POLYGYNY AND CHILD GROWTH IN A TRADITIONAL PASTORAL SOCIETY

The Case of the Datoga of Tanzania

Daniel W. Sellen
Emory University

In this paper I use measures of childhood growth to assess from both an evolutionary theoretical and an applied public health perspective the impact of polygyny on maternal-child welfare among the Datoga pastoralists of Tanzania. I report that the growth and body composition of children varies in such a way as to suggest that polygyny is not generally beneficial to women in terms of offspring quality. Cross-sectional analysis of covariance by maternal marriage status revealed that children of first and second wives in polygynous marriages grow relatively poorly, that this is correlated with maternal physical status, and that the pattern is not modified by household wealth. I discuss how the dynamics of sexual conflicts operating during the formation and maintenance of marriages may be important factors in the etiology of poor child growth in this population, leading to complex patterns of variation in anthropometric indicators of both women and children. The theoretical conclusion is that improved evolutionary models of polygyny should be designed to examine the potential for adaptive tradeoffs between the currencies of offspring quality and quantity for all types of parents in a polygynous population. The practical conclusion is that a better understanding of the relationships between marriage practices and health outcomes would assist in the development of culturally appropriate health and nutrition interventions.

KEY WORDS: **Africa; Darwinian fitness; Herding; Household resource allocation; Marriage systems; Undernutrition; Wealth.**

Received March 31, 1998; accepted August 14, 1998.

Address all correspondence to Daniel W. Sellen, Department of Anthropology, Emory University, 1557 Pierce Drive NE, Atlanta GA, 30322. E-mail: dsellen@emory.edu

Human Nature, Vol. 10, No. 4, pp. 329–371. 1045-6767/99/$1.00+.10

INTRODUCTION: POLYGYNY, PASTORALISM, AND PUBLIC HEALTH

Anthropologists have reasoned that, in many modern populations, individual women (or their kin) selectively choose wealthier men as marriage partners rather than choosing bachelor males when they stand to gain access to greater resources (Borgerhoff Mulder 1988; Irons 1979a, 1983). This "female choice" mechanism may underpin the cross-cultural findings that polygyny is often associated with social and economic stratification (Betzig 1986), that only the wealthier or more prestigious men in "polygynous" societies become polygynous (Chagnon 1979), and that polygynists usually father more children (Casimir and Rao 1995). However, it is not clear whether this wealth, prestige, or status translates into better health or nutrition among wives and children or whether its effects are diluted within larger families (Borgerhoff Mulder 1992c; Borgerhoff Mulder and Sellen 1994; Sellen 1995). Although there are likely to be tradeoffs between offspring numbers and the quality of care or investment of resources available for offspring in many human populations (Blurton Jones 1997; Hewlett 1988, 1992; Hrdy 1992; Turke 1988), such tradeoffs have hardly been measured within polygynous families (Brabin 1984; Sellen et al. 1999; Strassmann 1997). In fact, since very few studies examine whether children of polygynous marriages grow more or as healthily as the children of monogamous parents or survive to adulthood at similar rates, the public health implications of polygyny remain poorly investigated. This is surprising because social scientists and public health workers are interested in how social relations and resource control relate to individual measures of well-being. The practice of polygyny is one dimension of such complexities in many modern populations, but it is rarely considered an important factor in public health approaches to child welfare (Dettwyler 1992).

Many pastoral societies in Africa maintain traditional subsistence and social practices and are politically and economically marginal within the state, under-served by health care infrastructures, and of poor nutritional status (Dowler et al. 1986; Sellen 1996; Swift et al. 1990). African pastoral populations have also been more robust to changes in marriage practices than other populations with a history of polygynous marriage (Spencer 1998). The very persistence in this region of this particular association between marriage pattern and form of subsistence suggests it is advantageous to at least some members of the society. Indeed, evolutionary ecological anthropologists have found a number of demographic indications that polygyny entails few costs in terms of fertility among East African pastoral and agropastoral populations (Borgerhoff Mulder 1988, 1992a, 1992c; Cronk 1991b). In an effort to complement and extend these studies, I looked for cross-sectional evidence that costs of polygyny vary with the position of a woman within a polygynous marriage in one community of pastoralists, the Datoga of the Eyasi Basin in northeastern Tanzania. Rather than looking only at fertility rates, I focused on child growth performance as a key outcome and maternal anthropometric status as a possible intervening variable.

Evolutionary Predictions of the Biosocial Correlates of Polygyny

Evidence that polygyny was quite common across past human societies (Betzig 1988) has led to suggestions that the practice had adaptive value under a range of conditions, and that this remains true for individuals in populations where it persists. Behavioral ecological anthropologists have proposed a number of evolutionary explanations for the function of polygyny (Borgerhoff Mulder 1992b). The most satisfying models measure the Darwinian benefits of polygynous marriage as increased fertility or decreased mortality of offspring and distinguish situations in which these accrue to men, to women, or to particular men and women. They also consider competition for both mates and resources in a complex and dynamic social and economic environment. In short, they problematize the concept of a fixed marriage system and emphasize the potential for conflict between the sexes during mating and marriage formation.

One class of behavioral ecological models links mating systems to resource distributions and predicts higher polygyny among that subset of males in a population which successfully acquire certain types of resources as a precursor for higher fitness (Emlen and Oring 1977; Searcy and Yakusawa 1989). Applying this reasoning to the human case, we expect polygyny to increase the reproductive success of individual men through increased fertility. Ethnographic data apparently support this prediction. First, there is cross-cultural evidence that the number of wives men marry is usually associated with their differential resource holding power, whether in terms of material goods or control of the labor of others (Betzig 1986; Chagnon 1979; Dunbar 1991; Irons 1979a, 1979b; Kaplan 1985; Lancaster and Kaplan 1992; also see reviews in Betzig 1988, 1997; Flinn and Low 1986). Second, within certain populations with some degree of polygyny it has been observed that individual levels of polygyny among men correlate with high status (Betzig 1992; Malinowski 1961; Spencer 1980), prestige (Casimir and Rao 1995), headmanship (Chagnon 1979), chiefly rank (Turke and Betzig 1985), personal violence (Chagnon 1988), gerontocratic coercion (Chisholm and Burbank 1991), hunting success (Kaplan and Hill 1985), and wealth holdings (Borgerhoff Mulder 1990; Irons 1979a). Third, higher resource ownership among more polygynous men is a more likely determinant of individual levels of polygyny than their wives' and children's productivity (e.g., Borgerhoff Mulder 1989b; Cronk 1991a).

Few analysts have suggested that polygyny is "adaptive" for all. Clearly, the above results show that the institution and practice of polygynous marriage and mating lowers fitness for some men. The fitness payoffs for women are less clear and have been the subject of much recent attention. Behavioral ecological models which incorporate conflicts of interest between male and female animals (Searcy and Yakusawa 1989; Vehrencamp and Bradbury 1984; Verner and Willson 1966) and focus on payoffs to females (Altmann et al. 1977; Cashdan 1996; Smuts 1993; Westneat and Sargent 1996) predict more complex patterns (Davies 1989, 1992; Smuts and Smuts 1993; Rees and Harvey 1991). A growing number of studies suggests these patterns exist among humans (Cronk 1991a; Borgerhoff Mulder 1992b; Smith 1993) and may underpin larger aspects of social structure (Rodseth et al. 1991). Demographic evidence accumulates that in some circumstances women's choice for resource-holding men is also important in structuring marriage systems (Borgerhoff Mulder 1989a, 1990; Voland and Engel 1990). The existence of a "polygyny threshold" (when conditions are such that some men with previous wives have more to offer prospective wives than bachelors; Borgerhoff Mulder 1988, 1992c) or low costs of polygyny owing to relatively high female productivity (Hames 1996) have been shown to result in reproductive benefits to individual women or their descendents (Josephson 1993). Male coercion, often exerted through male kin groups and alliances (Gowaty 1992; Smuts 1995), may underlie some forms of human polygyny (Chisholm and Burbank 1991; Gowaty 1992; Strassmann 1997). Although under simple harem-defense polygyny male coercion would result in a greater fitness payoff to males than females (Clutton-Brock and Parker 1995), evidence suggests that in some populations the potential negative effects on female fitness can be mitigated by co-wife cooperation (Chisholm and Burbank 1991; Irons 1983).

We can conclude that observations of ultimate (demographic) measures of fitness have confirmed a basic suite of evolutionary predictions about the individual consequences of human marriage patterns. Data exist which support evolutionary theoretical predictions that, under some conditions, polygyny offers advantages in terms of Darwinian fitness both to men presented with broad, and to women faced with limited, marital choices. The fitness advantages accrue rather obviously for men through increased fertility with multiple partners. They accrue rather less obviously for women, and we can suggest that coercion by men and judicious choice and strategy by women coexist in most human populations. To date most studies do not examine possible tradeoffs between the number and quality of men's offspring. In some circumstances, the quality of offspring of polygynous males may become poor enough to offset the fitness advantages of larger numbers. Wherever such tradeoffs have been indicated, monogamy appears to be common (Hewlett 1988; Hurtado and Hill 1992;

Hurtado et al. 1992). Nevertheless, the precise relationship between quantity and quality of paternal offspring warrants further investigation within and between polygynous populations.

Application to Human Affairs

One goal of evolutionary anthropology is to predict the strategies of individuals and their associated fitness payoffs based on an understanding of the constraints imposed by gender, class, and available social options. To the extent that variation in the components of fitness can be mapped on to variation in the outcome measures used in public health, it should be possible to apply these evolutionary models in specific populations so as to predict the pattern of differences in human well-being. In the case of polygynous marriage systems, this has involved a recent shift towards determining the mechanisms by which marital status affects tradeoffs between various components of fitness (Lancaster and Kaplan 1992; Strassmann 1997; Sellen et al. 1999). These components include measures pertinent to public health, such as offspring numbers (fertility) and offspring quality (survival, growth performance, functional capacity: Strassmann 1997; Sellen et al. 1999). Evolutionary anthropologists are currently developing and testing a number of models dealing with the distribution of essential resources both within and between polygynous households (Borgerhoff Mulder 1992b).

If household resources are distributed equally within polygynous marriages, and co-wife characteristics do not vary in any systematic way, we would not expect appreciable differences in health, nutrition, or human capital among co-wives in polygynous marriages (Borgerhoff Mulder 1988, 1992c; Sellen 1995). At the population or community level, if women are socially, spatially, and temporally unconstrained in their choice of marriage partners, and can choose among bachelors and already married men so as to promote their own best interests, we would not expect aggregate differences in health, nutrition, or human capital among mothers in monogamous and polygynous unions (Borgerhoff Mulder 1990, 1994:17; Sellen et al. 1999). However, if there is competition for resources among wives in polygynous marriages, there may be both overall differences in fitness or well-being and differences in the allocation to components of fitness or well-being. Darwinian fitness and phenotypic health differentials may also obtain where women are unable to exercise choices based on assessment of the husband's resources (e.g., "enforced" marriages, by a variety of definitions including coercion and constrained opportunity).

The potential exists for the application of evolutionary models of human behavior in predicting patterns of inequality arising from differential resource access and framing solutions at the level of social reconfiguration and behavioral change. In public health work, untested assumptions about the relative costs and benefits of polygynous marriage in terms of maternal-child health indicators are rife (Gage-Brandon 1992). Few studies investigate reproductive or health outcomes in relation to marital status within polygynous unions, and hardly any have examined the proximate mechanisms leading to these measured consequences. Only a handful have examined mortality (Chojnacka 1980; Isaac and Feinberg 1982; Strassmann 1997; Sellen et al. 1999) or measures of child growth (Brabin 1984; Bretschneider 1992; Strassmann 1997) in relation to estimates of polygyny. So far as this author is aware, no studies specifically examine whether the growth of children differs by the marital status of their polygynously married mothers. This is surprising because polygynous marriage today occurs in very poor settings where access to food and health care is limited. Where such environments constrain the growth of some children, any differences among co-wives in work activities, patterns of child care and hygiene, and control over household food and health care expenditure may result in growth and other functional differences among children. From a theoretical perspective, examination of differential growth, morbidity, and mortality among children of women in different types of union would help us understand the mechanisms that exert the ultimate evolutionary effects of polygyny on reproductive success. From an applied perspective, an understanding of the proximate public health implications of polygyny would improve the targeting and cultural sensitivity of public health interventions (Dettwyler 1992).

STUDY SITE

The community studied inhabits the Eyasi Basin and Yaeda Depressions in northern Tanzania, approximately between latitudes 4° and 4°30′ S and longitudes 34°30′ and 36° E. Lake Eyasi is a seasonally filled soda lake and lies at 1031 m above sea level on the floor of the East Rift Valley. The climate within the valley system is generally hot (daily maxima ranging from 19 to 42° C) and windy. The area contains a wide variety of arid vegetative regimes and terrain. Rainfall averages 300–500 mm per year (Tanaka 1969) and has been characterized as falling bimodally in November to December (short rains) and April to June (long rains) with long and short dry seasons in between. There is substantial year-to-year variation, and in some years the rains fail completely.

Ethnographic Background

The Datoga define themselves as "people who herd cattle," but herding may be combined with a variety of other subsistence strategies. The pop ulation subsists on herds of cattle, sheep, and goats. Livestock provide raw materials for household implements and milk, blood, fat, and meat for the diet. They are also sold to generate cash for the purchase of maize, cloth, shoes, women's jewelry, tobacco, honey (for brewing beer), and veterinary medicines. Maize cultivation has been attempted by a few households since at least the 1960s (Tomikawa 1978), but productivity is extremely low today. The social system is based on segmentary patrilineal kinship, patrilocality, and clan exogamy. Marriage and family formation involves a complex system of cattle exchanges and bridewealth. This system is still poorly understood by outsiders, but in marked contrast to most other East African pastoral groups, it appears to give women some control over livestock (Borgerhoff Mulder 1991; Klima 1964). Wider social networks are also based on the exchange of livestock. Applying the criteria suggested by (McCabe 1994:86), most modern Datoga maintain a highly "traditional" pastoral lifestyle in terms of subsistence.

The Datoga are linked to the Kalenjin cluster of the Southern Nilotic expansion on linguistic grounds, with a postulated split from the major Kalenjin groups occurring approximately 1,000 years ago (Borgerhoff Mulder et al. 1989). They occupied large areas of Tanzania and southern Kenya for much of the past millennium (Tomikawa 1979). A history of loss of land rights before, during, and after the colonial period means that today they live only in northwest Tanzania. No adequate census data exist for the Datoga, and total population estimates vary substantially from 30,000 to 200,000 (Borgerhoff Mulder 1992a).

The Eyasi Datoga are not permanently settled in the type of villages common throughout rural Tanzania, and they have been characterized as "semi-nomadic" (Tomikawa 1979; Umesao 1968). Distinct, named settlement areas or "neighborhoods" (*geseudamajega*) are found in clusters of up to 30 homesteads, scattered 0.3–8.0 km apart. A typical homestead (*ghed*) serves as physical "home" to one or more men (usually agnates), some or all of their wives and children (a "family"), a few collateral kin, and their respective livestock. In this study, a Datoga "household" was operationally defined as all those individuals dependent on the herd-management decisions of an individual man, the "household head" (Borgerhoff Mulder and Sellen 1994). A household therefore consists of a group of "families" who share a common herd and semipermanent living structures. All households fission as part of the household cycle, eventually moving to another neighborhood altogether. Migration between *geseuda*, which may be from 3 to 100 miles apart, occurs roughly every 1 to 5 years.

A single wife within a family and any living children she may have form the smallest domestic unit (*ga*). At any given time, 40% of families are polygynous (Figure 1). All adult women are married (even if only to a deceased husband's kinsman), 85% in polygynous unions and 35% as the first-married (senior) wife within a polygynous union. Within households, work tasks are delegated to household members depending on their age and sex. Men are responsible for herding, digging wells to obtain water, clearing bush, and constructing homesteads. They are also responsible for most of the sales of livestock and purchasing of grains, clothing, and household goods. Much of their time is spent traveling between homestead and markets. Children of both sexes begin herding sheep, young calves, and goats for short periods in the vicinity of the *ghed* at about 4 years of age. As they grow and their abilities improve they are given charge of more and larger livestock for longer periods of the day. Women's work activities include direct child care; fetching water and firewood; milking and watering cattle; processing and cooking maize, milk, and meat; and maintaining the living structure (Sieff n.d.). Each woman is expected to provide for the needs of her own children. Her nutritional contribution depends on the milk from her own cows (donated at marriage by relatives or designated for her use by the husband), the amount of maize allocated to her by her husband, and the products of her own work efforts in grinding the maize kernels. Meat consumption is infrequent and usually depends on the allocation from the husband, but sometimes women may consume small stock that they themselves own. In a polygynous family wives take turns cooking for the husband and his visitors.

Households vary greatly in size and wealth (Table 1), although a majority are very poor in comparison to other East African pastoralists (Sellen 1995: ch. 7). Household heads usually build several homesteads for their families over a lifetime. Cattle and family members are moved strategically between them to meet changing productive, reproductive, ecological, health, and social needs. High rates of mortality and fertility, movements of individuals in response to both daily and seasonal economic and herding demands, frequent and prolonged social visiting, and the practice of both polygyny and child fostering precipitate frequent changes in household residence. Highly polygynous men may establish more than one homestead at any one time, dividing their families among them to maximize herding efficiency or resolve conflicts.

Local Conditions and Variation in Child Growth

Material conditions are extremely simple and unhygienic for all Eyasi Datoga and do not vary with wealth in livestock. There is no permanent water supply, and cooking is fueled by foraged wood, creating a smoky indoor environment. All living structures are built entirely from bush materials, with dirt floors, thick dirt roofs, and no doors, and are infested with a variety of arthropods, reptiles, and rodents. Bite rates from fleas, ticks, and flying insects are high for all human inhabitants, especially after rain.

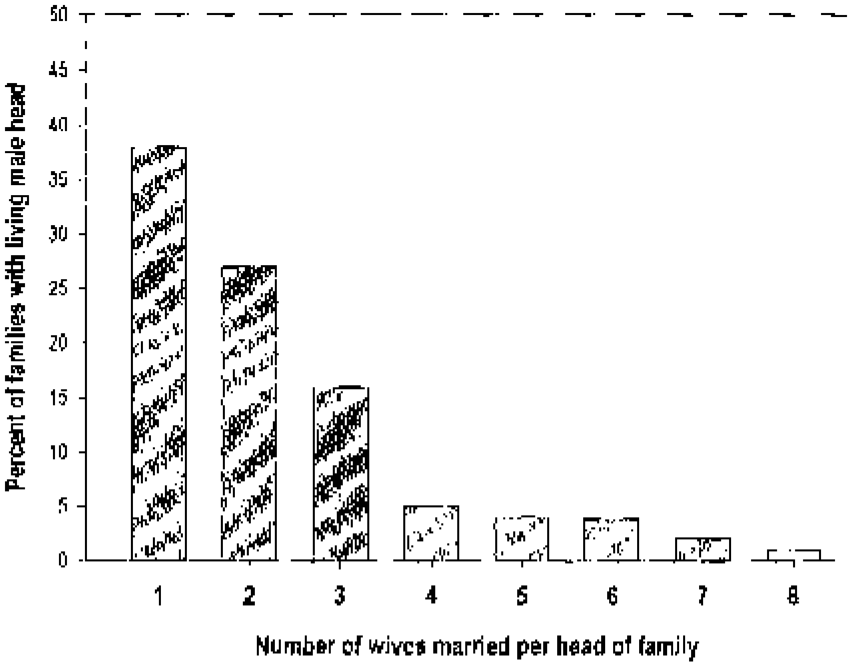


Figure 1. Prevalence of polygynous marriage among a sample of Datoga families. I recorded the total number of wives ever married by 164 living men. Some of the wives tabulated here were not present in the household owing to death and divorce. Higher levels of polygyny were reported for some deceased men, but since their households had already disbanded by the time of the fieldwork, they were not included in this sample.

No form of latrine is used; people defecate in the surrounding bush by day and in the cattle corrals by night. Small animals (cats, dogs, chickens, goats, sheep, and young calves) are always housed with the people, and despite regular sweeping, animal feces are often observed on floors and in the courtyards. No households visited during the time of this study had radios, functioning wrist watches, or western-style furniture. Health education and health care facilities are very limited, and no regular forms of motor transport, such as buses or supply trucks, visit the area. A primary school, some poorly provisioned stores, a monthly market, a rudimentary clinic, and dirt roads connecting to the main Tanzanian road network are available at *ujamaa* (development) villages about 40 km away. Missionary hospitals provide sporadic flying doctor services.

As might be expected given such conditions, the growth of Datoga children is generally poor when assessed against current international

Table 1. Household Residents and Domestic Livestock Holdings

	Mean	*s.d.*	*Range*
Total persons	10.4	5.7	5–29
Adults	5.3	3.8	2–18
Children	5.1	2.3	2–11
Men	1.8	1.0	1–5
Women	3.5	2.9	1–13
0–4.9 years	2.8	1.7	1–8
5–15.9 years	3.3	1.7	0–7
Total small stock	16.8	20.0	0–68
Goats	13.0	17.3	0–62
Sheep	3.8	5.4	0–24
Cattle	13.6	12.8	0–44
Donkeys	3.7	2.7	0–8
ILCA Tropical Livestock Units (TLU)	12.6	11.7	1.6–39.8
FAO Livestock Units (LU)	12.5	11.6	0.9–40.0

Note: Figures shown are based on monthly census of 20 households over a 10-month period in 1992, and are adjusted for days of absence and fluctuations in herd size. For international livestock unit conversion schemes, see Food and Agricultural Organization 1967; International Livestock Commission for Africa 1981.

references (Sellen 1999). Approximately 35% of all children 1–18 years are underweight (i.e., have achieved a low weight for their age), between 30 and 35% are growth stunted (i.e., have achieved a low height for their age), and between 10 and 15% are wasted (i.e., have achieved a low weight even for their achieved height: Sellen in press). However, the primary focus of this analysis is whether there is any systematic variation in child growth status within the population, and whether some of this is associated with the marital situation of mothers. My aim was to test the null prediction that Datoga children's growth has no independent associations with the marital status of mothers after controlling for potentially confounding variables.

METHODS

Simple assumptions about the ideal free distribution of mothers among unions in a polygynous society would predict no differences in the growth performance of children by the precise status of mothers in various types of union and wealth of households. I tested the null hypothesis that we should not detect systematic differences in achieved growth or anthropometric status of children by the position of the mother within the parental union or by household wealth. We collected anthropometric measures of a cross-sectional sample of 444 children and 230 women living around Lake Eyasi from April to June 1989 and from January to March 1991 (Sellen et al. 1993). We made all measurements following standard procedures (Frisancho 1990; Gibson 1990; Jelliffe and Jelliffe 1989). Bare-footed standing height was measured to the nearest millimeter using a portable anthropometer (Model 101, Seritex Inc, New Jersey). Body weights were measured to the nearest 0.1 kg using a digital scales (1989 survey 1: 12V battery-operated Weylux Model 850; later surveys: AA battery-operated Soehlner Model 7701; both scales available from CMS Weighing, 18 Camden High St., London). Where necessary, deductions were made for clothing and jewelry worn at measurement. Mid upper arm circumference (MUAC) was measured to the nearest millimeter using a small steel tape (Rabone Chesterman Ltd.). Triceps skinfold thickness (TRISF) and subscapular skinfold thickness (SUBSF) were measured to the nearest 0.2 mm with a Harpenden skinfold caliper (Hemco Corporation, Holland, Michigan), taking the average of three separate readings.

Since no birth records exist for the population, year and month of birth of children measured in the surveys were obtained from interviews with parents or other family members using standard cross-checking methods (Blurton Jones et al. 1992; Borgerhoff Mulder 1992a; Pennington and Harpending 1993). Informants were asked to place the date of birth of each child on a local calendar of events developed by previous researchers and updated by the present author (Sellen et al. 1993). We estimated children's age to the nearest month, but were aware that the margin of error increased with age. While different family members showed 100% concordance in recollecting the month of birth of young children (≤5 years), and concordance of estimates was common up to approximately 9 years of age, it diminished greatly for older children. Unless the child had been born in a particularly memorable month, age estimates of most children over 12 years were accurate only within about 6 months. Since age differences among women of reproductive age were less culturally marked and women rarely lived with older kin, we could not reliably ascertain the age of mothers. Therefore, we pooled data on women of all ages for analysis.

For children, data on height, weight, age, and sex were used to derive standardized measures of offspring quality by comparison to the appropriate reference sample in the CDC/NCHS/WHO tables (Department of Health, Education, and Welfare 1977a, 1977b). These summarize the cross-sectional growth patterns observed in a probabilistic U.S. sample. Since elites in most ethnic groups show similar cross-sectional growth patterns before adolescence (Habicht et al. 1974; Martorell and Habicht 1986) these growth curves are assumed to reflect the genetic potential for human growth. They provide benchmark (not necessarily "ideal") means and distributions at every age and sex to simplify comparisons between studies and are consequently used as an international "reference." The relative growth performance of any child at the time of measurement was expressed in terms of deviation from the appropriate reference value: Z-score = (Observed − $Reference_{age,sex}$) / $s.d._{reference}$. The weight-for-age Z-scores (WAZ) of all children for whom a reliable age and weight was obtained, height-for-age Z-scores (HAZ) of all children for whom a reliable age and height was obtained, and weight-for-height Z-scores (WHZ) of all children for whom height and weight was obtained were calculated for most children using a computer program (Centers for Disease Control 1991). The distribution of height-for-age Z-scores was examined for the cross-sectional sample, and cases with extreme values were excluded on the assumption that age reporting had been inaccurate. In order to remove any potential confounding from variability in ages at puberty onset (which appears late on average among the Datoga), we excluded all measures on teenagers.

We calculated a body mass index (MBMI, as weight/height^2) for each woman from measures of weight (MWT) and height (MHT). Measures of triceps skinfold (MTRISF) and mid upper arm circumference (MMUAC) were used to estimate the cross-sectional area of fat and muscle in the upper arm for each woman (MUFA, MUMA), following the method of Frisancho (1990) and others, with an adjustment for estimated bone area. We then calculated arm fat index (MAFI) by expressing the estimated fat area as a percentage of the estimated total cross-sectional area of the upper arm and summed triceps and subscapular skinfolds for all subjects (MSUMSF). We did not transform skinfold data for statistical comparisons, because they were normally distributed in this population.

Descriptive statistics were calculated using either SAS (SAS Institute 1989) or SPSS (SPSS Inc. 1997) on a personal computer. The analytic strategy was to test for associations between mother's maternal marital status (MMS) and each measure of child growth and body composition using a series of ANCOVA models controlling for any potentially confounding associations with age (AGEMON), sex (SEX), child's birth order (PARIT), season of measurement (SURVEY), and household wealth (WLTHCAT). We used the PROC GLM program under SAS/PC (SAS Institute, 1986) or the General Factorial subroutines in SPSS and made statistical decisions at the 5% level of significance. Initial models included age in months as a continuous variable, sex, and survey (a proxy for season of measurement) as dichotomous variables, and birth order as a categorical variable with 12 levels. Marital status and household wealth were coded as categorical variables. Data on marital and familial relationships were obtained for each measured individual through interviews conducted in KiSwahili. For women, marital status was recorded as the order of marriage to the current husband. For children, mother's marital status (MMS) was recorded in the same way. Unions were also categorized as monogamous or polygynous according to whether the current husband had one or more wives at the time of measurement. Since few women married as the fourth or later wife, data on such women and their children were pooled to reduce the number of degrees of freedom in the model. In this analysis marital status was therefore designated as M1 (first and only wife), P1 (first wife in a polygynous marriage), P2 (second wife in a polygynous marriage), P3 (third wife in a polygynous marriage), and P4+ (fourth or later-married wife in a polygynous marriage). For a subsample of the children measured, an index of household wealth was estimable from information on the total number of animals in the father's household herd collected by structured interview. Livestock numbers were expressed in Tropical Livestock Units (TLU), a measure by which cattle, sheep, and goats can be tallied in terms of their mutual exchange value (International Livestock Commission for Africa 1981). This index was used to categorize households as being richer (upper tercile), medium (middle tercile), or poorer (lower tercile) in wealth (WLTHCAT). All two-way interaction effects were included in the initial models, and non-significant terms sequentially removed.

RESULTS

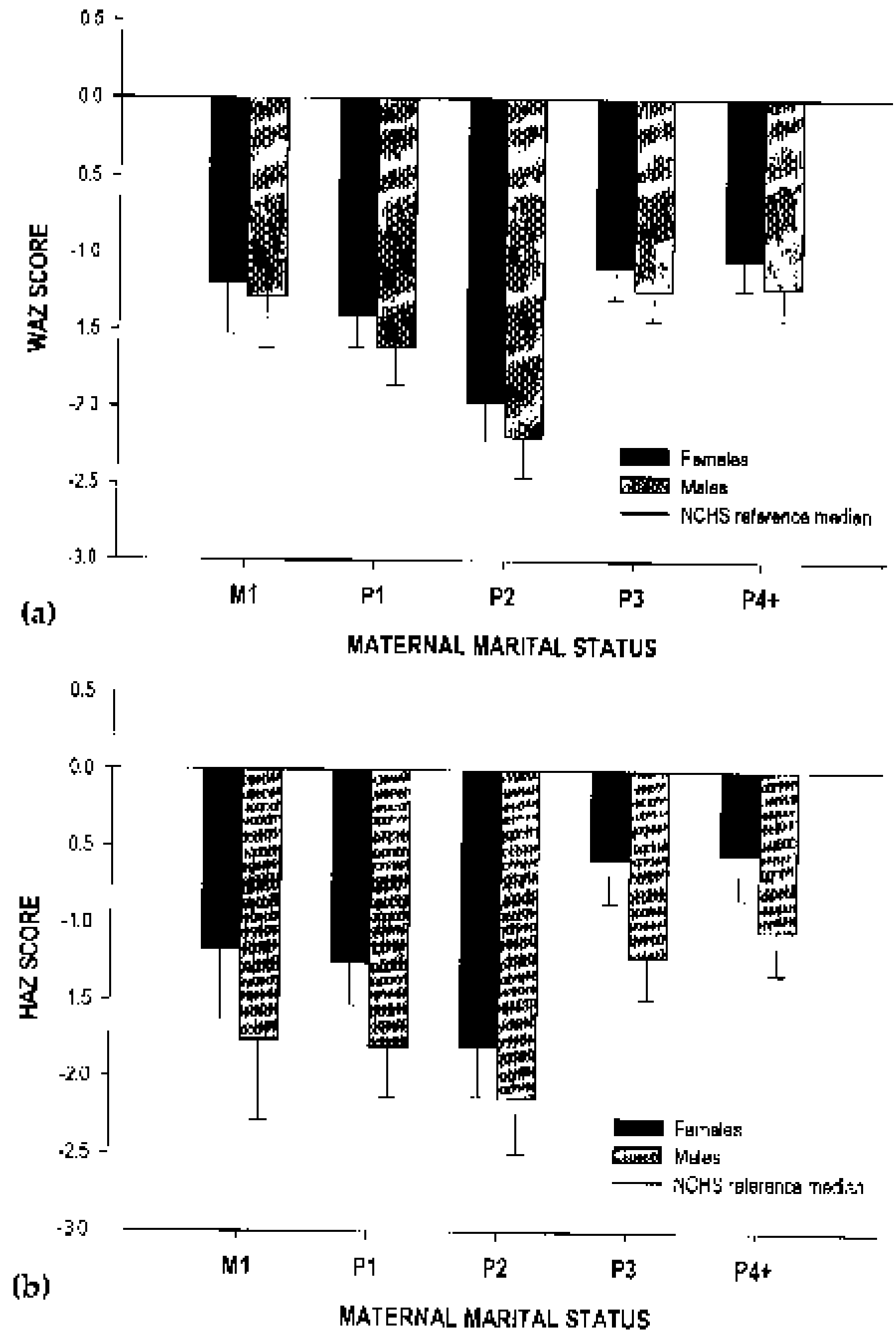
Reliable anthropometric data on 253 children and 190 mothers not known to be pregnant at the time of measurement were retained for analysis. Approximately 13% of children measured were from monogamous families (in which the mother was the first and only wife to enter a marriage with the father: M1 children). The remaining children from polygynous families were approximately evenly distributed among mothers who were first, second, third, and fourth or higher-order wives. As a group, the children of polygynous marriages were found to have slightly poorer growth scores than the children of monogamous marriages, but the differences were not statistically significant (Table 2). Examination of the mean Z-scores of children by mother's marital status revealed that children of the first two wives in polygynous marriages were smaller in weight and stature at all ages (Figure 2). The association with marital status remained statistically significant after adjusting for sex, age, survey, and birth order by analysis of covariance and excluding children measured in both surveys (see legend, Figure 2). Similar patterns were seen in the data on body composition. Mid upper arm circumference, an index of lean body mass, and summed skinfolds, a measure of adiposity, were lower among children of first and second wives in polygynous marriages for both girls and boys (Figure 3). However, the adjusted differences were of small magnitude and were not statistically significant after controlling for age.

Table 2. Comparison of Mean Growth Scores and Indicators of Body Composition between Children (0–11.9 Years) of Monogamous and Polygynous Families

Type of Parental Union	*Growth Scores*			*Indices of Body Composition*					
	WAZ	*HAZ*	*WHZ*	*MUAC*	*TRISF*	*SUBSF*	*SUMSF*	*UFA*	*AFI*
Monogamous	1.06	−0.97	−0.68	14.55	7.42	5.29	12.71	4.93	29.52
N	27	16	15	27	27	27	27	27	27
sd	1.39	2.07	0.54	1.45	2.70	1.43	2.78	1.49	8.11
Polygynous	1.39	−1.26	−0.92	14.72	7.11	4.87	11.95	4.79	27.96
N	226	168	158	228	230	229	229	226	228
sd	1.36	1.54	0.89	1.49	2.41	1.35	3.78	1.60	8.85
All combined	−1.35	1.24	−0.89	14.71	7.14	4.91	12.03	4.81	28.13
N	253	184	173	255	257	256	256	255	255
sd	1.37	1.58	0.86	1.48	2.39	1.37	3.24	1.59	8.86

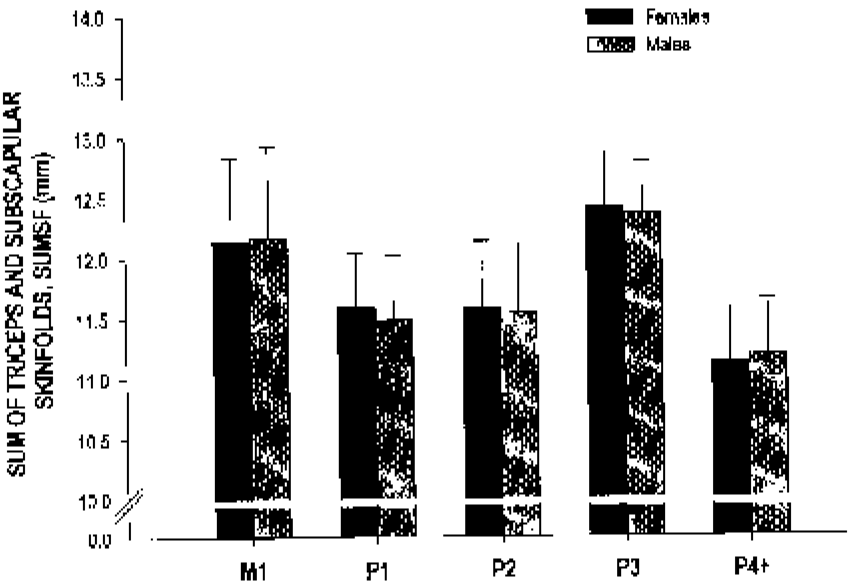
Data on household wealth were available for 189 children and 178 mothers. A significant proportion of the variation in weight, stature, summed skinfold, and arm circumference of children was associated with the wealth of the household in which each child lived. Therefore, step-wise analyses of covariance were repeated after including wealth tercile as a main effect and also its interactions with age, sex, season of measurement, birth order, and mother's marital status. Measures of skinfolds and arm circumference on children under 2 years were excluded. Although stature, summed skinfolds, and arm circumference remained significantly positively associated in these models with wealth, and weight marginally so, the associations with marital status were not entirely removed (Table 3).

Figure 2. (Facing page) Marital status and growth scores of surviving children (0–11.9 years, $n = 250$). Bars show means and standard deviations by position of the mother in her current marriage after adjusting for age, birth order of the child, and season of measurement by analysis of covariance (SPSS Inc. 1997). Median lengths and weights of American children would fall on the $y = 0$ reference line. Marital status is designated as M1 (first and only wife), P1 (first wife in a polygynous marriage), P2 (second wife in a polygynous marriage), P3 (third wife in a polygynous marriage), P4+ (fourth or later-married wife in a polygynous marriage). The ANOVA models included age in months as a covariate, sex of child and season of survey as dichotomous variables, and birth order as a fixed factor with 12 levels. (*a*) Relative weight for age (WAZ score) was significantly associated with marital status (partial $F_{4,248} = 2.529$, $p = 0.041$). (*b*) Relative height for age (HAZ score) was also significantly associated with marital status (partial $F_{4,180} = 2.786$, $p = 0.028$). Growth scores were not significantly associated with sex, birth order, or season of measurement, and only WAZ was significantly associated with age (partial $F_{1,248} = 5.612$, $p = 0.019$).

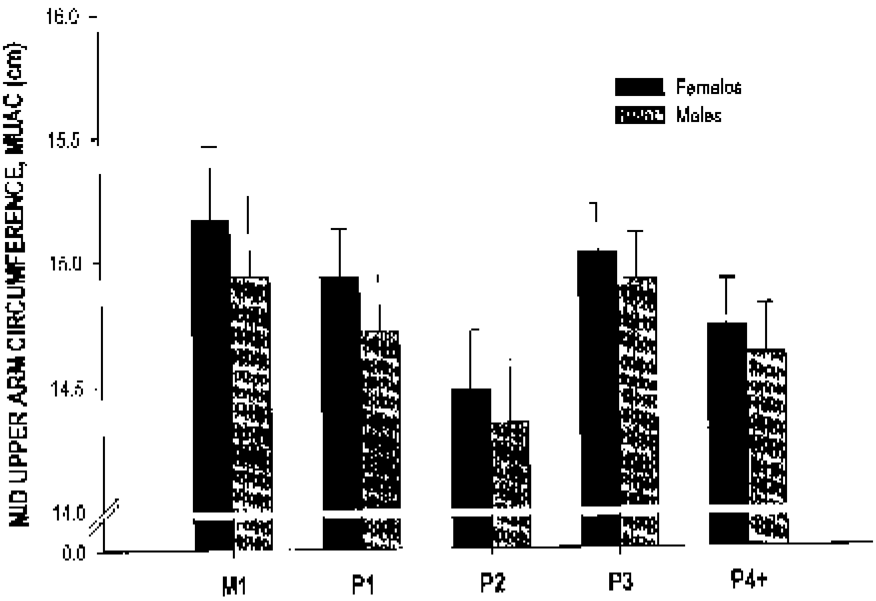


0.5
0.0
0.5
-1.0
1.5
-2.0
-2.5
-3.0
WAZ SCORE
Females
Males
NCHS reference median
M1
P1
P2
P3
P4+
(a)
MATERNAL MARITAL STATUS
0.5
0.0
0.5
-1.0
1.5
-2.0
-2.5
-3.0
HAZ SCORE
Females
Males
NCHS reference median
M1
P1
P2
P3
P4+
(b)
MATERNAL MARITAL STATUS

Figure 2.



(a) MATERNAL MARITAL STATUS



(b) MATERNAL MARITAL STATUS

Figure 3.

Table 3. Factors Associated with Growth Indicators for Children 0–11.9 Years of Age

				2–11.9 *yrs*‡			
		0–11.9 *yrs*†		MUAC		SUMSF	
Model Parameters	*df*	*WAZ*	*HAZ*	*Girls*	*Boys*	*Girls*	*Boys*
Sample size (girls, boys)		189 (108, 81)	147 (82, 65)	86	67	86	67
Adjusted r^2		.565	.472	.996	.994	.953	.946
Model F ratio		8.421	12.939	1605.3	1063.5	216.9	147.52
Model *p* value		*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
Partial *p* values:							
Marital status of mother (MMS)	4	*.042*	.100	.259	.573	.252	.409
Wealth of household (WLTHCAT)	2	.118	*.045*	*.028*	*.012*	.948	*.047*
Age (AGEMONS)	1	*.094*	.959	*<0.001*	*0.001*	*<0.001*	*<0.001*
Sex (SEX)	1	.189	*.035*	—	—	—	—
AGEMONS*MMS		—	—	*.022*	—	—	—

† ANCOVA, Type III sum of squares, both sexes aggregated. No interactions were significant.
‡ ANCOVA, Type III sum of squares, disaggregated by sex. Only significant interactions were included in the models.
HAZ = height for age Z–score; WAZ = weight for age Z score; WHZ = weight for height Z–score; MUAC = mid upper arm circumference (cm); SUMSF = sum of triceps and subscapular skinfolds (mm).

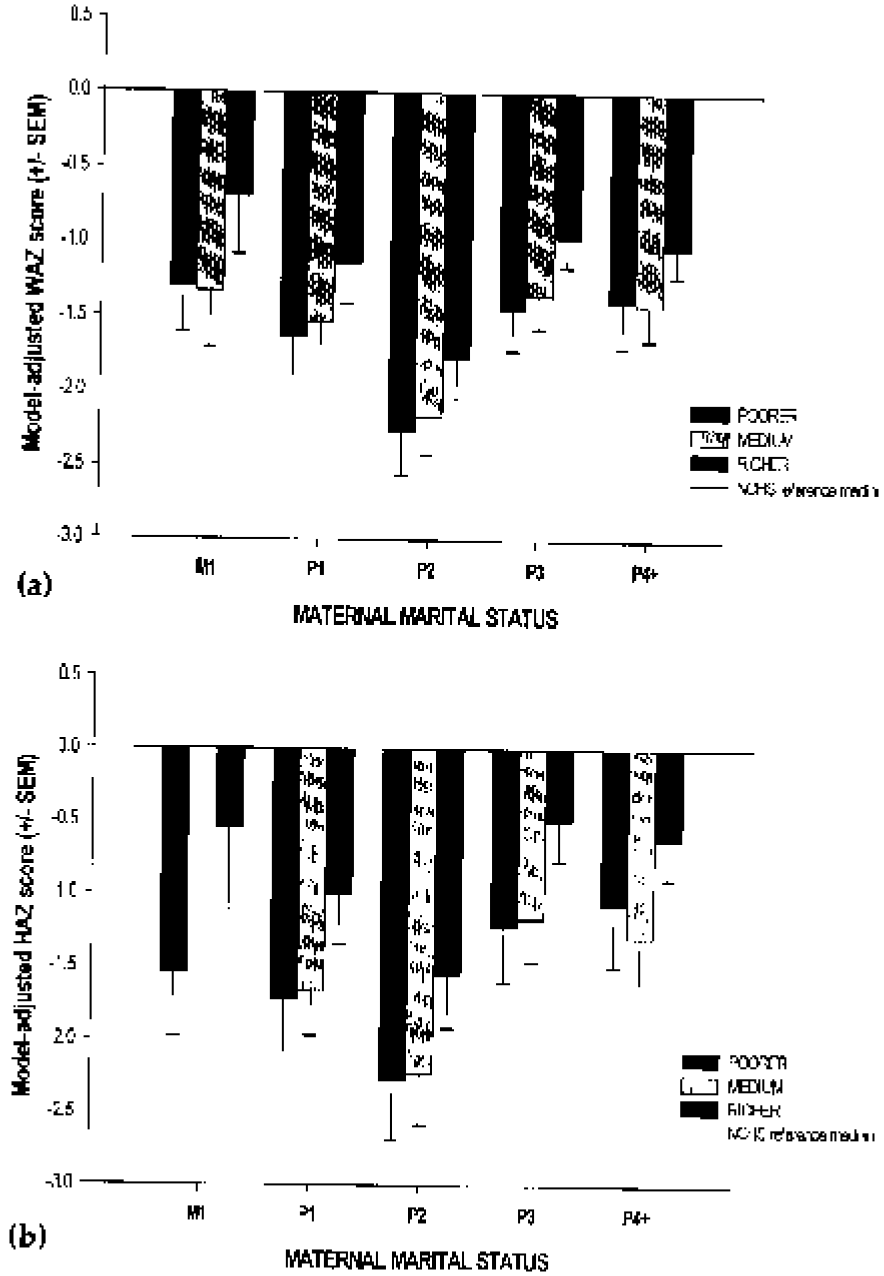
Mother's marital status explained an appreciable amount of the variation in achieved stature, and was more strongly associated with weight than was wealth category of the household. Importantly, there was no significant interaction between mother's marital status and household wealth in these data for any outcome measured. Thus, the same association with mother's marital status was paralleled in all wealth strata. When the pat-

Figure 3. (Facing page) Marital status and indicators of body composition among surviving children (0–11.9 years, $n = 250$). Bars show means and standard deviations by position of the mother in her current marriage after adjusting for age, sex, birth order of the child, and season of survey by analysis of covariance (SPSS Inc. 1997). Variables were defined and entered in the ANCOVA models as in Figure 2. (*a*) Summed subscapular and triceps skinfolds (SUMSF). (*b*) Mid upper arm circumference (MUAC). Contrasts by marital status of the mother were not statistically significant after controlling for significant associations with age ($F_{4,251} = 93.288$, $p < 0.001$ and $F_{4,251} = 106.297$, $p < 0.001$ for SUMSF and MUAC, respectively).

terns of child growth and body composition were reexamined after adjusting for wealth, in each wealth tercile children of first and second wives in polygynous unions were found to have poorer weight scores (Figure 4a) and poorer height scores (Figure 4b) than others. The same patterns were repeated across wealth categories for skinfolds and arm circumferences of both sexes (Figure 5), although again the independent effect of marital status was not statistically significant in these models.

Measures of child growth performance were highly correlated with maternal anthropometric indicators after covarying out the effects of sex, birth order, and age of child in months, maternal height, and wealth of household (Table 4). There were also systematic differences in maternal anthropometry by marital status that paralleled those in children's anthropometry. Mothers who were first and second wives within polygynous unions presented with lower body weights, body mass indices, and indicators of adiposity (Table 5). Mothers who were first wives in monogamous marriages weighed on average 2.1 kg more than polygynously married mothers ($t_{30,47} = 1.44$, $p = 0.154$), which corresponded to a significant difference in BMI of 1.42 kg/m^2 ($t_{30,47} = 3.29$, $p = 0.002$). Differences in indicators of lean body mass and fatness suggested that much of this weight difference was due to greater adiposity among the monogamous mothers. Indicators of peripheral body fat were marginally greater (MTRISF: $t_{30,47} = 1.48$, $p = 0.143$; MAFI: $t_{30,47} = 1.54$, $p = 0.128$) and indicators incorporating a measure of central body fat were significantly greater (MSUBSF: $t_{30,47} = 3.78$, $p = 0.001$; MSUMSF: $t_{30,47} = 3.04$, $p = 0.004$) among these mothers. Although upper arm circumferences were similar (MMUAC: $t_{30,47} = 0.791$, $p = 0.431$), upper arm muscle area was estimated to be greater among the mothers in polygynous marriages (MUMA: $t_{24,58} = -1.53$, $p = 0.130$). Comparison of mothers who were first and second wives within polygynous unions revealed a slightly different pattern of

Figure 4. (Facing page) Association of growth indicators with household wealth and marital status among surviving children (0–11.9 years, $n = 188$). Bars represent estimated residual means and standard errors after adjusting for age and sex of the child by analysis of covariance (SPSS Inc. 1997). Marital status of the mother is designated as in Figure 2. The data are categorized according to the reported size of the household herd at interview (poorer tercile, <17 TLU; medium tercile, 17–54 TLU; richer tercile, >54 TLU). The ANCOVA models also included sex of child and age in months as covariates and are summarized in Table 2. (*a*) Relative weight for age (WAZ score) remained significantly associated with marital status after controlling for wealth of the household. (*b*) Relative height for age (HAZ score) was significantly associated with wealth and sex of the child



Model-adjusted WAZ score (+/- SEM)
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
POORER
MEDIUM
RICHER
NCHS reference median
M1
P1
P2
P3
P4+
(a)
MATERNAL MARITAL STATUS
Model-adjusted HAZ score (+/- SEM)
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
POORER
MEDIUM
RICHER
NCHS reference median
M1
P1
P2
P3
P4+
(b)
MATERNAL MARITAL STATUS

Figure 4.

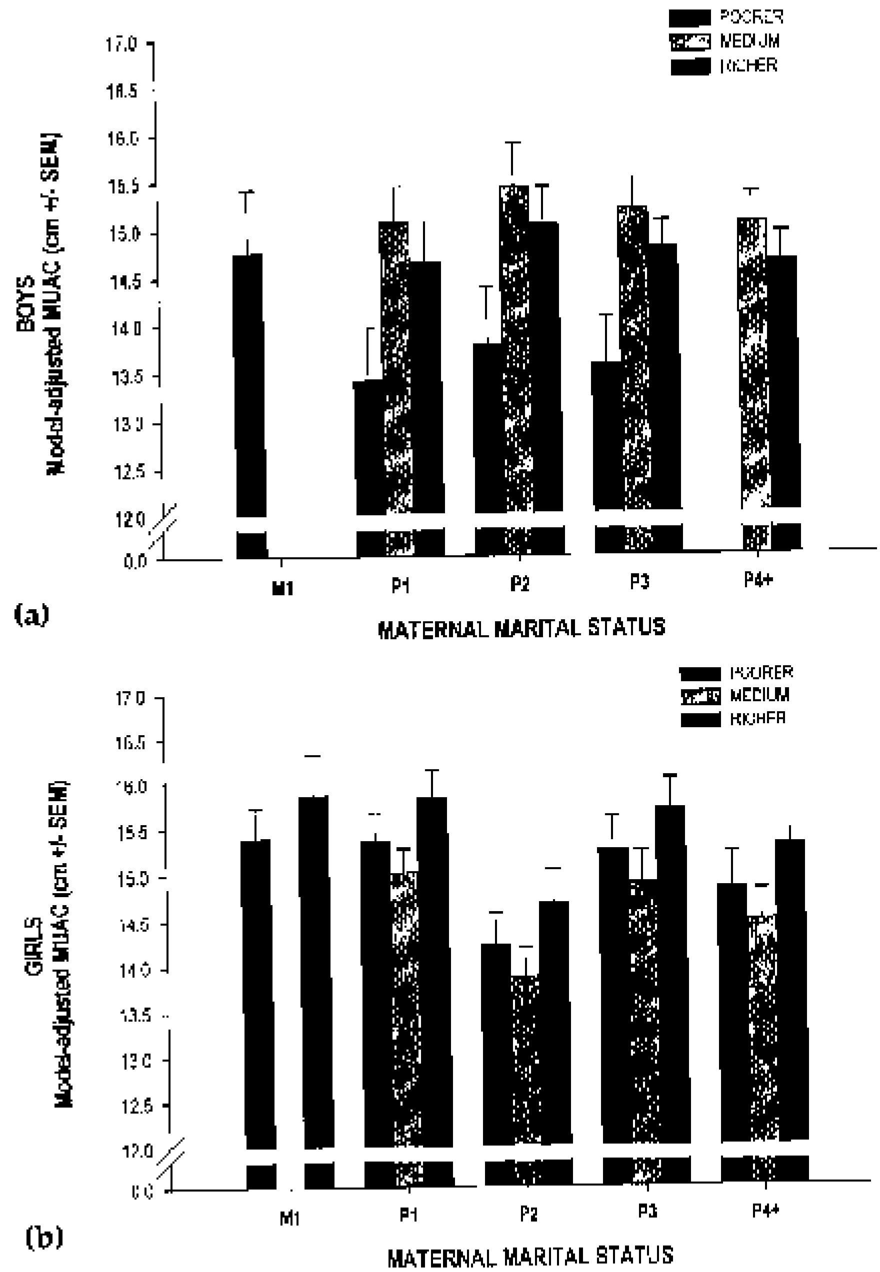
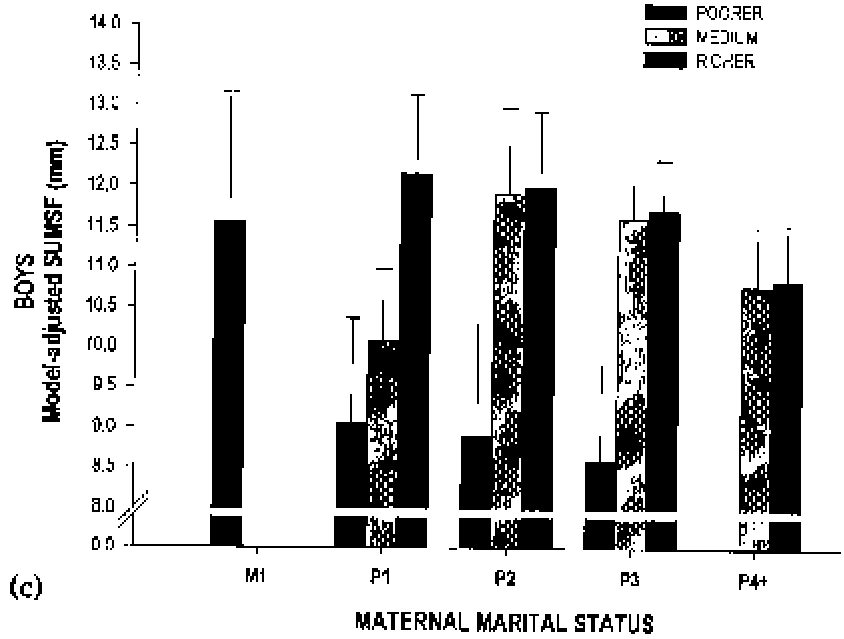
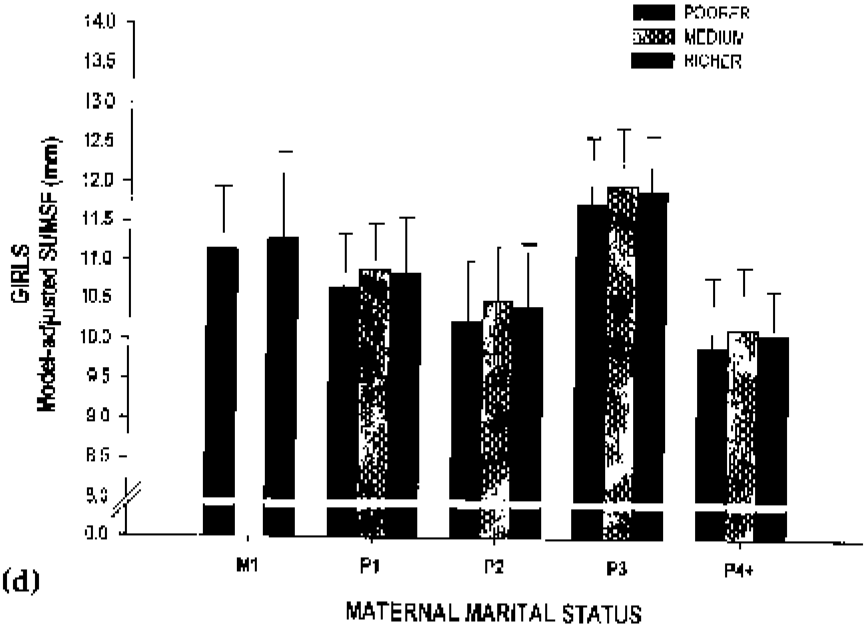


Figure 5. Association of indicators of body composition with household wealth and marital status among surviving children (2–11.9 years, $n = 153$). Bars represent estimated residual means and standard errors after adjusting for age of the child by analysis of covariance (SPSS Inc. 1997). Variables defined as in



(c)



(d)

Figure 2 and significance of main effects and interactions summarized in Table 2. (a) Mid upper arm circumference (MUAC) of boys 2–11.9 years; (b) Mid upper arm circumference (MUAC) of girls 2–11.9 years; (c) Summed subscapular and triceps skinfolds (SUMSF) of boys 2–11.9 years. (d) Summed subscapular and triceps skinfolds (SUMSF) of girls 2–11.9 years.

Table 4. Associations between Maternal Anthropometry and Measures of Child Growth Performance and Body Composition

	Child Measures			
Maternal Measures	*WAZ*	*HAZ*	*MUAC*	*SUMSF*
MBMI	.4013	.2090	.1054	−.0963
p	.000	.021	.250	.293
MWT	.4029	.2130	.1177	−.0793
p	.000	.019	.198	.387
MMUAC	.4120	.2381	.1323	.1131
p	.000	.009	.148	.217
MSUMSF	.3471	.1977	.1040	−.0805
p	.000	.030	.256	.380
MAFI	.2778	.2058	.0669	−.1091
p	.002	.024	.466	.234

MBMI = maternal body mass index (kg/m^2); MWT = maternal weight (kg); MMUAC = maternal mid upper arm circumference (cm). MSUMSF = maternal sum of triceps and subscapular skinfolds (mm); MAFI = maternal arm fat index.
Numbers shown are the Pearson partial correlation after controlling for sex and age of child in months, birth order, maternal height and wealth of household and the p–value of the partial association.

anthropometric differences. Although the second wives (P2) weighed on average 1.9 kg less than first wives (P1) and had very low average BMI values, the differences were not statistically significant. Their significantly (or marginally significantly) greater skinfold measurements at all sites suggested that differences in lean body mass and stature explained most of the difference in weight and BMI.

Anthropometric differences among mothers were not an artifact of wealth differentials among households. Zero-order correlations between wealth and measures of maternal anthropometry showed no linear associations. Although in ANCOVA models most maternal anthropoetric measures were weakly associated with wealth insofar as mothers in middle-wealth households were heavier and more adipose than others, all measures remained strongly independently associated with marital status (Table 6). The pattern of difference by marital status was not parallel across wealth strata, and all measures showed a significant interaction between wealth and marital status. Pair-wise comparisons by marital status after adjusting for main effect and interaction of wealth revealed that although most indicators decreased slightly from M1 to P1 to P2 in all households, third wives (P3) in middle-wealth households were significantly taller and heavier and had higher BMI and measures of lean body mass and adiposity. Thus, in contrast to child anthropometry, the relationship between maternal anthropometry and marital status is modified by wealth.

Table 5. Comparison of Anthropometric Indicators among Mothers o

	Marital		
Anthropometric Measures†	*M1*	*P1*	
n	30	47	
Height (cm)	157.1 ± 5.6	159.1 ± 7.0	(1.
Weight (kg)	49.1 ± 5.9	47.0 ± 7.0	(
Body Mass Index (kg/m^2)	19.9 ± 1.9	18.5 ± 1.8^a	(
Mid upper arm circumference (cm)	24.3 ± 2.3	23.6 ± 2.0	(
Upper arm muscle area (cm^2)	12.8 ± 3.8	14.5 ± 4.8	(
Triceps skinfold (mm)	9.7 ± 3.9	8.5 ± 3.5	
Subscapular skinfold (mm)	9.3 ± 3.9	6.5 ± 1.5	
Sum of skinfolds (mm)	19.1 ± 6.8	14.8 ± 4.3^c	(
Arm fat index (% cm^2)	22.5 ± 5.6	20.7 ± 5.0^e	(

† Includes measures on women not known to be pregnant during two cross-se

a. Significant difference between first wives in polygynous marriages and mon

b. Significant difference between first and second wives in polygynous marriag

c. Significant difference between first wives in polygynous marriages and mon

d. Significant difference between first and second wives in polygynous marriag

e. Significant difference between first wives in polygynous marriages and mon

f. Significant difference between first and second wives in polygynous marriag

Table 6. Determinants of Anthropometric Indicators of Moth

Main Effects†	*df*	MHT	*MWT*	*MBMI*	*MMUA*
Partial *p*-values					
WLTHCAT	2	.189	.208	.045	.025
MMS	4	.008	<.001	<.001	<.00
WLTHCAT*MMS	7	<.001	<.001	<.001	<.00
Sample size		178	178	178	178
Error df		164	164	164	164
Adjusted r^2		.999	.982	.953	.990
Model *F*-value		129,991.0	686.5	730.8	1,278.
Model *p*-value		<0.001	<0.001	<.001	<.00

† ANOVA with fixed effects, Type III sum of squares, including moth
for definition of variables.
MHT = stature; MWT = estimated body weight; MBMI = body mass
MUMA = upper arm muscle area; MTRISF = triceps skinfold; MSUBS
two skinfolds; MAFI = arm fat index (% fat in upper arm).

DISCUSSION

The simplest interpretation of these data is that, contrary to our null hypothesis, the practice of polygyny is associated with significantly reduced growth of some children. Both household wealth and the position of the mother within her marriage influence the growth performance of Datoga children. Children present with lower growth scores if their mothers are currently the first or second wives in a polygynous marriage. Although children from wealthier households present with relatively better physical indicators, the association with mother's marital status appears in all wealth strata.

Specifically, three types of anthropometric outcome appear to be associated with maternal marital status: children's achieved weight and height (growth Z-scores); children's lean muscle mass and adiposity (arm circumference and skinfolds); and indicators of maternal energy balance (BMI and measures of adiposity). Children's growth and fatness are strongly associated with both maternal marital status and household wealth. In turn, maternal anthropometric status is more strongly related to position within the marriage than household wealth. Women who are the first or second wives in polygynous marriages are lighter and leaner than others are, and a proportion show signs of chronic energy deficiency. It is the children of these women who are lighter (low WAZ), thinner (low MUAC), and leaner (low SUMSF) than other children, and appear to have grown more poorly as a result of more severe or more pernicious chronic undernutrition (low HAZ or "stunting"). Thus, the associations between maternal anthropometric status and child growth and anthropometric status suggest that maternal marital status is an intervening variable that captures something about the social factors influencing variation in children's growth both within and between households.

Undernutrition in both adults and children can arise through complex interactions between low nutrient intake, high energetic expenditure, high susceptibility to infection, and greater severity and duration of infections. The pattern of lower anthropometric scores among mothers with a small number of co-wives and their children is consistent with the hypothesis that household resource dilution and inequality in the allocation of food resources, health providers, caregiving, and labor are part of the underlying mechanism. If correct, such an interpretation has both theoretical and practical implications. However, before discussing this interpretation it is wise to consider several problems with the research design.

Limitations of the Study

First, it is possible that the apparent differences among children of first and second wives in polygynous marriages versus others are an artifact of unmeasured and uncontrolled factors. Second, current data do not allow us to decide whether the level of difference in child growth is sufficient to produce differences in child morbidity and survival. Third, the cross-sectional study design precludes direct observation of the mechanisms by which the observed differences in children's growth arise. The indications of a proximate or ultimate "cost" to polygyny for some women must therefore be interpreted with caution.

With regard to the first problem, we must evaluate the success of the methods and models in minimizing the effects of a number of sampling biases and potential confounds. Anthropometric measures are usually associated with age and sex, and so both the nature of the relationship and the way in which these associations are teased apart from any other associations of interest demands careful attention. In the present study, visual inspection of the raw data did not suggest any particular biases in the age or sex distribution of children by mother's marital status or wealth category. Boys were found to be smaller, leaner, and thinner at all ages relative to the reference than girls, so that disaggregating by sex or including sex as a control variable in the analyses was appropriate. As in many traditional populations cross-sectional data on Z-scores indicate a decrease with age between birth and 2 years, and little change between 2 and 11.9 years (Sellen in press). For both sexes mid upper arm circumference showed an approximately linear increase and skinfolds showed an approximately linear decrease over the 0–12 age range. Control for age to the nearest month and the use of Z-scoring corrected for allometric effects and unbalanced sampling. To the extent that age estimates were accurate, the effects of age were apparently well controlled in the models. Indeed, the magnitude of the differences in skinfolds and derived measures of adiposity between children of different sexes and ages was small because virtually all individuals were exceptionally lean. Moreover, although there were some differences between the two surveys in the dispersion of anthropometric indicators, there were no appreciable differences in mean values and time of survey was not a significant effect in the ANCOVA models (see Sellen in review for a discussion of seasonal buffering in Datoga children).

The potential influence of maternal age and parity (a proxy for maternal age) was less clearly controlled. Since birth weight is a strong predictor of postnatal growth performance, maternal depletion (Merchant and Martorell 1988; Winkvist et al. 1992) might be an important determinant of child anthropometric status. Maternal depletion has been observed in many populations with poor nutrition and high disease load (Adair and Popkin 1992; Adair et al. 1983; Garner et al. 1994; Harrison et al. 1975; Merchant et al. 1990a, 1990b; Tracer 1991; see Miller 1989, Winkvist et al. 1994 for exceptions), including African pastoralists (Gray 1995; Little et al.

1992). If a negative association between parity and birth weight exists among the Eyasi Datoga then the differences in child anthropometry reported here may derive from age and parity differences between mothers of different marital status rather than from other differences among them. The available evidence suggests this is unlikely. First, there was no association between birth order of children measured in the present study and mother's marital status ($F_{4,182} = 1.622, p = 0.171$). Second, although we have no data on birth weights, there was in fact no significant independent association of anthropometric indicators with birth order of the child in these data. Third, no association between age and marital status was found in a different sample of 49 mothers from the same population (Sellen 1995: Table 8.17). Therefore, while the observed differences in child anthropometry by marital status were associated with differences in maternal anthropometry, these were probably not spuriously attributable to systematic differences in age or parity among mothers.

The results may have been influenced by other sampling biases inherent in the cross-sectional design. For example it is possible that the apparently poorer growth of some children from polygynous families is an artifact of improved survival of severely malnourished children in polygynous families rather than a result of diminished maternal-child health conditions within these families. In other words, if children of first wives in monogamous marriages were actually at greater risk of death than others, then the average growth scores among the survivors would be inflated by sampling bias owing to excess deaths among the severely growth-stunted. The large epidemiological sample needed to test for this possibility is not yet available for the Eyasi Datoga. However, longitudinal measurements on a sample of children under 3 years of age provide little indication of a cohort effect whereby children with extremely low growth scores do not survive beyond the first few years (Sellen 1998). Retrospective demographic data also indicate that mortality risks prior to the fifth birthday do not differ appreciably by marital status (although they are greater among women in poor households with a single co-wife at the time of the birth: Sellen et al. 1999).

Since no data were available on marital histories of mothers in this sample, the possible effects of stepparenting on child growth are not examined. It is therefore possible that some mothers in the sample had married polygynously to the current husband after failed earlier marriages had already affected their children's growth. Indeed, if this were true, the data should not be interpreted as showing costs to polygyny, but as evidence that many current second wives have escaped unfavorable marriages. However, participant observation did not produce any evidence for such patterns, except perhaps in the case of women married by levirate, whose children were excluded from analysis. The large numbers of women marrying polygynously in the population (Figure 1) and the large sample measured in the surveys render such sampling biases unlikely.

The Relevance of Alternative Causal Explanations to Theory and Practice

If we assume the findings are robust to these potential problems, then they are consistent with the general hypothesis that polygyny is costly to women among the Eyasi Datoga. Since the costs were estimated in the currency of offspring quality using standardized measures of growth performance and anthropometric status, we must consider the possible implications for fitness, which is usually estimated in the currency of offspring numbers using relative demographic measures of offspring production and survival. In order to better evaluate competing hypotheses to account for the origin and maintenance of polygyny among the Datoga, and to draw inferences about other polygynous or pastoral societies, we must also ask by what mechanisms the poorer growth of children of polygynously married women comes about. Knowledge of these mechanisms might help us understand why Datoga women tolerate marrying polygynously if the growth of their children is compromised. Understanding the causes of associations between children's growth and marriage patterns will not only contribute to our understanding of the evolution of human polygynous systems, it may also have implications for the design of public health interventions among the Datoga and other African pastoralists.

What are the fitness consequences of poor growth and physical status of children? There are good grounds for interpreting such indicators of human offspring quality as a proxy for parental fitness in traditional and developing societies (Sellen n.d.a). In traditional or developing settings with high intrinsic mortality rates, child growth status is a very strong predictor of risk of death, impaired adult functional capacity, relatively poor cognitive performance, and reduced physical work capacity (Haas and Habicht 1990; Waterlow et al. 1977; World Health Organization 1986, 1995). There are methodological limitations when age is not precisely known (Boerma et al. 1992; Cole 1993; Dibley et al. 1987; Gorstein 1989; van Loon et al. 1986) and the achieved size of young children is a nonspecific rather than a precise indicator of risk of unfavorable outcomes (Allen 1993; Beaton et al. 1990; Grantham-McGregor 1993; Pelletier et al. 1994). Nevertheless, those children identified in this study as being of poorer physical status may less likely to survive into adulthood, and those who do may have lower lifetime reproductive success. A mean difference of almost one standard deviation in height-for-age values between children of first and second wives in polygynous marriages is probably of biologically significant magnitude given the adverse conditions under which all Datoga children live. Follow-up studies have yet to be conducted, but it is likely that the children of monogamous wives will have lower mortality and greater functional capacity. Their better growth status suggests that they were more resistant to pathogens prior to measurement and also that they will be more able to survive illness and other environmental insults subsequent to measurement.

What are the mechanisms that result in poorer physical status of children of first and second wives in polygynous marriages? Given that growth of young humans is highly sensitive to parental manipulation, we might expect children's growth to be associated with mother's marital situation if women's position within a polygynous marriage influences either her own anthropometric status or her ability to feed and provide care for her children. The fact that growth appears to be compromised among children of both first and second wives in polygynous marriages suggests that resource dilution may be operating and is consistent with ethnographic evidence against paternal favoritism for first wives or initial systematic differences among women who enter monogamous or polygynous marriages.

Comparison of the offspring growth performance and physical status of first wives who are the only wife (M1) and first wives who must share with co-wives (P1) provides a way to tease apart the effects of wife seniority versus competition for resources. On average, the addition of a second wife appears to have a negative effect on the growth of first wife's children among the Eyasi Datoga (Figure 3). In addition, the lower BMI and skinfolds among P1 relative to M1 mothers suggests the nutritional status of first wives decreases when they are joined by co-wives. In contrast, there is little indication that those women who married as first wives were initially in better nutritional status than other women, for example because they came from wealthier families. On average there were no differences in height among women of different marital status. Moreover, the anthropometric differences between mothers of different marital status were not solely attributable to systematic differences by household wealth.

A more plausible explanation is that addition of a second wife to a marriage entails a reduction in the per capita availability of food for wives and their children, increased disease, increased workloads, or some combination of these factors ("resource-dilution" hypothesis). The observation of even greater relative costs in terms of reduced child growth for the second wives is consistent with a hypothesis of resource dilution, but also suggests that the senior wife is more successful in reducing these costs to herself and her children. Pair-wise comparisons indicated that although the differences between the growth of children of monogamous wives and first wives in polygynous marriage (M1 vs. P1) were marginally statistically significant, children of second wives in polygynous marriages showed significantly poorer growth than children of monogamously married women (P2 vs. M1, Bonferroni test differences in WAZ, $p = 0.003$; Bonferroni test differences in HAZ, $p = 0.081$). These differences parallel those observed in a longitudinal study of very young children (Sellen et al. 1999). Such differences are especially intriguing given ethnographic observations of equal treatment of wives within polygynous families. Male elders and younger adults of both sexes repeatedly stress that traditional Datoga law forbids polygynists to favor one wife over another with respect to allocation of livestock, cash, food, and other resources. Indeed, men can be tried in "women's courts" (*garamaneda hau*) if they breach this code and are fined in cattle if judged guilty of acting without fair cause.

If it is true that co-wives receive equal investment from the husband within Datoga families, there may be ways in which the first wife might be better able to mitigate the cost of the presence of a second wife. First wives may be able to co-opt the labor of the junior wife, or they may receive more help from their natal family members. They may be able to return to their parents home more often or for longer periods than other women (perhaps through greater proximity), or they may be visited by female relatives more frequently as a result of their marital status. Either way, the net effect may be an increased level of help with work tasks that interfere with child care. Recruiting kin or co-wives to help with fetching water and collecting fuelwood may be particularly crucial. Datoga mothers always leave young children behind at the homestead when they perform these tasks. If repeated for long periods on an almost daily basis, such work may reduce breast-feeding duration for young children and reduced health care seeking behaviors by mothers of weanlings (Sellen 1998). Growth deficits occurring among partially breast-fed and early weaned infants of polygynous women may never be recouped, and could underlie the patterns reported here. The significantly lower arm muscle areas of M1 wives in the presence of significantly greater weight for height and skinfolds (Table 5) lend support to the hypothesis that they work less arduously, and so develop less arm musculature and remain in more positive energy balance.

The apparent lack of such negative effects on third and higher-order wives and their children demands explanation. On the face of it, one might expect that the association between household wealth and levels of polygyny in this population would mean that women who marry as third and higher wives are better off because their husbands are sufficiently wealthy as to mitigate any resource dilution effects. However, the pattern remained after adjusting for absolute household wealth stratum. There are several testable hypotheses as to why the negative effects of polygyny are not observed among late-married wives in highly polygynous unions, all of which would require collection of additional data. Women who marry wealthy men as high-order wives may receive more cattle gifts from their parents and kin (Sieff 1995), perhaps to compensate for their marital status. They may also enter households at a more favorable point in the household cycle. Most Datoga men have a distinct career in terms of relative size of household herd and family, and middle-sized or mid-career families appear to enjoy relatively better household food supply and labor ratios (Sellen n.d.b).

It should be noted that the analysis does not compare relative growth of children born to mothers within the same family, but rather cross-sectional samples of women and children drawn from many unions. Further investigations will attempt to measure within-family effects and control for other systematic differences among families, such as those caused by deaths and divorces of wives in polygynous marriages and by numbers of helpers. The cross-sectional design also makes it difficult to interpret the correlation between maternal and child anthropometry and their parallel associations with marital status and wealth. On the one hand, those women who are able to maintain higher physical status will, on average, conceive at higher pre-pregnancy weights, show greater pregnancy weight gains, and give birth to higher birth weight babies. *Ceteris paribus*, such babies will have higher growth scores at all ages, and we would model the effects of marital status on child growth as mediated through effects on maternal physical status. On the other hand, the physical status of mothers and children may simply reflect common conditions within the household, and would thus be best examined in a multivariate analysis of household conditions. Until longitudinal studies can provide data to tease these two mechanistic pathways apart, it is most parsimonious to assume that maternal physical status is both a covariate and a predictor of child growth.

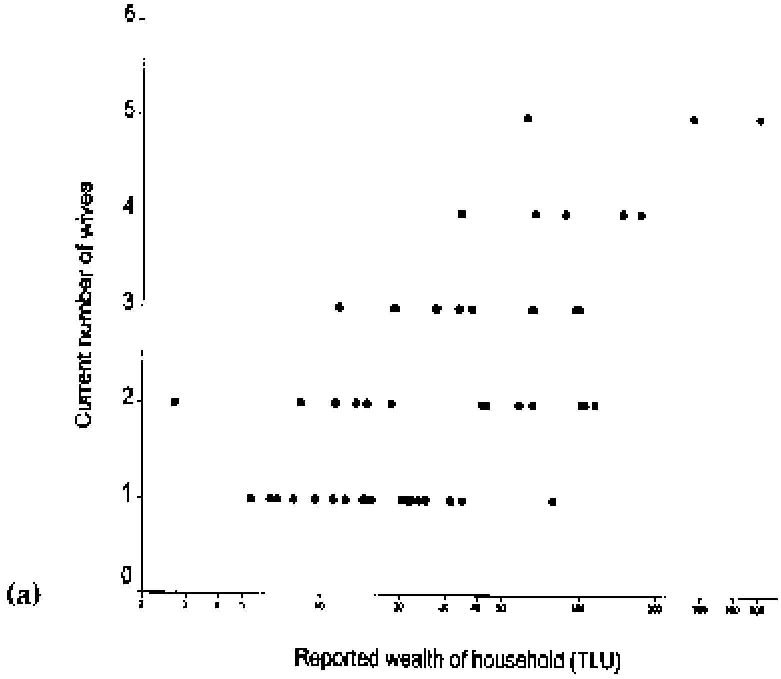
What are the implications for evolutionary explanations for Datoga polygyny? Recently, evolutionary anthropologists have developed and tested a number of models dealing with the distribution of essential resources both within and between polygynous households. Taken together, the patterns of growth and anthropometric status among Datoga children and their mothers force us to reject a straightforward "female choice" model to explain the evolution and maintenance of Datoga polygyny. Women in polygynous unions accrue costs in terms of reduced offspring quality. These vary by marital status for reasons that are not yet clear, and in a complex pattern. In the absence of richer ethnographic and observational data we therefore cannot rule out covertly unequal division of household resources among multiple wives as a possible mechanism underlying the reported patterns ("unequal resource-dilution" hypothesis). Datoga mothers are also likely to be employing a number of compensating strategies which can only be properly understood in diachronic perspective (Borgerhoff Mulder 1992c; Borgerhoff Mulder and Sellen 1994).

In sum, although ethnographic observations suggest that Datoga women who marry a polygynist may not differ in any systematic way from women who marry bachelors, and are not overtly discriminated against by husbands, we are forced to reevaluate evolutionary explanations for the maintenance of Datoga polygyny by unconstrained female choice. These data clearly suggest polygyny serves male interests but not female interests. At the time of the study wealthy men were more likely to be polygynous (Figure 6a) and to father more offspring (Figure 6b). However, even in wealthy families the children of some women in polygynous marriages grew more poorly than children of monogamous women. This is an indication that there may be tradeoffs between offspring quality and quantity even for men. If fewer of their children survive, then the social and Darwinian benefits to polygyny for men, usually reported as having many descendents and a large family labor force, will be diminished. In this sense, polygyny might also be interpreted as costly to men.

Such conflicting results make it clear that both the decision of a Datoga woman to marry polygynously and its various consequences are conditioned on a complex of factors. Studies designed to discover them will be more productive than simple comparisons of monogamous versus polygynous marriages. It is also apparent that use of different outcome measures (e.g., fertility vs. children's growth performance) might lead to very different conclusions. Studies involving a variety of measures will be more informative. On the basis of present evidence we can suggest that the average Datoga woman should choose to marry a bachelor if the opportunity arises, and a wealthy one if possible. However, the dynamics of conflict with the husband's reproductive interests and with those of incoming co-wives will make it hard for her to predict the outcome of this decision in terms of maternal-child health.

CONCLUSIONS

Significant associations of variation in achieved weight, stature, and indicators of lean body mass of Datoga children with maternal marital status suggest that the position of mothers within households influences growth performance and nutritional status of children in this population. Children of first and second wives in polygynous unions appear to grow more poorly relative to other children. This pattern is consistent with the hypothesis that the practice of polygyny is associated with adverse outcomes for some mothers in terms of poor growth and physical status of their children. Since the pattern is not simply attributable to greater wealth, and presumably better nutrition, hygiene, and care in polygynous households, it suggests (*a*) that some women are constrained into polygyny and (*b*) that



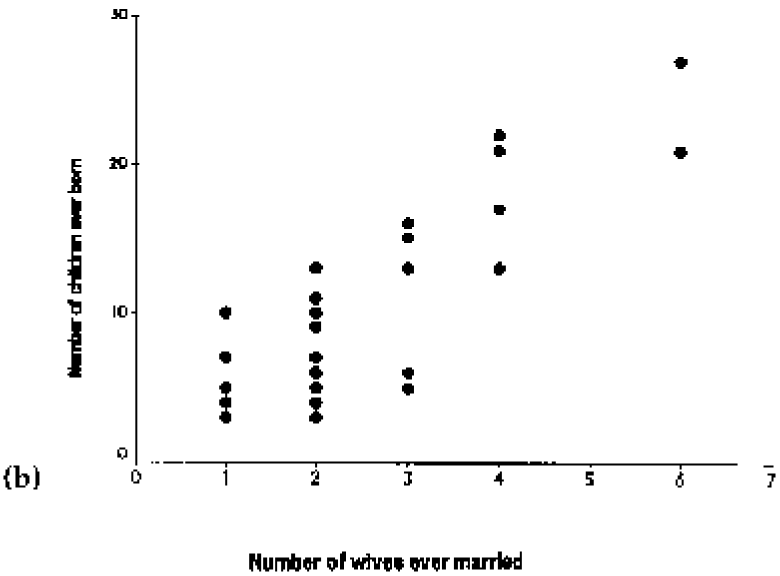


Figure 6. Associations between wealth and fertility among Datoga men in the Eyasi area. (*a*) Relationship between absolute wealth of a household and number of wives ever married by the household head. (*b*) Relationship between number of wives ever married by household heads and the number of children attributed to them.

a tradeoff between numbers and quality of offspring may be operating among polygynous men.

Understanding the mechanisms underlying the observed patterns presents a major challenge. Clearly, proper interpretation of these findings will only be possible after richer ethnographic and observational data become available. Most important, these data should not be used in arguments decrying the practice of polygyny, but as part of attempts to understand the wider implications of traditional social adaptations. The results may be indicative of an indigenous system under stress since the colonial period rather than of institutionalized inequalities. However, if this pattern stands up to more rigorous investigation and is found in other African pastoral societies where polygyny is prevalent, then it will be of concern to those involved in maintaining or improving the health and welfare of pastoral populations, not least the people themselves. It is in this regard that evolutionary anthropology will interface with public health. The broader inference from the present study is that the practice of polygyny has potentially important public health implications. A renewed research focus on the public health implications of polygyny among African pastoral populations might prove fruitful. If similar patterns were consistently found in other populations, it might be desirable to target children in polygynous families for public health interventions. In testing a specific model derived from evolutionary theory (that polygyny has no costs in terms of young child growth) using established public health indicators (anthropometric status), I demonstrate the usefulness of evolutionary anthropology in the applied domain.

Thanks to the Tanzanian Research Council for Science and Technology (UTAFITI) and local village chairmen for granting research permission and to the many Datoga families who allowed me to work among them. Grants from the Wenner-Gren Foundation for Anthropological Research, the Royal Anthropological Institute of Great Britain, and the Leverhulme made the work possible. The Program in International Nutrition at the University of California, Davis provided institutional support during analysis. Momoye Bashgei Merus, Monique Borgerhoff Mulder, and Daniela Sieff shared information on ages of children and assisted with data collection. Discussions with Monique Borgerhoff Mulder, Kristen Hawkes, and Nick Blurton Jones strengthened the design and analysis. Janet Peerson and Kathryn Dewey advised on statistical approaches. Three anonymous reviewers made helpful comments on the manuscript.

Daniel Sellen (B.A., M.A. Zoology, University of Oxford, 1987; M.A. Anthropology, University of Michigan, 1989; Ph.D. Ecology and D.E. International Nutrition, University of California-Davis, 1995) is an assistant professor in the Department of Anthropology at Emory University; adjunct professor in the Department of International Health, Rollins School of Public Health; and a visiting fellow in the Public Health Nutrition Unit at the London School of Hygiene and Tropical Medicine.

His research interests are in nutritional ecology; the relations between subsistence, marriage systems, and demography; and the evolution and current diversity of young child feeding and caregiving practices. In addition to work on the Datoga, he has published "A phylogenetic analysis of the relationship between fertility and mode of subsistence" (*Current Anthropology* 38:878–889, 1997, with R. Mace) and "Termination of reproduction in non-human and human female primates" (*International Journal of Primatology* 16:205–220, 1995, with Caro, Parish, Frank, Brown, Voland, and Borgerhoff Mulder).

REFERENCES

Adair, L., and B. Popkin

1992 Prolonged Lactation Contributes to Depletion of Maternal Energy Reserves in Filipino Women. *Journal of Nutrition* 122:1643–1655.

Adair, L., E. Pollitt, and W. Mueller

1983 Maternal Anthropometric Changes during Pregnancy and Lactation in a Rural Taiwanese Population. *Human Biology* 55:771–787.

Allen, L.

1993 The Nutrition CRSP: What Is Marginal Malnutrition, and Does It Affect Human Function? *Nutrition Review* 51(9):255–267.

Altmann, S., S. Wagner, and S. Lenington

1977 Two Models for the Evolution of Polygyny. *Behavioral Ecology and Sociobiology* 2:397–410.

Beaton, G., A. Kelly, J. Kevany, R. Martorell, and J. Mason

1990 *Appropriate Uses of Anthropometric Indices in Children*. Nutrition Policy Discussion Paper No. 7. Geneva: United Nations Administrative Committee on Coordination, Subcommittee on Nutrition.

Betzig, L.

1986 *Despotism and Differential Reproduction: A Darwinian View of History*. New York: Aldine de Gruyter.

1988 Mating and Parenting in Darwinian Perspective. In *Human Reproductive Behaviour: A Darwinian Perspective*, L. Betzig, M. Borgerhoff Mulder, and P. Turke eds. Pp. 3–20. Cambridge. Cambridge University Press.

1992 Roman Polygyny. *Ethology and Sociobiology* 13:351–383.

1997 Introduction: People Are Animals. In *Human Nature: A Critical Reader*, L. Betzig, ed. Pp. 1–17. New York: Oxford University Press.

Blurton Jones, N.

1997 Too Good to Be True? Is There Really a Tradeoff between Number and Care of Offspring in Human Reproduction? In *Human Nature: A Critical Reader*, L. Betzig ed. Pp. 83–86. New York: Oxford University Press.

Blurton Jones, N., L. Smith, J. O'Connell, K. Hawkes, and C. Kamuzora

1992 Demography of the Hadza, an Increasing and High Density Population of Savanna Foragers. *American Journal of Physical Anthropology* 89:159–181.

Boerma, J., A. Sommerfelt, and G. Bicego

1992 Child Anthropometry in Cross-sectional Surveys in Developing Countries: An Assessment of the Survivor Bias. *American Journal of Epidemiology* 135:438–449.

Borgerhoff Mulder, M.
1988 The Relevance of the Polygyny Threshold Model to Humans. In *Mating Patterns*, C. Mascie-Taylor and A. Boyce, eds. Pp. 209–230. Cambridge: Cambridge University Press.
1989a Marital Status and Reproductive Performance in Kipsigis Women: Re-evaluating the Polygyny-Fertility Hypothesis. *Population Studies* 43:285–304.
1989b Polygyny and the Extent of Women's Contribution to Subsistence. *American Anthropologist* 91:178–180.
1990 Kipsigis Women's Preferences for Wealthy Men: Evidence for Female Choice in Mammals? *Behavioural Ecology and Sociobiology* 27:255–264.
1991 Datoga Pastoralists of Tanzania. *National Geographic Research and Exploration* 72:166–187.
1992a Demography of Pastoralists: Preliminary Data on the Datoga of Tanzania. *Human Ecology* 20:383–405.
1992b Reproductive Decisions. In *Evolutionary Ecology and Human Behavior*, E. Smith and B. Winterhalder eds. Pp. 339–374. New York: Aldine de Gruyter.
1992c Women's Strategies in Polygynous Marriage. *Human Nature* 3:45–70.
Borgerhoff Mulder, M., and D. W. Sellen
1994 Pastoralist Decision-making: A Behavioral Ecological Perspective. In *African Pastoralist Systems. An Integrated Approach*, E. Fratkin, K. Galvin, and E. Roth, eds. Pp. 205–230. Boulder: Lynne Rienner.
Borgerhoff Mulder, M., D. Sieff, and M. Merus
1989 Disturbed Ancestors: Datoga History in the Ngorongoro Crater. *Swara* 12:32–35.
Brabin, L.
1984 Polygyny: An Indicator of Nutritional Stress in African Agricultural Societies. *Africa* 54:31–45.
Bretschneider, P.
1992 Sociobiological Models of Polygyny: A Critical Review. *Anthropos* 87(1–3): 183–191.
Cashdan, E.
1996 Women's Mating Strategies. *Evolutionary Anthropology* 5:134–143.
Casimir, M., and A. Rao
1995 Prestige, Possessions, and Progeny: Cultural Goals and Reproductive Success among the Bakkarwal. *Human Nature* 6:241–272.
Chagnon, N.
1979 Is Reproductive Success Equal in Egalitarian Societies? In *Evolutionary Biology and Human Social Behavior: An Anthropological Perspective*, N. Chagnon and W. Irons, eds. Pp. 374–401. North Scituate, Massachusetts: Duxbury Press.
1988 Life Histories, Blood Revenge and Warfare in a Tribal Population. *Science* 239:985–992.
Chisholm, J., and V. Burbank
1991 Monogamy and Polygyny in Southeast Arnhem Land: Male Coercion and Female Choice. *Ethology and Sociobiology* 12:291–313.
Chojnacka, H.
1980 Polygyny and the Rate of Population Growth. *Population Studies* 34: 91–107.

Clutton-Brock, T. H., and G. Parker
1995 Sexual Coercion in Animal Societies. *Animal Behavior* 49:1345–1365.

Cole, T.
1993 The Use and Construction of Anthropometric Growth Reference Standards. *Nutrition Research Review* 6:19–50.

Cronk, L.
1991a Human Behavioral Ecology. *Annual Review of Anthropology* 20:25–53.
1991b Wealth, Status and Reproductive Success among the Mukogodo of Kenya. *American Anthropologist* 93:345–360.

Davies, N.
1989 Sexual Conflict and the Polygamy Threshold. *Animal Behavior* 38:226–234.
1992 Beyond Dunnocks: Sexual Conflict, Parental Care and Mating Systems. In *Dunnock Behavior and Social Evolution*. Cambridge: Cambridge University Press.

Dean, J. A., D. Coulombier, D. C. Smith, K. A. Brendel, T. G. Arner, and G. D. Dean
1995 *Epi Info, version 6.0.* A word processing, database, and statistics system for epidemiology on microcomputers. Atlanta: Centers for Disease Control and Prevention.

Department of Health, Education, and Welfare
1977a *NCHS Growth Curves of Children, Birth–18 Years, United States*. Series 11 165. DHEW Publication No. (PHS) 78-1650. Washington, D.C.
1977b *NCHS Tables of Growth, Birth–18 Years, United States*. Series 11 124. Washington, D.C.

Dettwyler, K.
1992 The Biocultural Approach in Nutritional Anthropology: Case Studies of Malnutrition in Mali. *Medical Anthropology* 15:17–39.

Dibley, M., N. Staehling, P. Nieburg, and F. Trowbridge
1987 Interpretation of Z-score Anthropometric Indicators Derived from the International Growth Reference. *American Journal of Clinical Nutrition* 46:749–762.

Dowler, E., A. Hall, and C. Schofield
1986 *The Nutrition and Health of Pastoralists and Agro-pastoralists in Africa: A Bibliography*, second ed. Occasional Paper 4. Department of Human Nutrition, London School of Hygiene and Tropical Medicine.

Dunbar, R.
1991 On Sociobiological Theory and the Cheyenne Case. *Current Anthropology* 32:169–173.

Emlen, S., and L. Oring
1977 Ecology, Sexual Selection and the Evolution of Mating Systems. *Science* 197:215–223.

Flinn, M., and B. Low
1986 Resource Distribution, Social Competition and Mating Patterns in Human Societies. In *Ecological Aspects of Social Evolution: Birds and Mammals*, D. Rubinstein and R. Wrangham, eds. Pp. 217–243. Princeton: Princeton University Press.

Food and Agricultural Organization (FAO)
1967 *FAO Production Yearbook*. Rome.

Frisancho, A.
1990 *Anthropometric Standards for the Assessment of Growth and Nutritional Status.* Ann Arbor: University of Michigan Press.

Gage-Brandon, A.
1992 The Polygyny-Divorce Relationship: A Case Study of Nigeria. *Journal of Marriage and the Family* 54:285–292.

Garner, P., T. Smith, M. Baea, D. Lai, and P. Heywood
1994 Maternal Depletion in a Rural Area of Papua New Guinea. *Tropical Geography and Medicine* 46(3):169–171.

Gibson, R.
1990 *Principles of Nutritional Assessment.* New York: Oxford University Press.

Gorstein, J.
1989 Assessment of Nutritional Status: Effects of Different Methods to Determine Age on the Classification of Undernutrition. *Bulletin of the World Health Organization* 67(2):143–150.

Gowaty, P.
1992 Evolutionary Biology and Feminism. *Human Nature* 3:217–249.

Grantham-McGregor, S.
1993 Assessments of the Effects of Nutrition on Mental Development and Behavior in Jamaican Studies. *American Journal of Clinical Nutrition* (supplement) 57:303–309.

Gray, S.
1995 Correlates of Breastfeeding Frequency among Nomadic Pastoralists of Turkana, Kenya: A Retrospective Study. *American Journal of Physical Anthropology* 98:239–255.

Haas, J., and J.-P. Habicht
1990 Growth and Growth Charts in the Assessment of Pre-school Nutritional Status. In *Diet and Disease in Traditional and Developing Societies*, G. A. Harrison and J. C. Waterlow, eds. Pp. 160–183. Symposia of the Society for the Study of Human Biology 30. Cambridge: Cambridge University Press.

Habicht, J.-P., et al.
1974 Height and Weight Standards for Preschoool Children. How Relevant Are Ethnic Differences in Growth Potential? *Lancet* 1:611–614.

Hames, R.
1996 The Costs and Benefits of Monogamy and Polygyny for Yanomamo Women. *Ethology and Sociobiology* 17:1–19.

Harrison, G., A. Boyce, and C. Platt
1975 Body Composition Changes during Lactation in a New Guinea Population. *Annals of Human Biology* 2(4):395–398.

Hewlett, B.
1988 Sexual Selection and Parental Investment among Aka Pygmies. In *Human Reproductive Behavior: A Darwinian Perspective*, L. Betzig, M. Borgerhoff Mulder, and P. Turke, eds. Pp. 263–276. Cambridge: Cambridge University Press.
1992 *Father-Child Relations.* New York: Aldine de Gruyter.

Hrdy, S.
1992 Fitness Tradeoffs in the History and Evolution of Delegated Mothering with Special Reference to Wet-nursing, Abandonment and Infanticide. *Ethology and Sociobiology* 13:409–442.

Hurtado, A., and K. Hill

1992 Paternal Effect on Offspring Survivorship among Ache and Hiwi Hunter-gatherers: Implications for Modeling Pair-bond Stability. In *Father-Child Relations*, B. Hewlett, ed. Pp. 31–55. New York: Aldine de Gruyter.

Hurtado, A., K. Hill, H. Kaplan, and I. Hurtado

1992 Trade-offs between Female Food Acquisition and Child Care among Hiwi and Ache Foragers. *Human Nature* 3:185–216.

International Livestock Commission for Africa (ILCA)

1961 *Introduction to the East African Range Livestock Study*. Nairobi: International Livestock Commission for Africa/Republic of Kenya.

Irons, W.

1979a Cultural and Biological Success. In *Evolutionary Biology and Human Social Behavior: An Anthropological Perspective*, N. A. Chagnon and W. Irons, eds. Pp. 257–272. North Scituate, Massachusetts: Duxbury Press.

1979b Political Stratification among Pastoral Nomads. In *Pastoral Production and Society*, Equipe Ecologie et Anthropologie des Societes Pastorales, ed. Pp. 361–374. Cambridge: Cambridge University Press.

1983 Human Female Reproductive Strategies. In *Social Behavior of Female Vertebrates*, S. Wasser, ed. Pp. 169–213. New York: Academic Press.

Isaac, B., and W. Feinberg

1982 Marital Form and Infant Survival among the Mende of Rural Upper Bar-bara Chiefdom, Sierra Leone. *Human Biology* 54:627–634.

Jelliffe, D., and E. Jelliffe

1989 *Community Nutritional Assessment with Special Reference to Less Technically Developed Countries*. New York: Oxford University Press.

Josephson, S.

1993 Status, Reproductive Success and Marrying Polygynously. *Ethology and Sociobiology* 14:391–396.

Kaplan, H.

1985 Prestige and Reproductive Success in Man: A Commentary. *Ethology and Sociobiology* 5:115–118.

Kaplan, H., and K. Hill

1985 Hunting Ability and Reproductive Success among Male Ache Foragers: Preliminary Results. *Current Anthropology* 26:223–245.

Klima, G.

1964 Jural Relations between the Sexes among the Barabaig. *Africa* 34:9–19.

Lancaster, J. B., and H. Kaplan

1992 Human Mating and Family Formation Strategies: The Effects of Variability among Males in Quality and the Allocation of Mating Effort and Parental Investment. In *Human Origins*, T. Nishida, W. McGrew, P. Marler, M. Pickford, and F. de Waal, eds. Pp. 21–33. Topics in Primatology 1. Tokyo. University of Tokyo Press.

Little, M. A., P. W. Leslie, and K. L. Campbell

1992 Energy Reserves and Parity of Nomadic and Settled Turkana Women. *American Journal of Human Biology* 4:729–738.

Malinowski, B.

1961 *Argonauts of the Western Pacific*. New York: Dutton. (originally published in 1921)

Martorell, R., and J.-P. Habicht
1986 Growth in Early Childhood in Developing Countries. In *Methodology: Ecological, Genetic and Nutritional Effects on Growth*, second ed., F. Falkner and J. Tanner, eds. Pp. 241–262. *Human Growth: A Comprehensive Treatise*, Vol. 3. New York: Plenum Press.

McCabe, J.
1994 Mobility and Land Use among African Pastoralists: Old Conceptual Problems and New Interpretations. In *African Pastoralist Systems: An Integrated Approach*, E. Fratkin, K. Galvin, and E. Roth, eds. Pp. 69–90. Boulder: Lynne Rienner.

Merchant, K., and R. Martorell
1988 Frequent Reproductive Cycling: Does It Lead to Nutritional Depletion of Mothers? *Progress in Food and Nutrition Science* 12:339–369.

Merchant, K., R. Martorell, and J. Haas
1990a Maternal and Fetal Responses to the Stresses of Lactation Concurrent with Pregnancy and of Short Recuperative Intervals. *American Journal of Clinical Nutrition* 52:280–288.
1990b Consequences for Maternal Nutrition of Reproductive Stress across Consecutive Pregnancies. *American Journal of Clinical Nutrition* 52:616–620.

Miller, J.
1989 Determinants of Intrauterine Growth Retardation: Evidence against Maternal Depletion. *Journal of Biosocial Science* 21:235–243.

Pelletier, D., E. Frongillo, D. Schroeder, and J.-P. Habicht
1994 A Methodology for Estimating the Contribution of Child Mortality in Developing Countries. *Journal of Nutrition* (supplement) 124:2106–2122.

Pennington, R., and H. Harpending
1993 *The Structure of an African Pastoralist Community*. Research Monographs on Human Population Biology. Oxford: Clarendon Press.

Rees, J., and P. Harvey
1991 The Evolution of Animal Mating Systems. In *Mating and Marriage*, V. Reynolds and J. Kellet, eds. Pp. 5–45. Oxford: Blackwell Scientific.

Rodseth, L., R. Wrangham, A. Harrigan, and B. Smuts
1991 The Human Community as a Primate Society. *Current Anthropology* 32: 221–254.

SAS Institute
1989 *SAS/PC version 6.0*. Cary, North Carolina. Statistical Analysis Software, Inc.

Searcy, W., and K. Yakusawa
1989 Alternative Models of Territorial Polygyny in Birds. *American Naturalist* 134(3):323–343.

Sellen, D. W.
1995 *The Socioecology of Young Child Growth among the Datoga Pastoralists of Northern Tanzania*. Ph.D. dissertation, Department of Anthropology, University of California at Davis.
1996 Nutritional Status of Sub-saharan African Pastoralists: A Review of the Literature. *Nomadic Peoples* 39:107–134.
1998 Infant and Young Child Feeding Practices among African Pastoralists: The Datoga of Tanzania. *Journal of Biosocial Science* 30:481–499.

1999 Growth Patterns among Semi-nomadic Pastoralists (Datoga) of Tanzania. *American Journal of Physical Anthropology* 109:187–209.

in press Age, Sex, and Anthropometric Status of Children in an African Pastoralist Community. *Annals of Human Biology*, in press.

in review Temporal Changes in Nutritional Status of Women and Children in a Tanzanian Pastoral Community. Submitted to *American Journal of Human Biology*.

n.d.a Child Physical Status as a Proxy for Fitness: An Underutilized Tool for Investigating the Causes of Reproductive Differences in Evolutionary Anthropology. Ms. in the author's possession, Department of Anthropology, Emory University, Atlanta.

n.d.b Datoga Household Economics: Food Security and Labor in a Stochastic Pastoral System. Ms. in the author's possession, Department of Anthropology, Emory University, Atlanta.

Sellen, D. W., M. Borgerhoff Mulder, and D. Sieff

1999 Fertility, Offspring Quality and Wealth in Datoga Pastoralists: Testing Evolutionary Models of Intersexual Selection. In *Human Behavior and Adaptation: An Anthropological Perspective*, L. Cronk, N. Chagnon, and W. Irons, eds. New York: Aldine de Gruyter, in press.

Sellen, D. W., D. Sieff, and M. Borgerhoff Mulder

1993 *Human Ecology, Subsistence, and Reproduction of Pastoralists in the Lake Eyasi Area of Arusha Region, Tanzania*. Tanzania National Research Council, Dar es Salaam, Tanzania.

Sieff, D.

1995 *The Effects of Resource Availability on the Subsistence Strategies of Datoga Pastoralists of Northwest Tanzania*. Ph.D. thesis, Department of Anthropology, Oxford University.

n.d. Women's Time Allocation in The Datoga Pastoralists of Tanzania: A Preliminary Analysis. Ms. in the author's possession, Department of Anthropology, University of California at Davis.

Smith, E.

1993 Human Behavioral Ecology II. *Evolutionary Anthropology* 1:50–55.

Smuts, B.

1993 Male Aggression against Women: An Evolutionary Perspective. *Human Nature* 3:1–44.

1995 The Evolutionary Origins of Patriarchy. *Human Nature* 6:1–32.

Smuts, B., and R. Smuts

1993 Male Aggression and Sexual Coercion of Females in Nonhuman Primates and Other Mammals: Evidence and Theoretical Implications. *Advances in the Study of Behavior* 22:1–61.

Spencer, P.

1980 Polygyny as a Measure of Social Differentiation in Africa. In *Numerical Techniques in Social Anthropology*, J. C. Mitchell, ed. Pp. 60–71. Philadelphia: ISHI.

1998 *The Pastoral Continuum: The Marginalisation of Tradition in East Africa*. New York: Oxford University Press.

SPSS Inc.

1997 *SPSS Proprietary Software, release 7.5*. Chicago: SPSS Inc.

Strassmann, B.

1997 Polygyny as a Risk Factor for Child Mortality among the Dogon. *Current Anthropology* 38:688–695.

Swift, J., C. Toulmin, and S. Chatting

1990 *Providing Services for Nomadic People: A Review of the Literature and Annotated Bibliography.* Geneva: WHO/UNICEF Joint Nutrition Support Programme.

Tanaka, S.

1969 Natural Environments of Mangola. *Kyoto University African Studies* 3:1.

Tomikawa, M.

1978 Family and Daily Life: An Ethnography of the Datoga Pastoralists of Mangola. *Senri Ethnological Studies* 1:1–36.

1979 The Migrations and Inter-tribal Relations of the Pastoral Datoga. *Senri Ethnological Studies* 5:1–46.

Tracer, D.

1991 Fertility-Related Changes in Maternal Body Composition among the Au of Papua New Guinea. *American Journal of Physical Anthropology* 85:393–405.

Turke, P.

1988 Helpers at the Nest: Childcare Networks on Ifaluk. In *Human Reproductive Behavior: A Darwinian Perspective,* L. Betzig, M. Borgerhoff Mulder, and P. Turke eds. Pp. 173–188. Cambridge: Cambridge University Press.

Turke, P., and L. Betzig

1985 Those Who Can, Do: Wealth, Status and Reproductive Success on Ifaluk. *Ethology and Sociobiology* 6:79–87.

Umesao, T.

1968 Hunting Culture of the Pastoral Datoga. *Kyoto University African Studies* 3:77–92.

van Loon, H., V. Saverys, J. Vuylsteke, R. Vlietinck, and R. Eeckels

1986 Nutritional Anthropometry in Children from 0 to 6 Years of Age in Different Geographical Areas. *Annals of Tropical Paediatrics* 6:79–92.

Vehrencamp, S., and J. Bradbury

1984 Mating Systems and Ecology. In *Behavioral Ecology: An Evolutionary Approach,* second ed., J. Krebs and N. Davies, eds. Pp. 251–278. Sunderland, Massachusetts: Sinauer.

Verner, J., and M. Willson

1966 The Influence of Habitats on Mating Systems of North American Passerine Birds. *Ecology* 47:143–147.

Voland, E., and C. Engel

1990 Female Choice in Humans: A Conditional Mate Selection Strategy of the Krummhorn Women (Germany, 1720–1874). *Ethology* 84:144–154.

Waterlow, J., R. Buzina, W. Keller, J. Lane, M. Nichaman, and J. Tanner

1977 The Presentation and Use of Height and Weight Data for Comparing the Nutritional Status of Groups of Children under the Age of 10 Years. *Bulletin of the World Health Organization* 55(4):489–498.

Westneat, D., and R. Sargent

1996 Sex and Parenting: The Effects of Sexual Conflict and Parentage on Parental Strategies. *Trends in Ecology and Evolution* 11:87–91.

Winkvist, A., F. Jalil, J.-P. Habicht, and K. Rasmussen
1994 Maternal Energy Depletion Is Buffered among Malnourished Women in Punjab, Pakistan. *Journal of Nutrition* 124:2376–2385.
Winkvist, A., K. Rasmussen, and J.-P. Habicht
1992 A New Definition of Maternal Depletion Syndrome. *American Journal of Public Health* 82:691–694.
World Health Organization (WHO)
1986 Use and Interpretation of Anthropometric Indicators of Nutritional Status. *Bulletin of the World Health Organization* 64(6):929–941.
1995 *Physical Status: The Use and Interpretation of Anthropometry*. WHO Technical Report 854. Geneva.