"Explaining monogamy and polygyny among foragers and horticulturalists."

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Abstract

Understanding differences in mating systems across human societies is a classic area of research in anthropology. Among the principal variables of interest is the frequency of monogamous vs. polygynous marriages, which is both easily measurable and has strong and direct effects on male and female reproductive outcomes. Why are multiple-wife families common in some societies while nearly absent in others? This paper reviews the primary hypotheses aimed at explaining variation across the monogamy-polygyny continuum, then evaluates and extends empirical tests of these hypotheses using data from the Standard Cross-Cultural Sample (SCCS), focusing especially on forager and horticulturalist societies.

Theory

The field of behavioral ecology attempts to explain behavioral variation via causal pathways extending back to (effectively) exogenous properties of an organism's ecological setting and niche based on the assumption that individuals adjust their behavior to maximize their material and reproductive success. In domains of social and sexual decision-making, these adjustments are often highly dynamic, and depend on the strategic interaction of individuals with both overlapping and divergent interests. A husband and wife, for example, both have a stake in the success of their shared offspring, yet the husband may be motivated to forsake these offspring to pursue additional wives. His ability to do so, however, is constrained by the number of adult women available, the vulnerability of his children, and other factors impacting his current wife's relative bargaining power. Ecological parameters (e.g. importance of high quality land for agricultural production) may affect behavioral outcomes through multiple

pathways (e.g. warfare and variance in male quality), and intermediate causal factors may co-vary due to shared dependence on upstream parameters.

Hypothesized determinants of monogamy and polygyny in forager and horticulturalist societies include (1) the importance of male provisioning to the nuclear family (2) degree of variance in male resource holdings (3) the importance of male protection (4) the importance of high-quality male genes, and (5) sex ratio. The ecological parameters affecting each of these determinants and the pathways by which they operate will be addressed in turn.

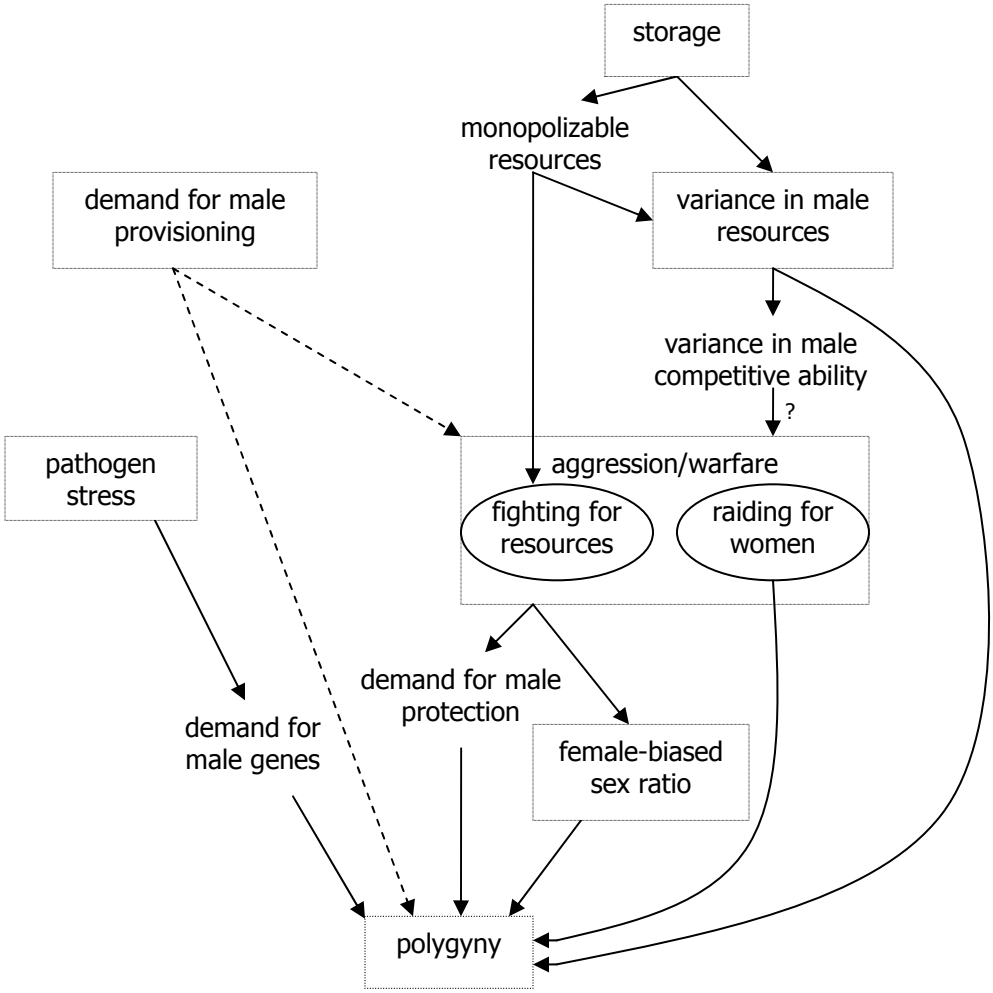

Figure 1. Conceptual model of the factors promoting polygyny. Dashed lines indicate negative effects. Boxed variables are coded in the SCCS.

(1) *Demand for male provisioning*. In some environments, complementarities between male and female investment in offspring produce a sexual division of labor whereby male provisioning of protein and fat is crucial to

household income. The calories a father produces are a rival good (two individuals cannot consume the same calorie), which places a limit on the number of dependents (wives and children) he can support; polygyny becomes prohibitively costly to the reproductive success of husbands and wives alike, except in the case of extraordinarily productive individuals. Such complementarities exist where high-return production tasks are incompatible with direct childcare, as in hunting large or medium-size game (Kaplan and Lancaster 2003).

In environments where women can more easily produce the macronutrients necessary for offspring wellbeing, children suffer less when a father's time and energy are split between multiple wives or channeled into non-provisioning activities. Fathers in this situation are furthermore freed up to allocate more resources toward mating effort through courtship or bride capture. As intrasexual competition and raiding between groups intensifies, polygyny can additionally be favored by way of increased demand for male protection and skewed sex ratios.

The hypothesized variables associated with complementaries in provisioning and demand for male production include challenging environments where uniparental care is insufficient, the inability to cache or carry offspring during production, high returns to high-risk strength-intensive activities such as medium and large game hunting, and high returns to simultaneous cooperative production between husband and wife (Kaplan and Lancaster 2003; Winking 2005).

(2) *Variance in male resources*. Where labor is translated into food within the timespan of hours or days, as is the case with most nomadic foragers, variance in household income stems mainly from variance in individual return rates and effort, which is generally too low for women to "double up" on more productive men. Where the ecology allows greater resource inequalities to develop between men, however, such doubling up can become more common. Such is the case when land or capital become "economically defensible", as in territory-based agricultural systems or pastoralist societies; those who maintain exclusive access to these resources accrue more wives and children (Dyson-

Hudson and Smith 1978). Sellen and Hruschka (2004), for example, have shown that polygyny is associated with dependence on food resources that are clumped and defensible in a sample of foragers of Western North America around European contact. Food storage is an additional factor that may lead to socio-economic inequalities by way of nepotistic inheritance and processes of cumulative advantage; inequality can also result as function of the fact that stored goods also constitute patchy and defensible resources (Bowles 2005; Testart 1982).

Inequality in male resources might, in some circumstances, additionally promote promote polygyny through its effect on levels of aggression and warfare, which may increase the demand for male protection (point 3) and/or bias sex ratios toward women (point 5). Manson and Wrangham (1991) have proposed that intergroup aggression among chimpanzees and humans is more likely where imbalances of power translates to very low costs for would-be aggressors. Resource holdings (e.g. land, animals, money) often form the basis of relative competitive ability, as wealthier individuals or groups can afford to compensate a larger number of supporters, access more and higher quality weapons, etc. Inequalities in wealth may lead directly to inequalities in competitive ability—and possibly higher levels of conflict—as a result.

Power inequalities within a group, on the other hand, may not necessarily lead to higher levels of violence. As resources become concentrated under the most powerful individuals, frequency of contests may decline. Inequalities in aggressive power lead to higher rates of violence only where dominance relationships (between individuals, between groups, or between sub-groups within a society) are important as well as *unstable*. Where the actors and relative fighting abilities are constant (e.g. no major migration, no major windfalls that benefit some but not others), we should expect a stable, low-violence equilibrium to be established after an initially tumultuous redistribution of resources. Resource inequalities are also generally associated with societal complexity, which brings with it policing and other forms of social control that may damper aggression and violence.

(3) *Demand for male protection*. Another complementarity between male and female roles arises when there is demand for protection against predation or—more importantly—assault by members of one's own or other groups. Male specialization in protection, because it is a less rival good than food resources, may loosen the constraints on polygyny that accompany complementarities in production. That is, a male with high competitive ability may be able to extend his protective umbrella over an additional wife (and set of offspring) without greatly diluting the protection he can provide a single nuclear unit. Family demand for protection should increase with the threats of violence within a community and attack from other groups.

The factors increasing the likelihood of violence likely include: those factors that free men from having to pour their resources into provisioning, discussed in point 1; resource patchiness leading to economic defensibility, addressed in point 2; and variance in male competitive ability, especially where dominance relationships are unstable, again discussed in point 2. Neighboring groups may be bellicose and aggression for reasons having little to do with the focal society. Keeley (1996) and LeBlanc and Register (2003) outline a number of other factors, such as population growth and resource stress, that may additionally contribute to the threat of violence across different socio-ecological settings.

(4) *Demand for male genes*. Bobbi Low has established a strong link between variation in human mating systems and the importance of 'gene shopping' across ecologies, driven primarily by pathogen stress (Low 1988; Low 1990; Low 2003). Where high quality genes are a key determinate of offspring survival and fertility, women may trade off male provisioning for genetic quality. As the benefits of high quality genes are not divided up between wives, this can lead to higher levels of polygyny.

The first, third, and fourth points deal with the weight of different characteristics in women's evaluation of male mate quality: provisioning ability, protective ability, and high quality genes. Unless these qualities are perfectly correlated, women are usually forced to trade off one for another; the theoretical perspective presented here suggests that the balance of traits that make up the

best mate possible in a given environment will shift depending on the character of the subsistence niche, the presence of internal or external threats, and pathogen environment. In some situations, this decision process will lead women to accept marriage into a polygynous household; in other situations women will choose to marry monogamously.

(5) *Sex ratio*. Sex ratio may have a simple effect on polygyny levels. Where men are in short supply (for whatever reason), women may be more willing to move into a polygynous household. Mortality due to violence and warfare usually affects men more than women, and so may drive sex ratios toward females, providing an additional pathway by which conflict may promote polygyny.

What is missing? The scheme presented this far does not account well for polygyny that occurs through bride capture or enslavement, which is recognized as an important proximate determinate of male reproductive success, especially in horticulturalist and pastoralist settings (Chagnon 1979; Kaplan and Lancaster 2003). We have addressed factors that impact men's allocation to paternal investment versus mating effort—including bride capture—as well as other factors that would press groups toward warfare that might result in the capture or enslavement of women (e.g. resource patchiness), but we are short of a comprehensive theory that links back to basic socio-ecological determinates.

Analyses

This section presents the results of new analyses of the Standard Cross-Cultural Analysis. The SCCS is intended to be a representative sample of world cultures that is free of phylogenetic bias (Murdock and White 1969). Each analysis was repeated for foragers, horticulturalists, and the full sample of 145 societies which have non-null values for percent of married men with more than one wife and percent of married women polygynously married. The criteria for inclusion in the forager sample are the same as those used by Marlowe (2003), which yield 31 societies with polygyny measures. Horticulturalists were defined as those societies whose subsistence economy was coded as horticulture or

simple or shifting cultivation (v833 = 2 or 3), of which 52 had polygyny measures. The sample sizes in some analyses were smaller due to missing data.

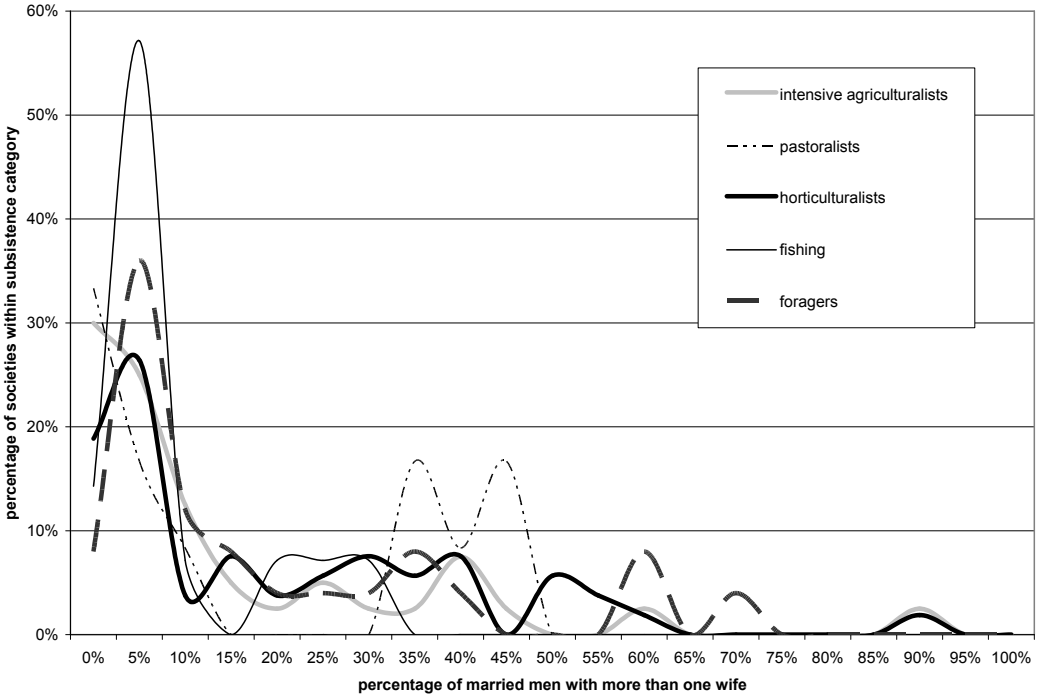

Figure 2. Frequency distribution polygyny for each subsistence type as defined by subsistence economy variable v833. Horticulture and simple or shifting cultivation are grouped as horticulture, and hunting and gathering are grouped as foraging.

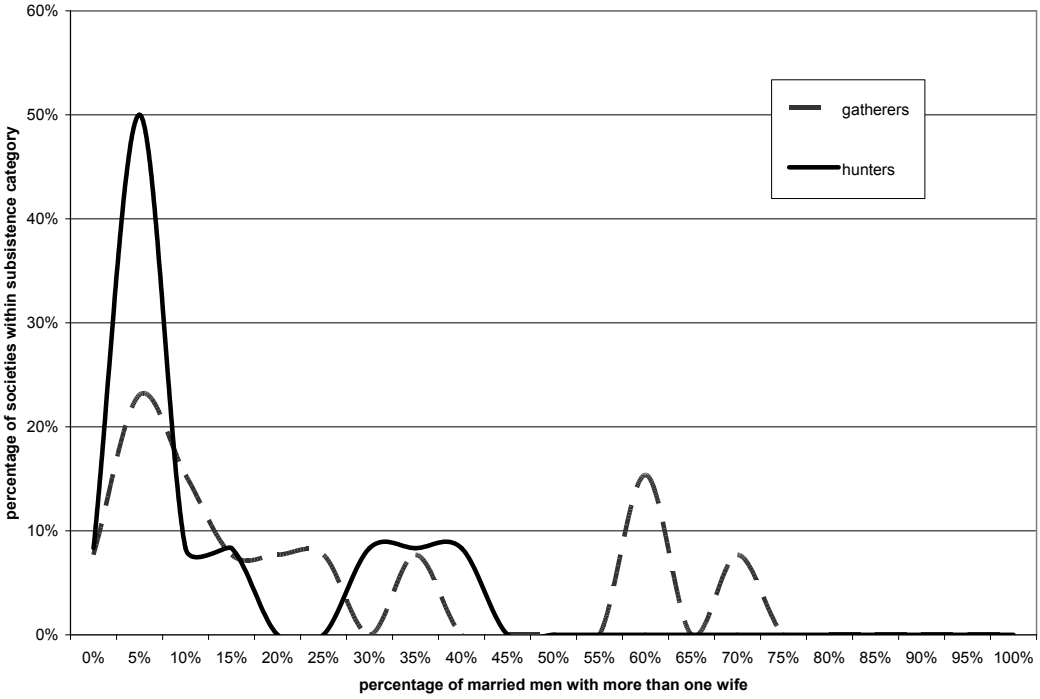

Figure 3. Frequency distribution of polygyny for societies with dominant subsistence economy variable coded as gathering versus hunting. The three foraging societies in the SCCS with polygyny levels above 45% are coded as predominantly gathering societies.

The frequency distribution of levels of polygyny for foraging, fishing, horticulturalist, pastoralist, and intensive agriculturalist societies in the SCCS in shown in figure 2. The distributions are not particularly revealing, except for a few points: predominantly fishing societies appear to have low levels of polygyny in comparison to other groups; pastoralists appear to have a bi-modal distribution, with a fair number of groups in which 30% to 50% of married men have more than one wife and another set of groups polygyny levels closer to zero; and the highest levels of polygyny (around 90%) are found in horticulturalist and agriculturalist societies. The forager category is crudely broken down into predominantly gathering versus hunting groups in figure 3. The three forager societies with over 45% polygynous married men are coded as predominantly gathering societies, a finding which bears out in the analyses.

The SCCS is an idiosyncratic dataset, and often contains multiple measures of a variable of interest, each with a slightly different definition and coding methodology. In order to evaluate the relationship between variables more systematically, I examined bivariate correlations between polygyny and a large scattering of predictor variables, as well as the correlations between these predictor variables; these results then guided the development of multiple regression models.

Four important variables neglected in these analyses are latitude, ecological zone, population size, and population density. All are potentially vital to the problem, and should be addresses in future work (Marlowe 2003).

Table 1. Pearson correlations between polygyny and subsistence variables in foragers, horticulturalists, and all groups.

	Foragers		Horticulturalists		Full sample	
SCCS Variable (10 total)	% Married Men Polygynous	% Married Women Polygynous	% Married Men Polygynous	% Married Women Polygynous	% Married Men Polygynous	% Married Women Polygynous
Dependence on Agriculture			0.270 *	0.264 *		
Dependence on Fishing	-0.431 **	-0.520 ***	-0.499 ****	-0.536 ****	-0.277 ****	-0.301 ****
Dependence on Gathering	0.405 **	0.445 **				
Dependence on Hunting			0.286 ** ×	0.306 ** ×		
Female Contribution to Subsistence: Average of Three Scores					0.278 ****	0.296 ****
Female Contribution to Subsistence: Barry and Schlegel				0.285 **	0.271 ***	0.276 ****
Female Contribution to Subsistence: Ethnographic Atlas	0.353 *				0.224 **	0.248 ***
Female Contribution to Subsistence: Martin Whyte	0.562 **	0.573 *			0.231 *	0.225 *
Percent Female Contribution to Agriculture			0.288 **	0.335 **	0.345 ****	0.339 ****
Percent Female Contribution to Domestic Animals			-0.395 **		-0.233 **	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$
× Correlation in opposite direction than predicted

The following four variables were not significantly correlated with polygyny measures ($p > 0.1$): Dependence on Animal Husbandry, Percent Female Contribution to Fishing, Percent Contribution to Gathering, and Percent Female Contribution to Hunting.

1. Subsistence economy, male provisioning and polygyny

Table 1 shows correlations between polygyny and dependence on different subsistence methods, general female contributions to subsistence, and female contributions to subsistence in specific domains for forager, horticulturalist, and all groups. Note that male contribution to subsistence is simply 100 – female contribution. As Marlowe (2003) found, and as figure 3 suggests, polygyny among foragers is positively correlated with a society's dependence on gathering (most commonly a female activity) and two measures of female contribution to subsistence, lending support for the male provisioning hypothesis. Dependence on gathering indeed predicts higher female contribution among foragers (table 4). Kaplan and Lancaster (2003) also found a relationship between the percentage of diet from gathering and polygyny in the Binford dataset of 145 hunter-gatherer societies (Binford 2001).

Among horticulturalists, there are significant positive relationships between polygyny and female contribution to agriculture, as well as one measure of female contribution to subsistence in general, again as predicted by the male provisioning hypothesis. The fact that there is a positive relationship between polygyny and dependence on hunting, however, is apparently counter to theory. Correlations for all groups, which benefit from larger sample size, show polygyny positively correlated with all measures of total female contribution to subsistence, as well as female contribution to agriculture, as found by White and Burton (1988). Somewhat surprisingly, correlations between polygyny and dependence on hunting, gathering, and agriculture are all insignificant for the full sample.

A strong negative relationship exists between polygyny and dependence on fishing across all three samples. This finding could support the male provisioning hypothesis if the importance of fishing indicated a reliance on men's production. As Marlowe (2003) found, and table 4 confirms, there is indeed a negative relationship between fishing and women's contribution among foragers. In the full and horticulturalist samples, however, these correlations are statistically insignificant, which may cast some doubt on the role of men's work to explain away the negative effect of fishing on polygyny. Tables 2 and 3 show fishing and female contribution regressed on polygyny levels in the forager and full samples. The effect of fishing is significant in both models, and does not appear to be mediated solely through sex-specific contributions to diet; female contribution drops out of the forager model but remains significant in the full sample.

Table 2. Regression model for percent of married women polygynously married, with fishing and female contribution to subsistence as predictors among foragers

Parameter	B	Standard Error	t	Significance
Intercept	33.46	18.437	1.815	0.820
Dependence on Fishing	-5.74	2.278	-2.518	0.019
Female Contribution to Subsistence: Ethnographic Atlas	0.22	0.362	0.605	0.551

Note: N = 25, R^2 = 0.282

Table 3. Regression model for percent of married women polygynously married, with fishing and female contribution to subsistence as predictors in the full sample

Parameter	B	Standard Error	t	Significance
Intercept	17.40	6.212	2.800	0.006
Dependence on Fishing	-3.63	1.225	-2.964	0.004
Female Contribution to Subsistence: Ethnographic Atlas	0.38	0.143	2.687	0.008

Note: N = 116, R^2 = 0.128

Table 4 presents the relationships between female contribution variables and the base subsistence variables. Among foragers, female contribution to subsistence is positively predicted by dependence on gathering and negatively predicted by dependence on fishing. In the full sample, agriculture and gardening both increase women's contributions to diet, while animal husbandry decreases it. Dependence on hunting also negatively predicts women's contributions; this effect is approaches significance in the forager sample as well.

In the horticulturalist and full samples, dependence on hunting is associated with higher female contributions to agriculture. This finding is intuitively appealing: among the Tsimane' of the Bolivian Amazon, who derive a substantial portion of their diet from both hunting and horticulture, men spend a significant portion of their time hunting, while women's production is limited to gardening and, to a lesser extent, fishing.

Table 4. Pearson correlations between female contribution to subsistence and subsistence economy variables in foragers, horticulturalists, and all groups.

	Foragers								
SCCS Variable	Contribution: Average of Three Scores	Contribution: Barry and Schlegel	Contribution: Ethnographic Atlas	Female Contribution: Martin Whyte	Female Contribution to Agriculture	Contribution to Domestic Animals	Female Contribution to Fishing	Female Contribution to Gathering	Female Contribution to Hunting
Dependence on Agriculture									
Dependence on Animal Husbandry									
Dependence on Fishing			-0.500 ***	-0.630 **				0.504 ***	
Dependence on Gathering	0.416 **		0.671 ****	0.529 **				-0.536 ***	-0.302 *
Dependence on Hunting		-0.314 *							0.348 **
	Horticulturalists								
SCCS Variable	Contribution: Average of Three Scores	Contribution: Barry and Schlegel	Contribution: Ethnographic Atlas	Female Contribution: Martin Whyte	Female Contribution to Agriculture	Contribution to Domestic Animals	Female Contribution to Fishing	Female Contribution to Gathering	Female Contribution to Hunting
Dependence on Agriculture						-0.345 **			
Dependence on Animal Husbandry						-0.286 *			
Dependence on Fishing					-0.217 *	0.333 **			
Dependence on Gathering									
Dependence on Hunting					0.382 ***				
	Full sample								
SCCS Variable	Contribution: Average of Three Scores	Contribution: Barry and Schlegel	Contribution: Ethnographic Atlas	Female Contribution: Martin Whyte	Female Contribution to Agriculture	Contribution to Domestic Animals	Female Contribution to Fishing	Female Contribution to Gathering	Female Contribution to Hunting
Dependence on Agriculture	0.143 *	0.175 **						-0.177 **	-0.252 ***
Dependence on Animal Husbandry			-0.213 ***	-0.347 ***	-0.374 ****		-0.150 *		
Dependence on Fishing						0.300 ***			0.192 **
Dependence on Gathering			0.270 ****	0.218 *					
Dependence on Hunting		-0.157 **			0.323 ****				0.244 ***

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001

2. Stratification, storage, and polygyny

I utilized six measures of social stratification or despotism (Class Stratification, Social Stratification, Social Stratification in the Larger Society, Social Stratification in the Local Community, Checks on Leader's Power Perceptions of Political Leaders' Power) as proxies for variance in male resources. *No correlations* between polygyny and these variables are statistically significant within the forager, horticulturalist, or full samples; the directions of the relationships are also inconsistent.

Table 5. Pearson correlations between polygyny and food storage in foragers, horticulturalists, and all groups.

	Foragers		Horticulturalists		Full sample	
SCCS Variable	% Married Men Polygynous	% Married Women Polygynous	% Married Men Polygynous	% Married Women Polygynous	% Married Men Polygynous	% Married Women Polygynous
food storage (recoded)	-0.446 ** ×	-0.513 *** ×			-0.142 * ×	-0.174 ** ×

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001
× Correlation in opposite direction than predicted
Food storage variable v20 was recoded as 1 or 0 to indicate the presence or absence of storage.

Food storage is implicated as a contributor to inequality in male resources. Table 6 confirms the positive relationship between storage and stratification found by Testart (1982) for foragers and extends it (weakly) to horticulturalists and (strongly) to the full sample. In the full sample, there are also fewer constraints on political leaders in storing societies. If this relationship between storage and inequality holds, and the relationship between inequality and polygyny holds, then food storage should be positively correlated with polygyny. Table 5, however, shows a *negative* relationship between food storage and polygyny among foragers and the full sample. The relationship is stronger and more significant among the forager sample.

Table 6. Pearson correlations between food storage and stratification, subsistence variables, and pathogen stress in foragers, horticulturalists, and all groups.

	Foragers	Horticulturalists	Full sample
SCCS Variable (16 total)	food storage (recoded)	food storage (recoded)	food storage (recoded)
Class Stratification	0.461 ***		0.266 ****
Social Stratification	0.585 ***	0.416 **	0.479 ****
Social Stratification in the Larger Society	0.562 **	0.390 **	0.441 ****
Social Stratification in the Local Community	0.562 **	0.323 *	0.367 ****
Checks on Leader's Power			-0.314 ***
Perceptions of Political Leaders' Power †			-0.226 **
Dependence on Agriculture			0.312 ****
Dependence on Fishing	0.611 ****		
Dependence on Gathering	-0.481 ***		-0.348 ****
Dependence on Hunting			-0.279 ****
Female Contribution to Subsistence: Average of Three Scores	-0.303 *		
Female Contribution to Subsistence: Ethnographic Atlas	-0.479 ***		
Female Contribution to Subsistence: Martin Whyte			-0.208 *
Percent Female Contribution to Domestic Animals		-0.305 *	
Percent Female Contribution to Gathering	0.410 **		0.175 **
Total Pathogen Stress	-0.103 ****		-0.125 *

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001
† Variable coded as follows: 1 = very powerful, 2 = somewhat powerful, and 3 = limited
Food storage variable v20 was recoded as 1 or 0 to indicate the presence or absence of storage.

The following six variables were not significantly correlated with food storage (p > 0.1): Dependence on Animal Husbandry, Female Contribution to Subsistence: Barry and Schlegel, Percent Female Contribution to Agriculture, Percent Female Contribution to Fishing, Percent Female Contribution to Hunting, and Sex Ratio.

I additionally investigated the relationships between storage and other subsistence variables (table 6). Among foragers, storage is negatively associated with gathering and positively associated with fishing and male contribution to subsistence: foragers that fish store food more often than foragers who don't. Among the full sample, storage is negatively associated with hunting and

gathering and positively associated with agriculture: societies that farm store more often than others.

To examine whether dependence on fishing might be driving the negative relationship between food storage and polygyny, I regressed the two variables on the percent of married women who were polygynous for both forager and full samples. While the forager regression was not statistically significant, the full-sample model controlling for dependence on fishing maintained a significant negative relationship between storage and polygyny (table 7).

Table 7. Regression model for percent of married women polygynously married with fishing and food storage as predictors in the full sample

Parameter	B	Standard Error	t	Significance
Intercept	43.36	5.302	8.178	0.000
Dependence on Fishing	-4.67	1.211	-3.855	0.000
Food storage (recoded)	-12.37	5.428	-2.279	0.024

Note: N = 138, R^2 = 0.125

How do stratification and despotism relate to subsistence economy? Tables 8, 9, and 10 show the relationship between stratification and subsistence variables for foragers, horticulturalists, and the full sample, respectively. Among foragers, stratification is positively associated with fishing and (weakly) negatively associated with hunting and women's contribution to subsistence. Among horticulturalists, stratification is positively associated with animal husbandry and negatively associated with hunting, gathering, and women's contribution to subsistence. In the full sample, social stratification and despotism are positively associated with agriculture and animal husbandry, and negatively associated with hunting, and (more weakly) gathering and fishing. There is also again less stratification where women contribute more to subsistence. This is true for overall contribution as well as in the specific domains of agriculture, fishing, animal husbandry, and hunting (in order from strongest to weakest association).

Table 8. Pearson correlations between stratification and subsistence variables in foragers.

SCCS Variable (14 total)	Foragers					
	Class Stratification	Social Stratification	Stratification in the Larger Society	Stratification in the Local Community	Checks on Leaders' Powers	Perceptions of Leader's Power†
Dependence on Agriculture						-0.404 *
Dependence on Animal Husbandry						
Dependence on Fishing	0.511 ***	0.426 **	0.591 **	0.591 **		
Dependence on Gathering			-0.425 *	-0.425 *		
Dependence on Hunting	-0.411 **					
Female Contribution to Subsistence: Average of Three Scores		-0.367 *				
Female Contribution to Subsistence: Barry and Schlegel						
Female Contribution to Subsistence: Ethnographic Atlas	-0.415 **	-0.407 *			-0.393 *	
Female Contribution to Subsistence: Martin Whyte						
Percent female Contribution to Agriculture						
Percent Female Contribution to Domestic Animals						
Percent Female Contribution to Fishing		-0.363 *				
Percent Female Contribution to Gathering	0.347 **					
Percent Female Contribution to Hunting						
food storage (recoded)	0.461 ***	0.585 ***	0.562 **	0.562 **		

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001

† Variable coded as follows: 1 = very powerful, 2 = somewhat powerful, and 3 = limited

Food storage variable v20 was recoded as 1 or 0 to indicate the presence or absence of storage.

Table 9. Pearson correlations between stratification and subsistence variables in horticulturalists.

SCCS Variable (14 total)	Horticulturalists					
	Class Stratification	Social Stratification	Stratification in the Larger Society	Stratification in the Local Community	Checks on Leaders' Powers	Perceptions of Leader's Power†
Dependence on Agriculture				0.299 *		
Dependence on Animal Husbandry	0.276 **		0.371 **			
Dependence on Fishing						
Dependence on Gathering	-0.277 **	-0.444 ***	-0.305 *	-0.371 **		
Dependence on Hunting	-0.251 **	-0.330 **			0.376 **	0.353 *
Female Contribution to Subsistence: Average of Three Scores			-0.344 *			
Female Contribution to Subsistence: Barry and Schlegel						
Female Contribution to Subsistence: Ethnographic Atlas			-0.397 **	-0.342 *		
Female Contribution to Subsistence: Martin Whyte	-0.361 *					
Percent female Contribution to Agriculture						
Percent Female Contribution to Domestic Animals	-0.367 **		-0.632 ***			0.561 **
Percent Female Contribution to Fishing		-0.306 *	-0.404 **			
Percent Female Contribution to Gathering						
Percent Female Contribution to Hunting					0.392 **	0.334 *
food storage (recoded)		,416 **	0.390 **	0.323 *		

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001

† Variable coded as follows: 1 = very powerful, 2 = somewhat powerful, and 3 = limited

Food storage variable v20 was recoded as 1 or 0 to indicate the presence or absence of storage.

Table 10. Pearson correlations between stratification and subsistence variables in all groups.

SCCS Variable (14 total)	Full sample					
	Class Stratification	Social Stratification	Stratification in the Larger Society	Stratification in the Local Community	Checks on Leaders' Powers	Perceptions of Leader's Power†
Dependence on Agriculture	0.351 ****	0.370 ****	0.414 ****	0.342 ****	-0.365 ****	-0.424 ****
Dependence on Animal Husbandry	0.279 ****	0.287 ***	0.382 ****	0.310 ***	-0.231 **	-0.209 *
Dependence on Fishing			-0.229 **			0.206 *
Dependence on Gathering	-0.392 ****					
Dependence on Hunting	-0.439 ****	-0.461 ****	-0.464 ****	-0.382 ****	0.379 ****	0.417 ****
Female Contribution to Subsistence: Average of Three Scores	-0.202 ***		-0.361 ****	-0.273 ***		
Female Contribution to Subsistence: Barry and Schlegel	-0.133 *		-0.268 **	-0.244 **		
Female Contribution to Subsistence: Ethnographic Atlas	-0.226 ***		-0.344 ***	-0.299 ***		
Female Contribution to Subsistence: Martin Whyte	-0.272 **		-0.282 **			
Percent female Contribution to Agriculture	-0.292 ****	-0.278 **	-0.458 ****	-0.349 ***		
Percent Female Contribution to Domestic Animals	-0.209 **		-0.237 *			0.303 **
Percent Female Contribution to Fishing	-0.193 **	-0.323 ***	-0.317 ***	-0.244 **		
Percent Female Contribution to Gathering						
Percent Female Contribution to Hunting	-0.171 **	-0.265 **			0.345 ***	0.340 ***
food storage (recoded)	0.266 ****	0.479 ****	0.441 ****	0.367 ****	-0.314 ***	-0.226 **

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001

† Variable coded as follows: 1 = very powerful, 2 = somewhat powerful, and 3 = limited

Food storage variable v20 was recoded as 1 or 0 to indicate the presence or absence of storage.

These relationships are generally intuitive: animal husbandry and agriculture are based on economically defensible resources (e.g. cattle or territory) and are often associated with larger, denser populations, and therefore greater social stratification.

The fact that fishing positively predicts stratification among foragers but negatively predicts stratification for the full sample is worth examining (the coefficients for the forager result are large and are significant across the stratification variables, while the full-sample result only appears for one variable). We have seen that polygyny is strongly negatively predicted by dependence on fishing across all three samples (table 1). Thus it appears that foragers that depend more on fishing are more stratified and less polygynous than other foragers.

Table 11. Regression model for percent of married women polygynously married with social stratification, women's contribution to subsistence, and food storage as predictors in the full sample

Parameter	B	Standard Error	t	Significance
Intercept	17.36	13.06	1.33	0.189
Social Stratification	6.77	4.46	1.52	0.134
Female Contribution to Subsistence: Ethnographic Atlas	0.44	0.21	2.05	0.045
Food storage (recoded)	-28.57	9.39	-3.04	0.003

Note: N = 61, R^2 = 0.196

Female contribution to subsistence, where significant, is consistently lower in more stratified societies in all three samples. Could this relationship nullify what might otherwise be a positive relationship between stratification and polygyny? The Social Stratification variable regressed on polygyny among married women alone yields a negative (and not significant) coefficient; when female contribution to subsistence and food storage are added to the regression (table 11), the stratification coefficient becomes positive and approaches, but does not reach, statistical significance (p = 0.134). Once storage and male provisioning are controlled for, stratification may thus show the predicted association with polygyny. Why food storage has such a strong negative relationship with polygyny, however, is still not clear theoretically; it is consequently unclear what causal force is being controlled for in the regression.

Table 12. Pearson correlations between polygyny and violence in foragers, horticulturalists, and all groups.

	Foragers		Horticulturalists		Full sample	
SCCS Variable (18 total)	% Married Men Polygynous	% Married Women Polygynous	% Married Men Polygynous	% Married Women Polygynous	% Married Men Polygynous	% Married Women Polygynous
At least some Wives taken from Hostile Groups					0.220 **	
Frequency of External War - Attacking†			-0.309 **	-0.327 **	-0.162 *	
Frequency of Internal War†					-0.188 **	-0.242 ***
Frequency of Internal Warfare			0.349 *			
Frequency of Internal Warfare involving Non-territorially Organized Groups within Unit of Maximal Political Authority						-0.001 *** ×
Frequency of Intraethnic Violence (v1776)	0.419 *	0.458 **				
Frequency of Violent Conflict Between Groups within Local Communities						-0.011 ** ×
Frequency of Violent Conflict Involving at Least One Maximal Effective Kin Group		0.511 *				
Individual Aggression - Assault	0.649 ***	0.684 ****			0.236 **	0.281 ***
Individual Aggression - Homicide			0.384 **	0.357 **	0.181 *	
Internal Warfare (v773)†					-0.211 *	-0.240 **
Male Aggression Guttman Scale		0.384 *			0.240 **	0.264 **
Moderate or Frequent Interpersonal Violence	0.370 *	0.407 **	0.305 **	0.372 **	0.249 ***	
Plunder (Including Captives for Slaves, Hostages, Adoption)†					-0.224 ***	-0.249 **
Rape: Incidents, reports, thought of as means of punishment, or part of ceremony					0.262 **	
Socially Organized Assault					0.398 **	
Value of War: Violence/War Against Non-Members of the Group†					-0.209 **	
Warfare or Fighting					0.220 **	

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001
× Correlation in opposite direction than predicted
† Variable coded from in reverse, from highest to lowest

The following eleven warfare/aggression variables were not significantly correlated with polygyny measures (p > 0.1): Aggressive Defense (Pre-Emptive Attack if Thought Enemy about to Attack), Defense, Frequency of External War - Being Attacked, Frequency of External Warfare (resolved rating), Frequency of External Warfare: Unit of Maximal Political Authority, Frequency of Internal Warfare (resolved rating), Frequency of Intraethnic Violence (v1778), Frequency of Violent Conflict Involving at Least One Local Community, Intensity of Intraethnic Violence, Internal Warfare (v1117), Overall Frequency of Warfare (resolved rating).

3. Violent conflict and polygyny

Correlations between variables related to aggression, violence, and warfare and polygyny are given in table 12. Of 29 variables, 18 correlate with either male or female polygyny rates within 90% confidence intervals in forager, horticulturalist, or all societies in the SCCS. All significant relationships are in the predicted direction (more violence ↔ more polygyny) except two, which have near-zero coefficients. Among foragers, polygyny correlates with variables related to interpersonal and within-group violence and aggression. The same is true for horticulturalists, with the addition of positive relationships with frequencies of internal and external warfare. The one external warfare measure (of four) significantly correlated with polygyny in horticulturalist societies and the full sample is a measure of *outward* aggression. It should be remembered that warfare (ignoring its effects on sex ratio) may lead to polygyny via either capture of women or increased demand for male protection; associations with outward aggression favor the first pathway, while associations with aggression from outside favor the second.

Six variables associated with polygyny in one or more of the samples were selected for use in analysis of co-variance and multivariate models: Frequency of External War – Attacking, Frequency of Internal War, Individual Aggression – Assault, Individual Aggression – Homicide, Moderate or Frequent Interpersonal Violence, and Plunder.

Table 13. Pearson correlations between violent conflict and subsistence variables, food storage, and stratification in foragers.

	Foragers					
SCCS Variable (18 total)	Frequency of External War - Attacking†	Frequency of Internal War†	Individual Aggression - Assault	Individual Aggression - Homicide	Moderate Interpersonal Violence	Plunder†
Dependence on Agriculture						
Dependence on Fishing				0.650 ****		
Dependence on Gathering				-0.346 *		0.421 **
Dependence on Hunting				-0.427 **		
Female Contribution to Subsistence: Average of Three Scores			0.348 *			0.410 **
Female Contribution to Subsistence: Barry and Schlegel				0.380 *		
Female Contribution to Subsistence: Ethnographic Atlas						0.466 **
Female Contribution to Subsistence: Martin Whyte						
Percent female Contribution to Agriculture						
Percent Female Contribution to Fishing						
Percent Female Contribution to Gathering					0.393 **	-0.436 **
food storage (recoded)		0.308 *	-0.408 **			-0.333 *
Class Stratification	-0.441 ***					
Social Stratification						
Social Stratification in the larger societies						
Social Stratification in the Local Community						
Checks on Leader's Power	0.422 *					
Perceptions of Political Leaders' Power ‡						

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001

† Variable coded from in reverse, from highest to lowest

‡ Variable coded as follows: 1 = very powerful, 2 = somewhat powerful, and 3 = limited

Table 14. Pearson correlations between violent conflict and subsistence variables, food storage, and stratification in horticulturalists.

	Horticulturalists					
SCCS Variable (12 total)	Frequency of External War - Attacking†	Frequency of Internal War†	Individual Aggression - Assault	Individual Aggression - Homicide	Moderate Interpersonal Violence	Plunder†
Dependence on Agriculture		-0.356 ***				
Dependence on Fishing						
Dependence on Gathering						
Dependence on Hunting		0.368 ***				
Female Contribution to Subsistence: Average of Three Scores			0.320 **			
Female Contribution to Subsistence: Barry and Schlegel						
Female Contribution to Subsistence: Ethnographic Atlas			0.389 **			
Female Contribution to Subsistence: Martin Whyte						0.446 **
Percent female Contribution to Agriculture	-0.377 ***					
Percent Female Contribution to Fishing		-0.283 *	0.358 **			
Percent Female Contribution to Gathering						-0.273 *
food storage (recoded)						
Class Stratification					0.279 **	
Social Stratification						
Social Stratification in the larger societies						
Social Stratification in the Local Community						
Checks on Leader's Power			-0.530 **	-0.524 **		
Perceptions of Political Leaders' Power ‡						

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001

† Variable coded from in reverse, from highest to lowest

‡ Variable coded as follows: 1 = very powerful, 2 = somewhat powerful, and 3 = limited

Table 15. Pearson correlations between violent conflict and subsistence variables, food storage, and stratification in all groups.

	Full sample					
SCCS Variable (12 total)	Frequency of External War - Attacking†	Frequency of Internal War†	Individual Aggression - Assault	Individual Aggression - Homicide	Moderate Interpersonal Violence	Plunder†
Dependence on Agriculture						0.155 **
Dependence on Fishing	0.208 ***	0.144 *				
Dependence on Gathering				-0.233 **		
Dependence on Hunting						-0.182 **
Female Contribution to Subsistence: Average of Three Scores			0.180 *			
Female Contribution to Subsistence: Barry and Schlegel			0.179 *	0.155 *		
Female Contribution to Subsistence: Ethnographic Atlas		-0.189 **				
Female Contribution to Subsistence: Martin Whyte						
Percent female Contribution to Agriculture					0.213 **	-0.229 ***
Percent Female Contribution to Fishing		-0.212 **				
Percent Female Contribution to Gathering						
food storage (recoded)						
Class Stratification	-0.256 ***				0.199 **	
Social Stratification	-0.251 **					
Social Stratification in the larger societies	-0.382 ****	0.194 *				
Social Stratification in the Local Community	-0.279 **				0.251 *	
Checks on Leader's Power	0.258 **					
Perceptions of Political Leaders' Power ‡	0.228 **				-0.285 **	

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001
† Variable coded from in reverse, from highest to lowest
‡ Variable coded as follows: 1 = very powerful, 2 = somewhat powerful, and 3 = limited

The following three variables were not significantly correlated with subsistence variables across all three samples (p > 0.1): Dependence on Animal Husbandry, Percent Female Contribution to Domestic Animals, Percent Female Contribution to Hunting.

Tables 13, 14, and 15 show the relationships between individual and group-level conflict and subsistence variables for the forager, horticulturalist, and full samples, respectively. The correlations are on the whole not strong, nor consistent across the conflict variables. Among foragers homicide is negatively

associated with hunting and positively associated with fishing. Plunder is negatively related to dependence on gathering and female contribution to subsistence. Among horticulturalists internal war decreases with hunting and increases with agriculture. As female contribution to subsistence increases, it appears that assault increases; plunder may decrease, but the direction of the relationship is not consistent across measures of female contribution. In the full sample, warfare is negatively associated with fishing as well as female contribution to subsistence. Homicide is negatively associated with gathering. Plunder is positively related to hunting and negatively related to agriculture.

The relationship between female contribution to subsistence and measures of violence supports the hypothesis that men's allocations to aggression trade off with parental investment. Decreased demand for male provisioning might thus lead to polygyny either directly via female indifference between monogamous and polygynous husbands (the main pathway discussed in point 1 of the theory section) or via increased demand for male protection (point 3). Regressing female contributions and assault on polygyny among married females shows that both effects remain significant in the full sample (table 16).

Table 16. Regression model for percent of married women polygynously married with women's contribution to subsistence and assault as predictors in the full sample

Parameter	B	Standard Error	t	Significance
Intercept	0.235	7.437	0.032	0.975
Female Contribution to Subsistence: Ethnographic Atlas	0.339	0.163	2.079	0.041
Individual Aggression - Assault	2.218	0.910	2.438	0.017

Note: N = 77, R^2 = 0.131

Food storage is positively related to assault among foragers, but is not significantly related to any of the five violence variables in the horticulturalist and full samples.

In the theory section the question was raised whether resource inequalities (and stratification) would show positive, negative, or null associations with violent conflict. In the full sample, all measures of stratification and

despotism are positively associated with aggressive warfare; one measure of stratification is positively associated with aggressive warfare in the forager sample. In the full and horticulturalist samples, however, stratification is negatively associated with measures of individual aggression and interpersonal violence. Thus, stratified societies may be internally safer, but more violent in their relations with other groups, a straight-forward but interesting result. The effect of inequality on polygyny via conflict would similarly be bi-directional: decreased within-group violence may drive down the demand for male protection, while increased inter-group warfare may drive it up.

4. Pathogen stress and polygyny

As reported by Low (1988), total pathogen stress is a strong positive correlate of polygyny in the full sample; the same is true for the forager and horticulturalist subsets, shown in table 17.

Table 17. Pearson correlations between polygyny and pathogen stress in foragers, horticulturalists, and all groups.

	Foragers		Horticulturalists		Full sample	
SCCS Variable	% Married Men Polygynous	% Married Women Polygynous	% Married Men Polygynous	% Married Women Polygynous	% Married Men Polygynous	% Married Women Polygynous
Total Pathogen Stress		0.398 **	0.301 **	0.352 **	0.288 ****	0.347 ****

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001

Correlations between pathogen stress and other predictor variables are summarized in table 18. Pathogen stress is strongly related to subsistence variables. It is consistently positively associated with agriculture, and negatively associated with fishing across all three samples. There is evidence for higher pathogen stress where women contribute more to subsistence in the full sample. Dependence on gather is associated with *higher* pathogen stress among foragers, but *lower* pathogen stress in the full sample. Earlier we found a negative association between pathogen stress and food storage in the forager and full samples, which may be driven by common ecological factors rather than any direct relationship per se.

Table 18. Pearson correlations between pathogen stress and stratification, subsistence variables, and food storage in foragers, horticulturalists, and all groups.

	Foragers	Horticulturalists	Full sample
SCCS Variable (19 total)	Total Pathogen Stress	Total Pathogen Stress	Total Pathogen Stress
Class Stratification	-0.362 **		0.124 *
Social Stratification	-0.355 *	0.289 *	0.254 **
Social Stratification in the Larger Society	-0.454 *		
Social Stratification in the Local Community	-0.454 *		
Checks on Leader's Power			-0.207 *
Perceptions of Political Leaders' Power †			-0.285 ***
Dependence on Agriculture	0.446 ***	0.369 ***	0.449 ****
Dependence on Fishing	-0.644 ****	-0.330 ***	-0.368 ****
Dependence on Gathering	0.462 ***		-0.167 **
Dependence on Hunting			-0.341 ****
Female Contribution to Subsistence: Average of Three Scores			0.167 **
Female Contribution to Subsistence: Barry and Schlegel			0.133 *
Female Contribution to Subsistence: Ethnographic Atlas			0.153 *
Female Contribution to Subsistence: Martin Whyte		0.370 *	
Percent Female Contribution to Domestic Animals		-0.315 **	
Percent Female Contribution to Gathering	-0.610 ****		-0.296 ****
Percent Female Contribution to Hunting			-0.200 **
Food storage (recoded)	-0.103 ****		-0.125 *

* p < 0.1, ** p < 0.05, *** p < 0.01, **** p < 0.001
† Variable coded as follows: 1 = very powerful, 2 = somewhat powerful, and 3 = limited
Food storage variable v20 was recoded as 1 or 0 to indicate the presence or absence of storage.

The following three variables were not significantly correlated with food storage (p > 0.1): Dependence on Animal Husbandry, Percent Female Contribution to Fishing, and Sex Ratio.

The relationship between pathogen stress and stratification is confusing: it is *negatively* associated with social stratification among foragers (Class Stratification at p < 0.01; Social Stratification in the Larger Society, Social Stratification in the Local Community, and Social Stratification at p < 0.1) and

positively associated with stratification in the full sample (Social Stratification and Perceptions of Political Leaders' Power at $p < 0.05$; Checks on Leader's Power and Class Stratification at $p < 0.1$).

Analysis of total pathogen stress and the six aggression variables shows a negative relationship between pathogen stress and Individual Aggression – Assault in the horticulturalist and full samples, and between pathogen stress and Individual Aggression – Homicide in all three samples. That is, where pathogen stress is higher, individual aggression is lower. Relationships with internal and external warfare variables were not significant.

The co-variance of pathogen stress with other societal variables listed in table 18—especially dependence on fishing, agriculture, and women's contribution to subsistence—needs to be taken seriously in attempting to explain the causal connections between ecology and mating system.

5. Sex ratio and polygyny

No correlations between polygyny and sex ratio are significant, nor are they consistently in one direction. To test for the relationship between sex ratio and violent conflict posited in the model, I examined correlations between sex ratio and the six main aggression variables associated with polygyny. Only five out eighteen relationships are in the predicted direction (female-biased sex ratio ↔ conflict); the correlation with Frequency of Internal War is significant ($p = 0.03$) in the opposite direction than predicted.

I investigated relationships between sex ratio the other predictor variables. There are no significant correlations between sex ratio and subsistence variables, female contribution to subsistence, social stratification, storage, or pathogen stress in the full sample. Female-biased sex ratio is significantly positively associated ($p < 0.05$) with the Barry and Schlegel and averaged measures of female contribution to subsistence among foragers; it is also associated ($p < 0.05$) with the Martin Whyte measure of female contribution to subsistence and dependence on animal husbandry among horticulturalists. It is not clear whether these associations are meaningful, nor are they implicated in the theory presented here.

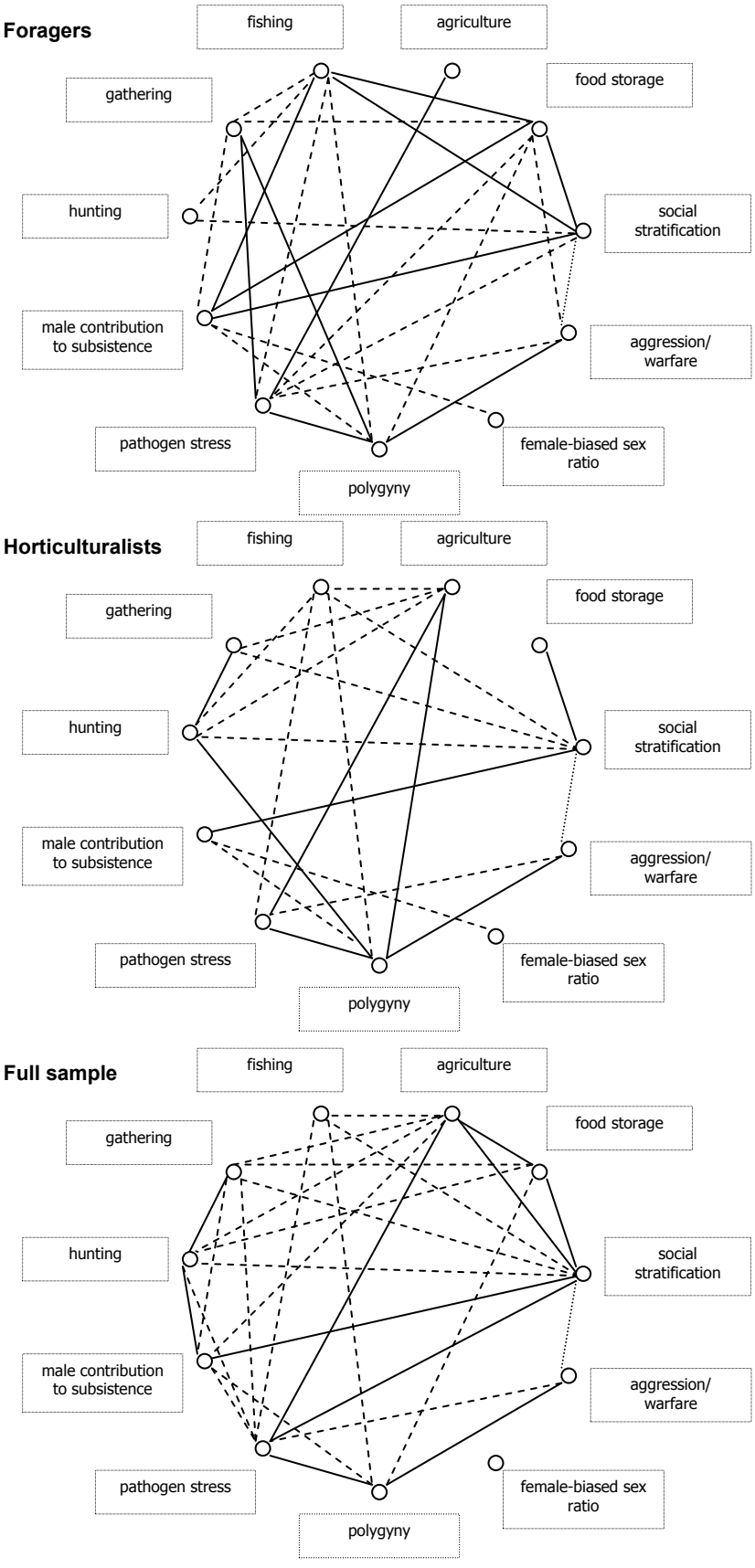

Figure 4. A sketch of significant relationships between polygyny and explanatory variables among foragers, horticulturalists, and all groups in the SCCS. Dashed lines indicate negative relationships. The dotted line between stratification and aggression/warfare indicates an ambiguous relationship, depending on the variable. Relationships between aggression/warfare and subsistence variables have been left out due to ambiguity.

Summary and conclusion

How do the results bear on the causal hypotheses outlined at the beginning of the paper?

1. The negative association between polygyny and male provisioning (and the importance of male-specific tasks) across all three samples indeed supports the demand-for-male-provisioning hypothesis. Fishing especially appears to promote monogamy, perhaps partly due to its association with high male contribution to diet.
2. Stratification, a proxy for variance in male resource holdings, does not show the predicted relationship with polygyny. Stratification may be a bad proxy for resource variance, or one that carries more baggage (e.g. covariance with urbanization, police, large-scale cooperative production) than it's worth. Controlling for male contribution and storage pushes the relationship between polygyny and stratification toward significance. The strong negative relationship between food storage and polygyny remains unexplained. Storage is closely related to other subsistence variables that appear to have an important effect on mating system, as well as stratification.
3. Warfare and interpersonal aggression show the predicted associations with polygyny. The relationship between violence and other variables, however, requires further investigation: it is clear that analyses need to distinguish between internal and external conflict, as well as interpersonal and socially organized violence. There is support for the hypothesized negative relationship between male provisioning and rates of aggression, at least among horticulturalists, suggesting that the two may indeed trade off each other. It is unclear whether aggression leads to polygyny as a result of the capture and enslavement of women (the coercion hypothesis), the demand for male protection (the female choice hypothesis), or some other pathway.
4. Pathogen stress continues to be a strong predictor of polygyny. Its associations with other predictor variables need to be evaluated in greater detail.

5. Sex ratio does not appear to be statistically connected to polygyny in the SCCS. If there is an effect, it may be washed over by more powerful causal variables such as subsistence strategy and pathogen stress.

The size of this paper has expanded greatly since its conception, and comprehensive multivariate analyses have received less attention than originally intended. Correlations between polygyny and the main predictor variables need to be translated into regression models that control for the effects of covariates, especially pathogen stress. Analyses additionally need to address the effects of latitude, ecological zone, population size, and population density. I plan to continue analyses of this type, focusing especially on other aspects of social evolution (e.g. social stratification, warfare) that have eluded quick explanation in both this paper and the field of anthropology in general.

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