) when he stated "Kinship is a unique characteristic of human societies, distinguishable precisely by its freedom from natural relationships." The hyperbole of this statement seems obvious. But while it is impossible to maintain the position that cultural kinship has nothing to do with genetic kinship, it is equally difficult to deny that people commonly organize themselves in ways that do not correspond to coefficients of relatedness.

Sahlins (1976:26) wrote, "...local kinship networks...will comprise a determinate and biased proportion of any person's genealogical universe." ² This is most apparent in

systems of unilineal descent. Genetic kinship does not distinguish between individuals equivalently related. People who follow norms of unilineal descent, however, define as kin only those persons who share common descent through either the male or female parent. In such systems, two people who are each equally related to Ego genetically may be defined differently according to kinship norms -- one as in-group member, the other as an out-group member. In Sahlins' words "...even so the son of a man's brother may be one of the clan of the ancestor's descendants while the son of his sister is an outsider and perhaps an enemy" (1976:12). In a patrilineal system the coefficient of relatedness for Ego and his mother's brother's son, and his father's brother's son (both called cousins in English) is 0.125. While the latter shares Ego's lineage identity, the former does not. The difference is not simply a semantic one, as I will show below. The social relationships between ego and these individuals differ though the genetic relationship does not (see Figure 1).

A kinship system based on kin selection, all other things being equal, predicts a bilateral descent or kindred system (implied by Murdock 1949:57). Kindreds are ego-based and consist of the group of all near relatives. In contrast to a unilineal system, in a kindred system no distinction is made between relatedness reckoned through one or other of the parents' lineages. Cross-cultural work notes the relative rarity of such systems; only 36% of the 857 societies in Murdock's ethnographic atlas have bilateral descent systems. Unilineal systems are much more common: 47% in Murdock's sample practice patrilineal descent, 14% practice matrilineal descent, and 3% claim a double descent system (Murdock 1967).

Structural-functional anthropologists of the mid 20th century offered a number of hypotheses to explain why groups might develop unilineal descent, though they did so without knowledge of kin selection theory, of course. The most compelling argument is that group members organized by unilineal kinship ties have the advantage of unambiguous group identity (Murdock 1949:60-61). This is because only full siblings share an identical network of kin since only sibs share parents. Other classes of relatives, like cousins for example, share only a portion of their kin in common. While cousins share a set of grandparents, they each also share a second set of grandparents with a different set of cousins (unless their parents were cousins themselves, of course).

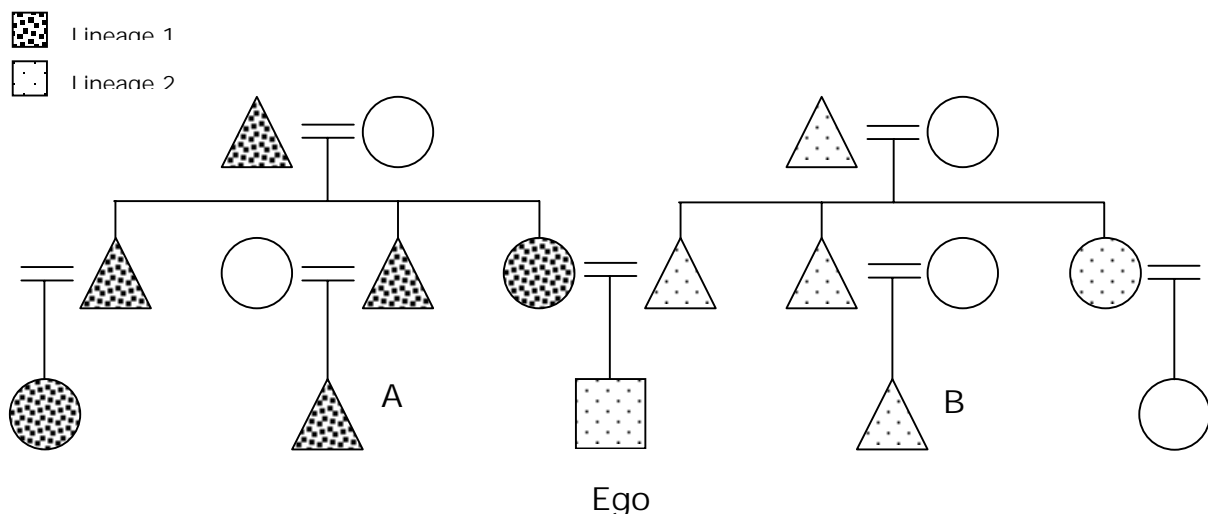


Figure 1. The relationships between ego and his two cousins marked A and B. The coefficients of relatedness between Ego and both A and B are 0.125. In a patrilineal system B shares Ego's lineage identity, A does not.

In what sorts of contexts would the advantages of unambiguous group identity obtained via unilineal descent play out? The answers tend to revolve around corporate political solidarity where groups reap benefits from acting collectively in defense of either property or persons (Sahlins 1961). A number of authors stress the advantages of unilineal descent in the context of conflict (Boehm 1992; Embers et al. 1974; Otterbein and Otterbein 1965; Sahlins 1961; Service 1962). Lower order segments that organize by unilineal descent principles can more easily combine into higher order segments when needed. Loyalties are not diffused like they are across kindreds. The advantage of such a system is exemplified by the Nuer and their territorial expansion at the expense of the Dinka (Evans-Pritchard 1940; Kelly 1985). Sahlins (1961) offers the Tiv expansion as another example. Other researchers argue that lineages are advantageous in a context where cooperatively held property is common (Goody 1962; Lowie 1920; Radcliffe-Brown 1935). Recent work on Chinese lineage systems, for example, show that lineages work to keep resources together and function to take advantage of economies of scale otherwise unattainable when inheritance disperses resources across bilateral kin (Cohen 1990; Freedman 1958).

While they differ in their foci, both sets of theories argue that unilineal descent systems are solutions to collective action problems. Van den Berghe (1979) evokes these earlier anthropologists when he tries to understand lineage systems from the perspective of kin selection theory. Like Sahlins, van den Berghe notes that at face value it is incongruous with kin selection theory that half of one's kin be excluded from those considered culturally as kin. Rather than reject kin selection theory, as did Sahlins (1976), van den Berghe offers a hypothesis that reconciles Sahlins critique with kin selection theory. Following Murdock (1949) and others, van den Berghe notes the problems organizing kinsmen into collective action with a kindred system. If cooperative groupings were based solely on kinship, conflicts of interest would erupt between kin related to a degree less than $r = 0.5$. Which group of kin does one ally with in a conflict? Who shares ownership of corporate property? Which set of cousins does one cooperate with? Van den Berghe argues that lineage systems solve this problem by normatively defining certain categories of relatives as kin and others as not kin. While disenfranchising half of one's kindred may result in certain lost benefits, otherwise unattainable within-lineage collective action benefits presumably outweigh the cost.

In addition to producing ambiguous groups, the ultrasocial character of human society leaves kin selection wanting as an explanation. While organization based on genetic kinship is predicted to easily produce small cooperative groups focused around the nuclear family, it is more difficult to see how larger groups of closely related individuals can form. This is because relatedness drops off rapidly as the genealogical distance from the nuclear family increases (Brown 1991; Jones 2000; Richerson and Boyd 1999). While kin selection can more easily explain the small-scale societies found among our non-human primate brethren, it is harder to example the complexity found in even simple foraging societies.

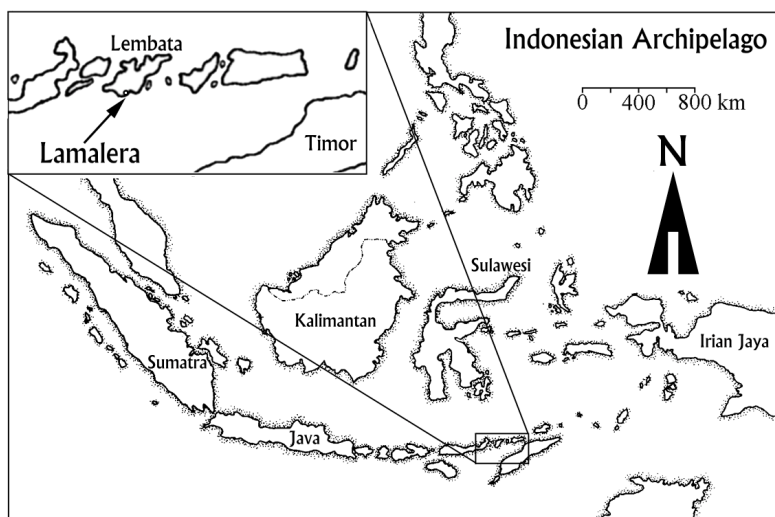
Foraging societies are simple by comparison with modern societies, but even the simplest contemporary hunting and gathering peoples, like !Kung San and the peoples of Central Australia, link residential units of a few tens of people to create societies of a few hundred to a few thousand people. This multi-band "tribal" level of organization is absent in other apes (Rodseth et al. 1991; Boehm 1992). Especially in the simplest cases, tribes are held together by sentiments of common membership, expressed and reinforced by informal institutions of sharing, gift giving, ritual, and participation in dangerous collective exploits (Richerson and Boyd 1999: 254).

It is perhaps because of his complete rejection of biological principles that Sahlins' criticism of kin selection theory was completely rejected by evolutionary anthropologists and others (Dawkins 1989). In addition, Sahlins did not offer a compelling alternative to explain why people do what he describes. The solution is not to dismiss kin selection, however, but rather to see how kin selection can be modified. This paper will explore these issues in the context of cooperative hunting. As I will argue in more detail below, groups involved in certain types of cooperative, technically referred to as coordination or mutualism, benefit greatly from social organization that produces unambiguous group membership. In the whaling community of Lamalera, sibships are not large enough to field a crew, much less produce enough members to form the corporate units required for maintaining whaling operations. Organization based on larger kindreds would provide ambiguous membership and the resulting problems discussed above. As a result, group identity based on unilineal descent is hypothesized to facilitate formation of sufficiently large corporate groups whose members have confidence in one another to follow norms of participation in resource acquisition, distribution, and defense.

Using affiliation data collected during hunts from the whaling community of Lamalera, I will test between strict kin selection and unilineal descent principles as hypothesized models organizing affiliation among hunters. While the Lamalerans have norms of patrilineal descent, it is unclear whether affiliative behavior follows the norms or whether hunters affiliate by kinship regardless of the norms.³ Since lineage and kinship are correlated (see below), both hypotheses predict that affiliates will be more closely related than expected by chance. Following the arguments above, if lineage identity is more salient than kinship for men who organize themselves into hunting crews, lineage membership is predicted to explain a larger proportion of the variance in affiliation among crews, after genealogical relationships are controlled. The strict kin selection argument predicts kinship per se will explain more of the variance in affiliation.

Field site

Data were collected from October 1998 through August 1999. The village of Lamalera is located on the south side of the island of Lembata, in the province of Nusa Tenggara Timur, Indonesia (Figure 2). The people of Lamalera are complex marine foragers. They are non-egalitarian, live at a relatively high population density for foragers, are not very mobile, have specialized occupations, corporate descent groups, and food storage.



Subsistence at Lamalera revolves around cooperative hunting for large marine mammals and ray. The primary prey are sperm whale (*Physeter macrocephalus*), and ray (*Mantis birostris*, *Mobula kuhlii*, and *Mobula diabolus*). The Lamalerans produce little of their own carbohydrates; most are obtained in the form of maize, plantains, manioc and rice at barter markets from villagers living in the interior of the island. Barnes (1996) provides a site. As of August 1999 there were

Figure 2. Field site location.

1,213 residents [328 adult males, 482 adult females, 403 individuals under the age of 18]. The Lamalerans reckon kinship via patrilineal descent, and practice asymmetric marriage alliance between descent groups (Barnes 1998). The village is divided into 21 major named patrilineal clans (*suku*), the larger of which are further divided into named lineages or segments called *lango béla* (great house). It is the segments that maintain whaling operations.

Eighteen of the segments maintain corporate whaling operations focused around traditional whaling vessels called *téna*. The eighteen sub-clans operated twenty active *téna* in 1999 (one sub-clan maintained three *téna*). There are many clan segments that do not operate their own whaling corporation. This is largely a function of segment size (Alvard 2002).

Killing prey with a *téna* is a manifestly cooperative activity, impossible to accomplish alone (Alvard and Nolin 2002). Participants in each whaling operation are divided into three general categories: the crew, corporate members, and technicians. *Téna* are crewed by 8-14 men. Within crews, there are a number of specialized roles that are usually though not exclusively the prerogative of one man. These include, the harpooner (*lama fa*), the harpooner's helper (*beréun alep*), and the helmsmen (*lama urî*). The balance of the crew, which include two bailers (*fai matā*), man the oars. The technicians - the carpenter, sail maker, smith, and harpoon bamboo provider (often the harpooner) are specialists and may or may not be clan members or crew. Finally, corporate members are lineage members who fill name corporate positions and are called upon to provide resources as needed; their contribution is most important when the boat is being rebuilt. Overseeing the operation is the *téna alep* (literally boat owner) who acts as a nexus for the whaling operation to coordinate the three groups.

During the active whaling season, which lasts from May 1 through September, boats go out daily except for Sundays, weather permitting. In 1999, 853 hunts were observed with 131 large game items harvested and providing approximately 40,103kg of meat. In contrast to many hunters (Hawkes 2001), Lamalera hunters retain control of their prey after they return to the village. Meat distributions follow a complex set of norms with primary shares limited to crew, technicians, and corporate members of the boats that participate in the kill (see Alvard 2002).

Crew composition is flexible and varies through the season. Most boats, however, have a core set of crewmembers that go out together regularly, as I will show. The core members are usually from the clan segment, but this is not always the case. Boat masters begin recruiting crews in the spring, especially in the relatively dead months of January and February when few people are at sea. Informants report a number of factors to explain why men crew certain *téna*. The most common response is that men who are kin and share lineage membership crew boats together. Informants also report that men will sometimes crew on the boats organized by their wife's or mother's lineage. This is especially important for men who belong to lineages that do not have enough members to field their own boat.

Methods

On every foraging day the identity of all crewmembers for each *téna* was recorded as the boats returned in the afternoon from the day's hunt. Crew counts collected each day as boats departed facilitated completing the lists. Crew identifications were collected for all hunts that occurred between May 3, 1999 and August 5, 1999. A total 853 *téna* hunts were observed over the course of the 80 hunt days. The number of observed man-hunts was 9,041 and 290 men were observed to have hunted.

Data on lineage memberships were obtained via interviews with informants. Lineage membership is widely known and is easily elicited from informants. Kinship data were collected through interviews, and parentage was determined for each individual. Kinship between pair of men is measured as the coefficient of relatedness [r] defined as the probability that two individuals share a copy of an allele through common descent (Wright

1922). For pairs of individuals within the community, the coefficient of relatedness was calculated using pedigrees developed from the kinship data and a computer program written by Dr. Jeff Long.

Depending on the analysis below, a number of samples are used. Most of the analyses focus on a sample of 189 of the 290 men who ever hunted. The 189-man sample is created in the following way. Since the resolution of r depends on the depth and completeness of the pedigree, the sample is first limited to individuals whose pedigrees are at least complete to their grandparents. This ensures resolution to the level of $r=0.125$. Second, the sample includes only men whose patriline is known. These two filters produce a sample of 220 men. Finally, to produce the sample of 189 the sample is additionally reduced to include only regular hunters. This is done by excluding men who fell below the 10th percentile in terms of the total number of days hunted. Men who hunted 6 days or more during the field season are included.

Affiliation is scored when two men crewed on the same boat on the same day. Using the crew affiliation data, an affiliation matrix A is created with each hunter represented by both a row (i) and a column (j). In each cell a_{ij} is placed the number of times each pair of men participated on the same hunt on the same day. The 189-man sample creates a matrix with 35,721 cells, although only 17,766 are unique and non-reflexive pairs. During the field session, men varied in the number of days they hunted; this number ranged from 71 to 6 days with a mean of 36 days ($N=189$). Because of this variance in the propensity to go hunting, some pairs of men might appear to be more affiliated simply because they both hunted more often. To solve this problem, the affiliation matrix is normalized using an iterative proportion fitting process. Following Bishop et al. (1975: 97-101), homogenous margins are fit to the affiliation matrix. That is, for each dyad, the normalized number of affiliations is determined by assuming that all hunters hunted the same number of times (in this case 100 times). To eliminate non-diagonal zeros, a small non-zero value (.00001 in this case) is added before normalization as suggested by Freeman et al. (1992). Finally, from the normalized matrix, a Pearson's product-moment correlation similarity matrix is produced. In this matrix each cell contains the correlation score for each pair of men (Row versus column) from the normalized matrix.

The model matrices are created as follows. The lineage affiliation matrix is created by scoring a 1 in the cell for dyads having a common lineage. If the pair does not share a lineage a zero is scored. The kinship matrix is scored with the coefficient of relatedness (r) for the pair in each cell.

The relationship between the normalized similarity affiliation matrix and the model matrices are examined using a matrix permutation test (QAP; Hubert and Schultz 1975; Krackhardt 1987). This test involves first computing a Pearson's correlation coefficient between the corresponding cells of the two matrices. The rows and columns of the observed matrix are then randomly permuted and the correlation is computed again. The permutation is repeated 2,000 times in order to compute the proportion of times that a random correlation is larger than or equal to the observed correlation. A low proportion (< 0.05) suggests a relationship between the matrices that is unlikely to occur by chance. Similar permutations techniques are used to do multiple matrix regression (Smouse et al. 1986; Smouse and Long 1992; Kapsalis and Berman 1996).

In order to identify groups of men who affiliate, the similarity matrix was subjected to a multidimensional scaling analysis. Multidimensional scaling (MDS) is used to represent dissimilarities between objects as distances in a Euclidean space (Kruskal and Wish 1978). The results are plotted and used to visualize grouping patterns in the data. To associate emergent groups with boats, a k-means cluster analysis was applied to the three dimensions. This method is designed to minimize within-cluster variability while maximizing between-cluster variability and then assign individuals to each cluster (Bishop 1995).

Results

Using the 189-man sample mentioned above, the MDS analysis specifying three dimensions results in a stress value = 0.272 after 6 iterations. While using more dimensions reduces the stress measure, the main goal of the MDS is to display and facilitate interpretation of the clusters. With the aid of the three-dimensional scatter plot display and rotation function of Data Desk (1999) software, interpretation is done most easily using three dimensions. A visual examination of the three-dimensional plot shows 20 clusters corresponding to the 20 téna.

In order to quantify these apparent groups and assign hunters to one of the 20 clusters, a k-means cluster analysis is done with the three roots from the MDS analysis. In addition, assignment of clusters to téna is accomplished by finding the téna that the men in each cluster most frequently crewed. In all but three of the 189 cases, men assigned to the same cluster crewed most often on the same téna. Men crewed on the boat assigned to the cluster between 63-99% of all their trips (Table 1). The MDS plot of the first two dimensions is presented in Figure 3. The polygons indicate the clusters identified by the k-means analysis.

Cluster	Associated téna	Associated Corperate lineage	Average proportion of trips on Téna	Range
1	Holo Sapang	Kifa Langu	0.64	1.00 - 0.43
2	Dolu Tena	Kebesa Langu	0.89	1.00 - 0.72
3	Bui Puka	Teti Nama Papa	0.90	1.00 - 0.77
4	Muko Tena	Ata Kei	0.91	1.00 - 0.66
5	Baka Tena	Tufa Ona	0.99	1.00 - 0.95
6	Kopo Paker	Ole Ona	0.55	1.00 - 0.36
7	Kebako Puka	Ola Langu	0.80	1.00 - 0.55
8	Nara Tena	Perafi Langu	0.87	1.00 - 0.65
9	Menula Blolo	Badi Langu	0.85	1.00 - 0.38
10	Sili Tena	Kifa Langu	0.73	1.00 - 0.46
11	Demo Sapang	Lali Nama Papa	0.93	1.00 - 0.57
12	Praso Sapang	Sinu Langu1	0.91	0.98 - 0.83
13	Java Tena	Jafa Langu	0.83	1.00 - 0.59
14	Boli Sapang	Hari Ona	0.84	1.00 - 0.63
15	Kelulus	Muri Langu	0.96	1.00 - 0.83
16	Kena Puka	Miku Langu	0.69	0.92 - 0.49
17	Teti Heri	Kaja Langu	0.80	1.00 - 0.37
18	Soge Tena	Musi Langu	0.68	1.00 - 0.50
19	Horo Tena	Kifa Langu	0.90	1.00 - 0.69
20	Sika Tena	Kelore Langu	0.63	1.00 - 0.36

Table 1. Clusters, their associated téna, and the average proportion of hunts that men assigned to clusters hunted on associated téna.

Lineage	Crew cluster																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Ata Folo					1																1
Ata Gora							1														1
Ata Kei				9*																	9
Badi Langu									4*										1		5
Bera Ona				1			1														2
Beradna Langu																			1		1
Blake Langu									1			1									2
Dae Langu					1																1
Dasi Langu																		1			1
Guma Langu									1	1		1									3
Guna Langu		1														1	1				3
Haga Langu											1		2*	1							4
Hari Ona			1			1			1					5*					1		9
Jafa Langu													2								2
Kaja Langu						1							1					3*			5
Kebesa Langu		3*										1								1	5
Keda Langu																	1				1
Kelake Langu		1				1															2
Kelodo Ona									1												1
Kelore Langu																				4*	4
Kifa Langu	2*				1					4*									3*		10
Kiko Langu		1																		1	2
Laba Langu		1							1	1			1		1	1			2		8
Lafa Langu									2												2
Lali Nama Papa											8*										8
Lango Fujo																1		1			2
Mana Langu										1	1										2
Miku Langu													1		2	6*	1				10
Muri Langu	2	1				1						1			6*	1	1		2		15
Musi Langu		2				1					1							7*		1	12
Nama Langu																				3	3
Ola Langu	1	1					8*	2												1	13
Ole Ona				1		3*			1												5
Perafi Langu								5*													5
Ribu Langu	2												1								3
Saja Langu			1					1	1						1						4
Sinu Langu1		1			2							3*								1	7
Teti Nama Papa			5*														2				7
Tufa Ona			1		6*			1				1									9
Total	7	12	8	11	11	8	10	9	13	7	11	8	8	6	10	10	9	9	10	12	189

Table 2. Frequency of lineages represented in crew clusters.

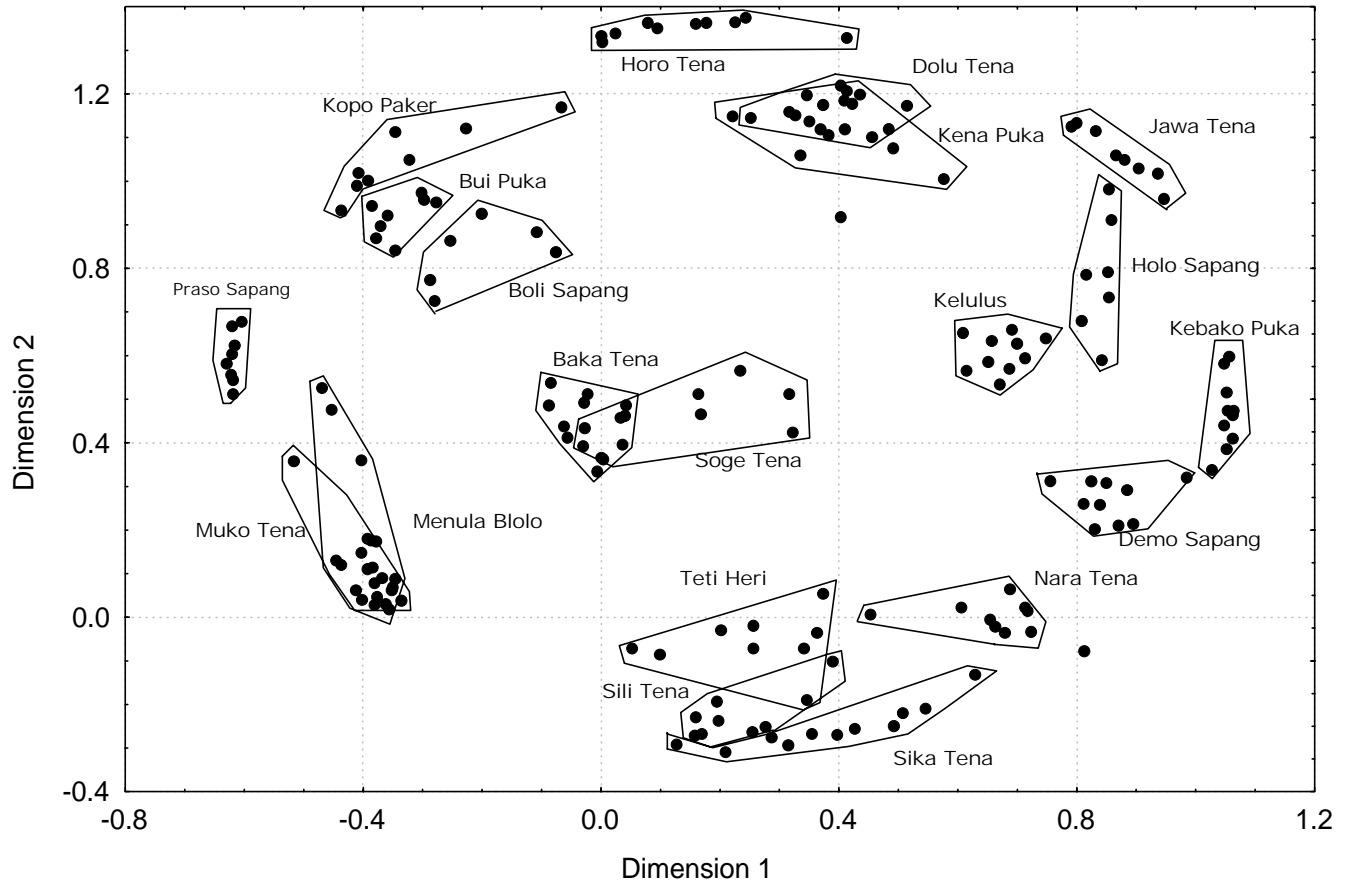


Figure 3. Scatterplot of the first two dimensions extracted from the MDS analysis.

There are a number of ways to determine if affiliated men assort non-randomly according to lineage membership. There are twenty clusters and 39 different lineages represented in the 189-man hunting sample, creating 780 possible associations. Using a simple Chi-square test to learn if the observed frequency of lineage members into clusters is nonrandom is inappropriate because the observed data show many associations with less than 5 occurrences. 680 associations did not occur at all, which provides a clue as to the non-random nature of the associations. As an alternative, I use Goodman and Kruskal's Lambda (λ) as a proportional reduction in error measure (PRE) to learn if knowledge of a hunter's lineage reduces the error assigning him to his observed crew cluster. The reduction in error is determined by comparing assignments made with lineage knowledge to assignments made randomly (Johnson 1988). This measure can also be interpreted as the strength of association between the two categorical variables of lineage identity and crew (Reynolds 1977). The analysis shows that $\lambda = 0.597$ ($P < 0.000$). This means that the error is reduced by nearly 60% over what is expected by random chance and thus shows that the association between affiliation and lineage identity is high. Table 2 shows the data. For 18 of the 20 clusters, the lineage that organizes the téna contributes the most crewmembers to the associated cluster. In the two remaining clusters, the lineage that organizes the téna tied for the lineage that contributes the most crewmembers to the associated cluster.

Since lineage membership in Lamalera is based on common agnatic descent, it is expected that fellow lineage members are more closely related among themselves than are

people within the village as a whole. The data show that this is true for both clan and clan segments. I use as a null measure of \bar{r} the average coefficient of relatedness for all dyads in the sample of 220 hunters for which pedigrees are known to the depth of grandparents. For all pairs of men in the 220-man sample $\bar{r} = 0.00631$ (sd=0.0448). Table 3 presents \bar{r} within the 32 lineages represented in the 220-man sample. A t-test of individual means shows that relatedness within lineages is much greater than expected by chance ($\bar{r} = 0.1160$, $t = 7.266$, $df = 40$, $p < 0.0001$). Correlation of the lineage matrix and the kinship matrix produces a Pearson's correlation coefficient $r = 0.460$ ($p < 0.000$; $N = 189$).

Lineage	\bar{r}	No. dyads in 220-man sample
Musi Langu	0.0522	91
Ola Langu	0.0659	91
Muri Langu	0.0886	91
Kifa Langu	0.0458	45
Miku Langu	0.0944	45
Ata Kei	0.1528	45
Hari Ona	0.0625	36
Tufa Ona	0.1597	36
Laba Langu	0.2639	36
Lali Nama Papa	0.1786	28
Sinu Langu1	0.0692	28
Perafi Langu	0.0179	21
Teti Nama Papa	0.0833	21
Kaja Langu	0.2000	15
Kebesa Langu	0.2417	15
Ole Ona	0.1563	10
Guna Langu	0.2219	10
Haga Langu	0.1750	10
Badi Langu	0.1125	10
Saja Langu	0.2500	6
Kelore Langu	0.2500	6
Guma Langu	0.2500	3
Lango Fujo	0.4167	3
Nama Langu	0.5000	3
Kiko Langu	0.4167	3
Ribu Langu	0.5000	3
Kelake Langu	0.5000	1
Blake Langu	0.0000	1
Lafa Langu	0.5000	1
Jafa Langu	0.1250	1
Bera Ona	0.5000	1
Mana Langu	0.5000	1
Weighted Mean	0.1160	

Table 3. \bar{r} for 32 lineages represented in the 220-man sample.

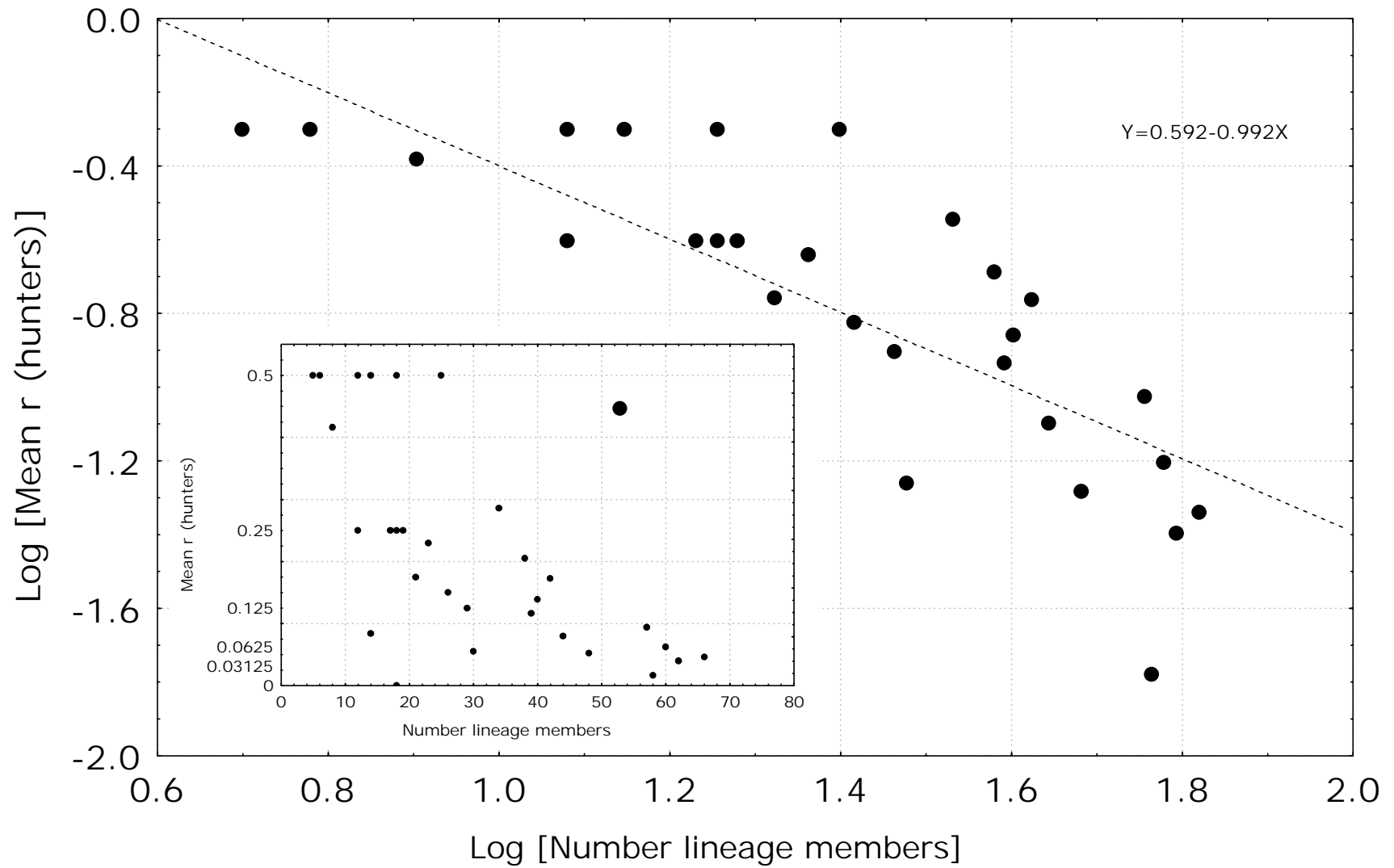


Figure 4. Within-lineage relatedness as a function of lineage size. Large plot has a logarithmic scale; small plot is same data plotted on a linear scale.

As Table 3 shows, relatedness within lineages varies widely and that much of the variation is explained in terms of lineage size. Figure 4 shows a significant negative, logarithmic relationship between lineage size (total number lineage members) and within-lineage \bar{r} for males in the 220-man sample. Large lineages become diffuse and members less related, though as I show elsewhere, it is easier for larger lineages to organize whaling operations because of the larger labor pool (Alvard 2002). This is consistent with the observation made earlier that relatedness declines as group size increases (Brown 1991).

If hunters assort non-randomly according to lineage membership, and lineage members are more closely related than expected by chance, then it is expected that affiliated men are also more closely related than expected by chance. Analysis shows that this is true for both the clusters extracted by the k-means procedure and actual téna crews. For the k-means clusters, $\bar{r} = 0.0440$ (sd=0.03275; N=20). This is significantly greater than the null ($t=5.156$, $df=19$, $p<0.0001$). For téna crews, $\bar{r} = 0.0362$ (sd=.02678; N=853). Again, this number is significantly greater than the null ($t = 4.995$, $df=19$, $p<0.0001$). There is no significant difference in the relatedness of members of the k-means groups and the relatedness of téna crews ($t=-0.8287$, $df = 38$ $p=0.4124$).⁴

It is not surprising that crews and affiliates are more related than expected by chance. But the result still begs the question - do men affiliate with kin as predicted by kin selection, thus explaining the high degree of relatedness among hunting partners? Or, do hunters affiliate with fellow lineage members and the kinship correlation is spurious and due to the correlation between lineage membership and kinship? In the second case, hunters do not affiliate with others because the others are kin *per se*, but because they are fellow lineage members; the resulting higher degree of relatedness is incidental.

To test between these two possibilities, I use multiple matrix regression with the two independent variables of kinship and lineage membership; affiliation is the dependent variable. The results confirm that while kinship is still significant, lineage membership explains more of the variance in affiliation among the hunters. The matrix Pearson's correlation for affiliation versus kinship is $r = 0.198$ ($p<0.000$); the Pearson's correlation for lineage membership is $r = 0.322$ ($p<0.000$). The regression parameter estimate for lineage alone is about a third again as large as for kinship alone. For the multiple regression analysis, both variables explain 10.7% of the variance in affiliation. The contribution made by lineage membership is greater than kinship, however (see the results of the regressions in Table 4). In this case, the partial regression coefficient for lineage is nearly four times as large as kinship. The addition of kinship does not significantly increase the strength of the model that includes only the lineage variable.⁵

a.

Independent variable	Standardized parameter estimate	p value
Kinship	0.1976	<0.000

b.

Independent variable	Standardized parameter estimate	p value
Lineage membership	0.3215	<0.000

c.

Independent variable	Standardized parameter estimate	p value
Lineage membership	0.2925	<0.000
Kinship	0.0631	<0.000

Table 4. Matrix regression analyses with the two independent variables of kinship and lineage membership, and affiliation as the dependant variable.

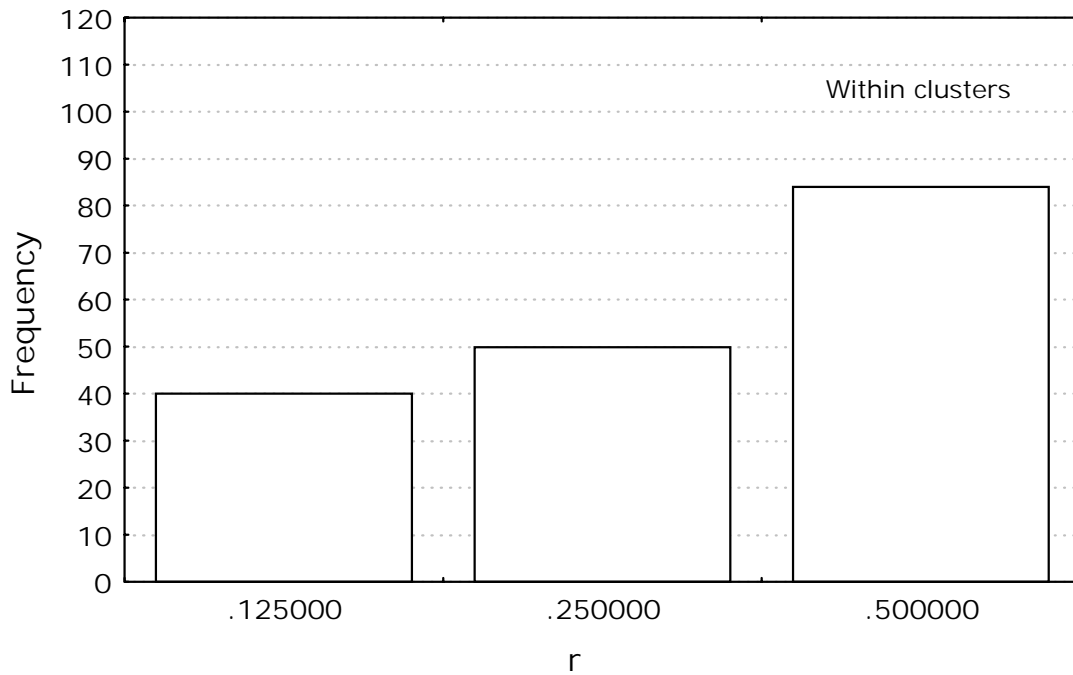
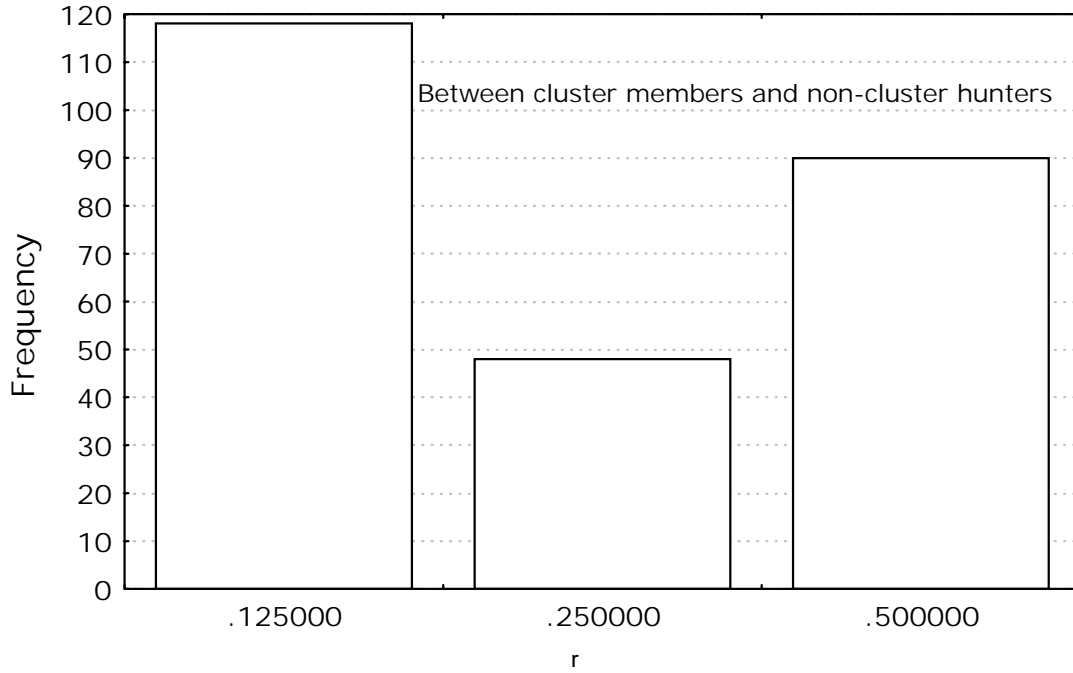


Figure 5. Number of dyads with indicated degree of relatedness.

This result obtains because pairs of men related to same degree of r (excluding siblings and father/son pairs) are just as likely to belong to different lineages and not affiliate with others as they are to share a lineage and affiliate during hunts. To demonstrate this, Figure 5 shows the number of dyads within clusters that share three categories of kinship, $r = 0.5, 0.25$ and 0.125 . The data are from the 189-man sample limited to men whose lineage actually organizes téna ($N=140$ men). Affiliative clusters have more dyads related at $r=0.50$ than they do dyads related at $r= 0.25$ or $r=0.125$. This is expected because groups of kin related at $r=0.50$ all belong to the same lineage. Figure 5 also shows the number of dyads related at these levels formed between cluster members and non-cluster members. Kin related at $r = 0.125$ are much more likely to be found outside the affiliate cluster. Kin related at $r = 0.25$ and $r = 0.50$ are equally likely to be found inside as outside the cluster.

If the hunters organize themselves into crews strictly according to kinship we would expect that the men be as related as possible within crews. To the contrary, analysis shows that men could affiliate much more closely with kin during hunts than was observed in Lamalera. To show this, I simulate crew formation using a computer algorithm written by David Carlson of Texas A & M University. The algorithm is designed simulate crew compositions and maximize mean relatedness within crews by exchanging hunters between crews. The starting points for the simulation are the 20 crew clusters produced by the K-means analysis above. I consider each of the 190 $[(20*(20 - 1)/2)]$ pairs of crews. For each pair of crews, all possible pairs of men (one man from each crew) are examined to see how the average relatedness of the two crews change if the two hunters exchanged positions. After all possible exchanges are compared, the hunters from one pair are swapped whose exchange produces the greatest increase in the mean relatedness of the two crews [no swap is made if mean relatedness does not increase]. Next, two more crews are chosen, all possible pairs are examined again, and a swap is made. After all pairs of crews have been examined, the mean relatedness is calculated across all boats and compared to the initial value. If the mean of relatedness across all boats is greater, another iteration is performed. The process is repeated until the mean relatedness across all boats no longer increases or until no swaps are made. As is hypothesized to be the case for the actual crew formation, this procedure makes no distinction made between lineage and non-lineage kin. As shown above, the initial mean relatedness across all 20 clusters is $\bar{r} = 0.044$. After 6 iterations of the algorithm and 113 swaps, the mean relatedness across all 20 crew clusters nearly tripled to $\bar{r} = 0.115$. This is a significant increase ($t = -4.57, df = 19, p = 0.000209$).⁶

The implication of this result is that if hunters preferred to associate with kin, they could associate in ways that would result in much higher within-cluster relatedness than is observed. The fact that they do not provides additional support to the hypothesis that it is lineage identity that is the main organizing principle structuring Lamalera whaling crews.

Discussion

The preceding analyses show that hunters at Lamalera affiliate during cooperative hunts more strongly according to lineage membership than they affiliate according to genetic kinship. While crew members are more closely related to one another than expected by chance, the analyses shows that this is due to the partial correlation between lineage and kinship. Hunters are just as likely not to affiliate with non-nuclear kin because half of such kin are non-lineage members. I showed that hunters could significantly increase their association with kin during hunts, but do not.

This paper's results support the hypothesis of the Structural-functional anthropologists, discussed above, who argued that the development of lineage systems facilitates collective action. It also supports the contention of van den Berghe (1979), who argued that kin selection alone cannot structure cooperation in groups larger than the

nuclear family because of the ambiguous group membership it provides. While the results do not refute kin selection theory, they do raise issues concerning the importance of kin selection for explaining certain cooperative behavior in humans, and the possibility of alternative mechanisms for the development of collective action.

A reassessment of the role of kinship in human societies is warranted given the ongoing reexamination of kin selection as an explanatory paradigm for cooperation among non-human animals. "The view that kin selection provides a satisfactory general explanation of specialized cooperative societies now appears less compelling than it did 20 years ago" (Clutton-Brock 2002:69). Kin selection provides a less persuasive argument for a number of reasons. First, better genetic data show that cooperative groups are often not more related than noncooperative groups. For example, recent empirical work on chimpanzees shows kinship plays a secondary role in structuring affiliative behavior among males (Mitani et al. 2000; Goldberg and Wrangham 1997). Cooperative territory and pride defense by male lions is not organized according to kinship (Grinnell et al. 1995). Studies using DNA analysis to determine the relationships within coalitions of male bottlenose dolphins cooperating to maintain mating access conclude, "The majority of male pairs within alliances were randomly related, although high relatedness values were found between males of different alliances in the resident population. These findings indicate that mechanisms other than kin selection may be foremost in the development and maintenance of cooperation between male bottlenose dolphins" (Moller et al. 2001:1941).

Griffin and West (2002) argue that another reason kin selection is less compelling for explaining cooperative behavior is an increased awareness that direct fitness benefits to the 'altruist' have been underestimated in previous work. Direct fitness benefits are those obtained by the individual himself, rather than indirectly through the help provided to kin (Maynard Smith 1964). There are a variety of other mechanisms that can lead to cooperation independent of, or in addition to kinship (Hirshleifer 1999; Mesterton-Gibbons and Dugatkin 1992). Griffin and West (2002) argue that in many cases apparently altruistic behavior has direct fitness benefits that may be the main factors influencing the degree of cooperation. They argue that although limited dispersal often results in groups made up of close kin, a prediction of kin selection, kin selection is not required to produce many of the cooperative groups found among birds and mammals. They conclude that in many cases, individuals behave cooperatively because it is in their own direct self-interest, while benefits obtained indirectly through kin are secondary for the development of the cooperative behavior (see also Chapais et al. 2001). The data in Lamalera are consistent with this argument.

For example, the well known behavior referred to as "helping at the nest", where individuals defer their own reproduction to help others rear offspring has been usually explained via kin selection (Emlen 1982). Griffin and West (2002) cite recent work that shows helping occurs in some species that do not live in family groups, as is the case with fairy wrens (Dunn et al. 1995). In other species, such as meerkats, the degree of helping done by subordinates is more related to their own reproductive status than their kinship to the young they help (Clutton Brock et al. 2001). There are a number of hypotheses of how direct benefits accrue to individuals in these cases. One explanation, referred to as 'group augmentation' can arise in the absence of kin selection if the mutualistic benefits of collective action are significantly great (Clutton-Brock 2002; Kokko et al. 2001). In this case, simply being part of a larger group provides individuals with sufficient direct benefits independent of any indirect benefits obtained via kin selection. See Smith (1985) and Sosis (2000) for a discussion of this idea in regard to human foraging groups. This last idea is important for the Lamalera case. The hunting data are consistent with the hypothesis that the benefits of collective action for individuals outweigh the costs of limiting association to a limited set of kin.

Hawkes (1983) anticipated many of these arguments when she addressed Sahlins' critique of kin selection and noted the role of socially determined identities for qualifying predictions of kin selection in humans. She concluded that a focus on coefficients of relatedness as predictors of behavior is a mistake, and that the costs and benefits of

alternative behaviors in the context of kinship is a much more powerful, albeit difficult, approach. More recently, Turke (1996:854) notes that a number of studies make clear that genetic relationships do matter in human social organization, while admitting that the evidence “does not deny the existence and importance of classificatory kinship systems or the existence and importance of friendships and alliances outside the sphere of genetic relationships. There is more to human sociality than nepotism based on degrees of genetic relationship.” This sentiment has been expressed elsewhere (Dunbar et al. 1995).

What ‘more there is’ may be found among emerging solutions to cooperative dilemmas focused around positive assortment (Boyd and Richerson 1993; Bowles and Gintis 2000; Dawkins 1976; Dugatkin and Wilson 2000; Pepper and Smuts 2002; Wilson 1977). Positive assortment occurs when a population is structured in such a way that individuals tend to form groups with others whom they share traits in common. Such assortative interaction can facilitate cooperation because individuals who cooperate without discrimination are vulnerable to noncooperators who take advantage of the cooperator’s willingness to act collectively. Kinship can provide this association because kin are more likely to be of the same type. Cooperative, kin-selected behaviors evolve because they are preferentially directed at like-types (Hamilton 1975). For example, the tit-for-tat solution to the prisoner’s dilemma will spread among a population of cheaters only if tit-for-taters can somehow preferentially identify and play with other tit-for-taters (Axelrod and Hamilton 1981). One way for this to happen within a population of defectors is if pairs of relatives, who are more likely to share the tendency to play tit-for-tat, cooperate via kin selection (Axelrod 1984).

Recent theory suggests that there are a variety of mechanisms, in addition to kinship, for individuals to identify fellow cooperators. These mechanisms involve honest signals linked to discriminating cooperative behavior that allow fellow cooperators to identify one another. The classic example is the “green beard” solution offered by Dawkins (1976). Imagine that the trait of having a green beard was associated with the trait of cooperating with other green beards. This hirsute signal allows cooperators to assort by type, direct cooperative behavior at fellow cooperators, and avoid free riding costs (e.g., Keller and Ross 1998). Similar models have been developed within anthropology and elsewhere to explain the rise of group markers, such as dress, speech patterns, and ornamentation that allow individuals to identify like-types and assort positively (Boyd and Richerson 1987; Nettle and Dunbar 1997; Riolo et al. 2001; van den Berghe 1981; Wiessner 1983). The key problem with the green beard solutions offered by these models is that the systems are vulnerable to individuals who mimic the signal (i.e., grow a green beard), but are not forthcoming with the cooperative behavior (Grafen 1990). These ‘cheaters’ do better because they receive the benefits but do not pay the cost. This is especially likely if the signal is relatively cheap to imitate and the benefits of cheating sufficiently great.

This problem is not as ruinous to the positive assortment hypothesis as it may appear. Most collective action is modeled game theoretically as a prisoner’s dilemma. The key feature of the prisoner’s dilemma, of course, is that the cooperative strategy is never a player’s best response to an opponent in spite of the fact that mutual cooperation is better than mutual defection (Poundstone 1992). Cooperation in such a context is true altruism and cheating has benefits. When cooperation is structured this way, the green beard solution is vulnerable to cheaters.

As alluded to above, however, there is an increased understanding that much behavior viewed broadly as cooperation may be better understood as mutualism or coordination rather than a prisoner’s dilemma (Alvard and Nolin 2002; Clements and Stephens 1995; Dugatkin 1997; Hirshleifer 1999; McElreath et al. in press). This is important because ‘green beard’ solutions to collective action problems are more feasible if payoffs are structured as coordination rather than a prisoner’s dilemma because there is no benefit for individuals to cheat (McElreath et al. in press).

Coordination games are characterized by common interest among players (Binmore 1994, Cooper 1999). In social situations structured as coordination, benefits accrue to individuals through collective action, and individuals are better off cooperating than they are

from defecting. While gains exist for collective action in a prisoner's dilemma, individuals are nonetheless always better off defecting. Mutualism, as discussed above and understood by most evolutionary anthropologists (Hawkes 1992: 275) is structurally a coordination game. Coordination problems are among the most basic of social problems. The classic example is the pure coordination involved in choosing the side of the street on which to drive. There is no benefit to cheating in such a game. Driving either on the right or on the left is equally good, as long as everyone drives on the same side. In spite of the apparent simplicity, however, there is much evidence that shows that cooperative solutions to such coordination problems are not as easy to obtain as one might intuitively think and results of coordination failure in experimental contexts have been widely reported especially in larger groups (Batillo et al. 2001; van Huyck's et al. 1990; see review in Ochs 1995).

Thomas Schelling in his book *The Strategy of Conflict* (1960) noted that people do readily solve coordination problems in certain contexts. Schelling's classic example is the relative ease with which people can solve the following coordination problem: two friends must meet in New York City, but for some reason have separated and cannot communicate. There are many places to meet, all of which are equally satisfactory – as long as both friends choose the same location. The idea of cheating is not applicable here, since both friends have a preference to cooperate. Schelling conducted informal experiments, where more than 50% of students from New Haven, Connecticut chose Grand Central Station as the place to meet. When asked to name a time, almost all chose noon. Formal experiments provided similar results in a number of different contexts (Mehta et al. 1994a). These results are extraordinary, given that there are a near infinite number of possible meeting locations.

How do the players decide where to meet each other? Schelling speculated that people are often able to coordinate around what he called focal points. He argued that it is the salience or prominence of focal point that draw people to them and that what is prominent depends on the time and place and who the people playing are (Schelling 1960: 58). Sugden (1986: 49) agrees that people use *shared notions* of prominence to solve coordination problems. These ideas have much in common with norms. Norms are regularities of behavior maintained through shared ideas of right and wrong (see McAdams 1997 for a review). Norms have increasingly been viewed as a way that coordination is more easily achieved (Ellickson 1991; Lewis 1969; McElreath et al. in press; Ostrom 1990; Posner and Rasmusen 1999).

Ellickson (1991) argues that norms function to reduce transactions costs for achieving cooperative outcomes. An economic concept, transactions costs accrue when people must establish and maintain property rights, broadly construed. Activities might include inspection, rule enforcement, policing, and measurement (Allen 1991). Without norms of road travel, for example, vehicles would need to slow their rate of travel when approaching oncoming traffic to determine which side of the road is appropriate to avoid collision. Such inspection transaction costs are avoided by norms.⁷ Because coordination problems are common, there are great advantages for individuals to associate with others who are more likely to share norms. Interacting with others who do not share norms or conventions of behavior increases the difficulty in solving otherwise simple coordination problems due to high transaction costs. An anthropologist would be quick to point out that what is salient to a group of students in New Haven, Connecticut may not be salient to whale hunters in Indonesia. The problems that ensue when one interacts frequently with others who do not share norms are well known to field anthropologists.

This brings us back to the issue of positive assortment. One solution to coordination problems is for individuals to preferentially assort with others who hold ideas similar to their own. How can individuals predict what others think and will do? How do participants in a collective action know that fellows share beliefs concerning behavior critical for coordination? There are a number of options. One could attempt to learn on one's own the beliefs of all potential cooperative partners. This could, however, prove difficult, time consuming and error prone. In the Lamalera case, there were 290 hunters in 1999 with

more individuals participating either as craftsmen or cooperate members. There are also numerous prey species that differ in ways that might effect butchering.

When defectors are not a threat, as is the case for coordination games, the green beard solution becomes more tenable. McElreath et al. (in press) formalized a model to show how marked groups can arise when social interactions are structured as coordination games. They show that under plausible conditions, selection can favor an association between markers and normative behavior because it pays for individuals to signal honestly when collective actions are structured as coordination games. In a related argument, Gil-White (2001) notes that people reify ethnic groups despite the fact that ethnic essences do not exist. He hypothesizes that selection favored this cognitive process because stereotyping people in terms of ethnic groups facilitates inductive generalizations about their nonobvious properties. Following Barth (1969), he argues that these generalizations help predict many strongly correlated yet hidden properties of others - such as commitments to certain interactional norms. This, in turn, helps people predict behavior, assort positively, and solve common coordination problems like those mentioned earlier. Atran (2001:537) agrees that "People cognitively privilege essentialized groups as providing the most dependable or trustworthy context for forming and inferring beliefs about themselves and others and for taking life-enhancing collective action based upon those beliefs (mating, war, economic cooperation)."

Social psychologists have long understood it is not difficult to get people to assume collective identities. The ease with which people associate themselves and others with groups implies strong selective advantages during our evolutionary history. The classic work of Henri Tajfel shows that it is very easy induce members of even so called 'minimal groups' to readily assume a shared identity. Members of these minimal groups have no face-to-face interaction and no history of interaction. In experimental situations simply classifying people according to arbitrary markers like eye color creates the groups. Group members show a strong tendency to discriminate and favor group members at the expense of others (Tajfel and Fraser 1978; Tajfel 1981; see Diehl 1990 for a review). Most of the work has tended to focus on the prejudice directed at out-group members (for example Peters 1987; Zimbardo 2000), although the role of group identity for enabling within group collective action is significant (for example Kelly and Kelly 1994; Kerr and Kaufman-Gilliland 1994). Recent experimental work shows how group identify and intragroup competition can significantly increase the likelihood of efficient outcomes in coordination games (Bornstein et al. in press).

Elsewhere, I have described the kinds of cooperative hunting found at Lamalera as coordination (Alvard and Nolin 2002). Groups of men who cooperatively hunt whales enjoy greater per capita return rates than do solitary fishers. The success of the subsistence strategy, however, rests on the each participant's shared understanding and expectations of both their own role in the collective action and the roles of each other participant. Put simply, cooperative hunting is mutually beneficial to participants only as long as hunters associate with others who can be expected to share ideas of what constitutes normative behavior.

For example, in Lamalera a whale is butchered and divided into 14 major whole shares that vary in size and quality. The shares are generally distributed to four types of recipients, the crew, corporate members, craftsmen, and two special clans (Alvard 2002). In, Lamalera the crew (*méng*) receive the bulk of their shares from the torso of the whale just posterior of the pectoral fins to roughly the end of the rib cage. The major corporate share (*kefoko seba*) is divided by 5 to 14 shareholders, depending on the boat. It consists of the torso of the whale from just posterior of the *méng* section extending back about 1.5 to 2m. One could easily imagine, however a number of equally satisfying alternative schemes to butcher and distribute a whale. There is no reason that the *méng* share could not be extracted from the location where the *kefoko seba* is extracted now, and vice versa. A hunter should be indifferent to many of these alternatives because in many instances the amount and quality of meat and fat is independent of the anatomical part of the whale from which it originates. While a hunter should be indifferent to which particular norm is used, it

is critical that all the hunters share the *same* norms for butchering and distribution. Men cooperating within a téna crew hunt with the assurance that their fellows will not lay claim to shares that they themselves believe they own. Without such assurance, it is easy to imagine that cooperative hunting may not be worth the effort. Imagine the transaction costs for resolving claims to téna harvests if norms of distribution did not exist for the whalers at Lamalera. Without shared norms of behavior, like the rules of meat distribution at Lamalera, it is likely that cooperative behavior would collapse due to high transactions costs.

How do the hunters at Lamalera know that their fellows share the same norms of behavior without expending considerable transaction costs learning for themselves? This paper has shown that hunters assort strongly according to lineage membership. I believe that lineage membership acts as an unambiguous, easily observed marker (like a green beard) that allows individuals to identify others who have a higher probability of sharing norms. Preferring to affiliate with someone who shares lineage identity increases the probability that they also share ideas of what is normative; it decreases anonymity, and provides assurance that fellows play by the same rules (see Barth 1969).

In contrast, groups organized along strict genealogical lines are ego-specific; as a result, strict kinship provides an ambiguous signal. My cousin, for example, might easily view himself as a member of a competing kindred with alternative norms... or not. Beyond the nuclear family, kinship [based solely on genealogical distance] is not a marker with sufficient resolution to organize collective action in groups larger than the nuclear family. Nonetheless, kinship organization does provide an exaptation, especially among simple societies. "... why do people settle on kinship as the convention so often? One possible answer: given that so much of the social system in small-scale societies is based on kinship, it's a very convenient pre-adaptation on which to hang your coalition structure" (Smith, ms).

At some point in our recent evolution history humans evolved the ability to transmit information culturally, and subsequently we see a dramatic increase of evidence for cultural diversity in the archeological record (Klein 1999, Mellars 1998). The transition in the Upper Paleolithic represents a watershed in the course of human evolution. While speculative, the adaptive advantages of being able to solve coordination problems may have been part of the selective forces that favored the development of the traits implicit in such cultural complexity. As I have shown, hunting provides a suite of such coordination problems.⁸ The idea that culture evolved in order to facilitate the planning and coordination involved in hunting is not new (e.g., Montagu 1976, Washburn and Lancaster 1968). The reasoning, however, has been by and large vague and untested. Cooperative hunting was probably more common in our evolutionary past than it is today. Hill (2002) notes that without projectile weaponry and poison it is difficult to imagine how many of the large game species present in hominid archeological assemblages were killed without cooperation. The data presented here do suggest that cooperative hunting is exactly the sort of coordination problem whose solution is facilitated by the ability of actors to establish and communicate behavioral norms. The ability to identify via inductive generalizations others who share social norms and cooperative intent has immense adaptive value in terms synergistic rewards – even if they come at a nepotistic cost.

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Notes

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² Most of Sahlins' criticisms of kin selection theory were not as cogent; for example he argued that kin selection theory could not apply to animals because they could not do the math to calculate degrees of relatedness. Dawkins replied famously in the second edition of *The Selfish Gene* (1989) that a snail shell is an exquisite logarithmic spiral, in spite of the fact that snails cannot read log tables.

³ The issue of whether people "do as they say" is not a trivial issue (e.g., Cronk 1999).

⁴ This is lower than the previously published average coefficients of relatedness for whaling crews. Morgan (1979) reports $\bar{r} = 0.274$ for nine crews among the Yupik whale hunters. Smith (1985) reports $\bar{r} = 0.013 - 0.185$ for a variety of hunt types among Inuit foraging groups.

⁵ There are a number of other factors that may play a role in the relatively small amount of variance in affiliation explained by lineage identity. First, many of the hunters do not belong to lineages that have téna. For the 189-man sample, 49 out of the 189 (26%) men belong to lineages that do not organize a téna. The balance of hunters belongs to lineages that have téna; 92 or 66% of these men went out most often on the téna organized by their lineage. Second, not all the téna went out every day – men often went out on other boats if their primary was not available. The number of days that particular boats went hunting ranged between 17 and 69 of the possible 80 observed hunting days. Some téna were able to hunt nearly every day - others had more difficulty. Accordingly, the number of boats that went out per day varied over the course of the season between 2 and 20 (mode = 9, $\bar{x} = 10.7$ boats, N = 80 days; Alvard and Nolin 2002). In addition, while the data were normalized as to hunting frequency, not all hunters hunted on the same days. Third, some lineages are smaller than others and their hunters had to associate with more non-lineage members to participate in crews of sufficient size. Finally, informants also report that men sometimes go out on the boats owned by their wives or mothers lineage. Each of these factors presents their own analytic issues that will be addressed in future analyses.

⁶ The algorithm was also done with a modified swap criteria. Above, hunters are swapped whose exchange produces the greatest increase in the mean relatedness of the two crews. This means that a switch would occur even if relatedness within one crew decreased as long as the average of both increased. We add the constraint that a swap cannot decrease relatedness within a crew. After 4 iterations of the modified algorithm, and 72 swaps, the mean relatedness across all 20 crew clusters nearly doubled to $\bar{r} = 0.078$. While less than the original outcome, this is a still significant increase ($t = -4.27$, $df = 19$, $p = 0.00286$).

⁷ Technically, traffic laws are not norms because they are written and enforced by the state.

⁸ It should be stressed that coordination problems are common and are not limited to hunting behavior. Depending on the context, marriage could be a coordination problem where each member of the pair shares the common interest of producing offspring (Hadfield 1999).