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Paternal Investment and Hunter-Gatherer Divorce Rates

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Ideas about the evolution of human pair bonding[1] have centered around the role of men as provisioners of wife and children. The idea rings true for many of us, but in this chapter we present comparative data from hunting and gathering societies that argues against provisioning by males as a cause of pair bonding. Our results imply that we should look more closely at competition over sexual access as an influence on pair bonding in our species.

Several authors have suggested that hunting was a crucial factor in human evolution because it allowed males to provision females and offspring, increasing the number of offspring a female could bear and keep alive (Lancaster and Lancaster 1983). Males would then trade off effort invested in provisioning mate and offspring (parenting) against effort invested toward fathering a greater number of offspring by a variety of females (mating effort). If provisioning was effective, costs of desertion by males would be great. Males would not desert and the result would be an enduring pair. Much research has been provoked by this scenario, and many predictions were confirmed.

Research on mating systems in simple farming and herding societies (Borgerhoff Mulder 1988; Cronk 1991; Hames 1996) has been primarily concerned with understanding the occurrence of polygamy, monogamy, and polyandry. This literature draws attention to the readiness with which men convert wealth not to healthier children with higher survivorship but to greater numbers of wives. Among researchers on hunting and gathering societies, the economy closest to that envisaged for the "environment of evolutionary adaptedness"—the context in which male provisioning, monogamy, mate preferences, and the nuclear family are supposed to have evolved—the assumption that hunting primarily functions as provisioning by males has been vigorously debated (Hawkes 1993; Hill and Hurtado 1993).

Hawkes (1990, 1991, 1993) argues that hunting is a poor way to provision wife and children. In some ecologies gathering provides more energy per hour of effort

than hunting, and in some, hunting and trapping small game gives much lower variance in offspring food intake, even after allowing for the effect of sharing meat from large game (Hawkes et al. 1991). Furthermore, hunters feed other men's children more than their own. Meat from large animals is widely shared, seemingly taking the form of a public good. The hunter is unable to restrict access to his catch, apparently unable to sanction those who take without giving in kind. A request is in order for clearer demonstrations of the route by which fathers or husbands make a difference to child survival and growth (when they do).

We began to analyze Hadza marriage and divorce because it seemed to offer data independent of our data on Hadza hunting and sharing (Hawkes et al. 1991) with which we could test for an influence of paternal provisioning. For instance, if male provisioning was important, and men stayed in a marriage because of the cost to their children from desertion, women with more small children should be less likely to get divorced (because smaller children are likely to be more vulnerable than older children to loss of paternal support). A similar argument would lead one to predict that divorced or widowed women with many small children were less likely to remarry than same-aged women with fewer small children. Buckle and colleagues (1996) presented positive results of such tests on North Americans and Europeans, supporting the paternal investment viewpoint. But thus far we have failed to produce any significant effects in such analyses of Hadza data. Negative findings do not make a convincing report, and further fieldwork is scheduled that will at least make their negativity more credible. Our analysis showed that despite the lack of evidence for an influence of provisioning on divorce and remarriage, Hadza were clearly living as couples. Very few individuals had more than one spouse at a time; many couples stayed together for more than the decade of our fieldwork; and many of these had been reported as married couples by previous fieldworkers. We turned to a comparative analysis.

Woodburn (1968b), emphasizing the ease with which a Hadza marriage is considered ended, reported a high divorce rate. In Blurton Jones et al. (1996) we attributed the supposed difference between Hadza and !Kung divorce rates to the difference between Hadza and !Kung children's contributions to their own food intake. Hadza children provide up to half their own daily requirement from age five onward. !Kung children seem to forage very little (Blurton Jones et al. 1994; Hawkes et al. 1995). We suggested that a father diverting resources from his children might have less effect on the survival of the children among the Hadza than among the !Kung. We reported census data showing that Hadza children's mortality was indeed no greater if their father died or divorced their mother, whereas death of mother had a striking effect. Thus costs of desertion were apparently [illegible] and could account for a higher divorce rate. Our analysis gave no attention to the opportunity to remarry, nor to the payoff that might accrue from a change in spouse.

Hurtado and Hill (1992) examined marital stability in the Ache and Hiwi. Although the effect of father upon child survival was much less among Hiwi than among Ache, Hiwi marriages were much more stable than Ache marriages. Hurtado and Hill sought to assess the tradeoff between benefits gained from continued paternal care and benefits from a new marriage. Divorce was assumed to lead to removal of paternal care from the children, at some cost to their survival ("father effect") and thus to diminish their contribution to their father's fitness. But it led, after successful but costly competition with other men, to a new marriage and new children. Hurtado and Hill assess the opportunity for a new marriage and new paternity by their measure "fertility units per male" (FU/m). This measure is obtained by multiplying the number of females age 15–40 by the total fertility rate (TFR), and dividing by the number of males age 20–55. Hurtado and Hill combine father effect, and fertility units per male, into a "parenting/mating index" that compares the effect of father on children's survival with the opportunity for new matings or added paternity. It turned out that although the effect of fathers on Ache children's survival was much higher[2] than the effect of Hiwi fathers, the difference in FU/male overwhelmed this effect. Among the Ache, where marriages are extremely unstable, opportunities for new matings, which FU/male aims to reflect, are much greater than among the Hiwi, and this apparently accounts for the difference.

Three points need to be made about the parenting/mating index. First, fertility units per male is similar to the "operational sex ratio," which has been proposed as a determinant of animal mating systems (Clutton-Brock and Parker 1992; Kvarnemo and Ahnesjo 1996). It indicates the strength of male-male competition for paternity. Second, for desertion to pay off, the prospective fertility of the new mate should exceed the continuing fertility of the current mate. The hidden assumption, that men are leaving less fertile (older?) wives for more fertile (younger?) ones, should be tested (e.g., Lockhard and Adams 1981) and examined for the further implication that men are seeking long-term relationships in which to recoup the gains of the new wife's greater reproductive value.

Third, father effect as measured by Hurtado and Hill is a good measure of father's cost of desertion but not necessarily of the size of male economic contributions. If loss of paternal care by a deserting father is offset by a willing stepfather, or by increased effort by the deserted mother, or by lengthened interbirth interval, desertion will not be associated with much increase in child mortality. But this is just what we need to measure to assess the father's cost of desertion. If care by another compensates for his lack of caregiving, his cost was low. This implies that economic contributions of men could be greater than indicated by this measure.

Comparisons that involve just two data points, like our !Kung-Hadza comparison and Hurtado and Hill's Ache-Hiwi comparison, can be informative but they are also dangerous. Predictions can be proved wrong with a two- case sample, but it is probably too easy for them to come out right. Here we will attempt the comparison with all four populations—Ache, Hiwi, !Kung, and Hadza. Is marriage stability predicted by the effect of loss of father upon children's survival, by his opportunity for new matings, or by the ratio of these two variables?

ETHNOGRAPHIC BACKGROUND

The 700–800 eastern Hadza occupy a 2,500 km^2 area in the Eastern Rift Valley, south and east of Lake Eyasi, in northern Tanzania.[3] The climate of this region is warm and dry. Annual rainfall is in the 300–600 mm range, falling in a six- to seven-month wet season (November–May). Vegetation is primarily mixed savanna woodland; medium/large animals are locally abundant. Ethnographic data on the eastern Hadza are available in the publications of James Woodburn (1968a, 1968b, 1979, 1988).

The language, Hadzane, has been studied by Woodburn and others, and recently by Sands (1995) and Sands and colleagues (1993). Linguists agree only that its connection to any other African language family is very remote indeed. Hadza must have remained culturally distinct from their neighbors (who currently represent the Bantu, Nilotic, and Cushitic language families) for many hundreds of years. At the beginning of this century, it appears that only the Hadza occupied this country (Obst 1912). They apparently lived entirely by hunting and gathering. Local incursions by non-Hadza pastoral and agricultural groups are recorded as early as the 1920s and have continued to the present (McDowell 1981; Woodburn 1988). Archaeological evidence suggests that farmers and pastoralists have been present for several centuries, hunter-gatherers far longer (Mehlman 1988; Marlowe 1996). During the past 50 years, various segments of the Hadza population have been subjected to government- and mission-sponsored settlement schemes designed to encourage them to abandon the foraging life in favor of farming. None of these schemes has been successful, and in every case most of the Hadza involved returned to the bush, usually within a few months. In each instance some Hadza avoided settlement and continued to live as full-time hunter-gatherers.

A summary of the daily cycle gives some feel for life in a Hadza bush camp. Between 7 and 9 A.M. people arise and wait for the cold to wear off; women sharpen and harden their digging sticks (sometimes helped by their children) and muster to go out to forage. Men leave, individually, for an early morning "walk about" (hunt) and move to "the men's place" on the edge of or just outside camp where those in camp spend the day. Small children face the question, "Will mother take me with her or leave me in the care of older brother?" Teenage girls decide whether to go with the women or stay home; teenage boys decide whether to go as "guards" for the women or stay home, often to leave later with a few friends. Between 9 and 11 A.M. the children in camp usually do some foraging. Between 11 A.M. and 1 P.M. they might forage more, or eat and play. The temperature reaches its daily peak by 1 P.M. Between 1 and 3 P.M. everyone who is in camp tends to be resting in the shade. Between 3 and 5 P.M. the women come home. The children rush to get a share of the food they brought. Between 5 and 7 P.M. the temperature has fallen to pleasant levels and most people are at home. Children play vigorous games, forage some more, and if there are several teenage girls in camp singing and dancing will begin and last until 9:30 or 10 at night.

Late in the dry season men will organize and prepare themselves for a cold night in a hunting blind at a nearby waterhole or game trail. By 7 P.M. all but the men who left for the night are in their houses and around the fire. People eat an evening meal, and then visit and chat in each other's houses and fireplaces. On moonless nights an epeme dance may be held, in which all participate. Silence, but for coughs, the occasional crying child, once in a while a noisy domestic dispute, closely investigating hyenas, and distant comforting lions, lasts from late evening until next morning. Thus, while a couple shares a house, in which man and wife sleep along with their younger children, eat much of the food that each other acquires (including shares of meat from other men), and eat an evening meal together, their daytime lives are, as Woodburn reported (1968a, 1968b), noticeably separate.

During our observations in the 1980s less than 5% of the food of people on whom we collected behavioral and ecological data came from domesticated sources. The proportion was greater in some parts of Hadza country. During the 1990s hunting became progressively more difficult as interference by outside agencies continued and incursions by other lifestyles increased, and the habitat was degraded. The situation in 1997 indicates imminent submersion of the Hadza into a new lower rung of Tanzanian rural society.

The !Kung of northwestern Botswana and northeastern Namibia, and their lifestyle of the 1950s to 1970s, are now so well known to anthropologist readers as to need little introduction. As among the Hadza, couples share a house in which they sleep along with their younger children. Houses are clustered in small "camps" of from two to a dozen or so houses to which people return daily. Camps are moved frequently in the wet season, much less frequently in the dry season when few water sources are available. Little formality accompanies either marriage or divorce, but our reading of the accounts suggest that parental influences may be greater among the !Kung than among the Hadza.

The Ache of Paraguay are also becoming well known to anthropological readers (Hill and Hurtado 1996 and references therein). Their pre- settlement, full-time forager lifestyle was much more mobile than the life of the other populations discussed here. Small groups moved almost daily through the forest, clearing a new sleeping area each evening. Couples and their children shared a fire, but people lived in much greater proximity at these overnight camps than in a Hadza or !Kung camp. Upon settlement people lived in larger houses and, Hill and Hurtado comment, the previously very high divorce rate declined. While !Kung are known to have practiced occasional infanticide, and Hadza claim never to have heard of such a practice, Ache regularly used to kill one or more children upon the death of their father. Hill and Hurtado describe informants' interpretations of this practice.

The Hiwi of southwestern Venezuela have been studied under more settled conditions than the other three populations, although they still subsist in large part on hunted and gathered wild foods. People are more mobile in the dry season than the wet, leaving the two residential settlements for smaller bush camps for up to four weeks at a time. Hurtado and Hill (1992) note the endurance of Hiwi marriages.

PROCEDURE

The !Kung data reported here are from Howell (1979), with additions from Pennington and Harpending (1988). The Hadza data come from our own fieldwork from 1984 to 1995. In addition to extended stays for behavioral and ecological observation that fuelled many of our papers (e.g., Blurton Jones et al. 1996; Hawkes et al. 1997; Marlowe 1997; O'Connell et al. 1992) we have conducted a series of censuses and anthropometry sessions between 1985 and 1997. In 1992 and 1995, 120 different Hadza women were interviewed about their reproductive histories, with previous census data in hand to provide a check and prompts. These data were combined to give a record of marriages, divorces, remarriages, deaths and widowings, and births and deaths of children. Data from a census conducted by Lars C. Smith in 1977 are also used to identify the longest-lasting marriages.

Father Effect

Survival of Hadza children (less than 5 years old at the start of the census period) across the five-year periods 1985–1990 and 1990–1995 was calculated from the interviews. Table 4.1 shows the number surviving or dying among those whose father died or divorced their mother at any time during the five year period, and among those whose father stayed with their mother. An earlier analysis of survival until 1991 of children under 5 in the 1985 census also showed no increase in survival when father was present (Blurton Jones et al. 1996).

Comparison among the four populations is not easy. Hurtado and Hill (1992:50) report father effect as offspring survivorship to adulthood with father divided by offspring survivorship without father, yet their table 1 gives a figure for

Table 4.1. Survival of Hadza children under 5 years of age whose fathers died or left their mother. (Mantel-Haenszel chi-square for association between father stay and child survive, controlling for observation period, = 0.001, $p = .975$)

	Child Survived	*Child Died*
1985–1990		
Father stayed	12	14
Father died or left	3	7
1990–1995		
Father stayed	13	9
Father died	12	5
Both Periods Stepdad		
Father stayed	25	23
Father died or left	15	12

Hiwi, which they say is based on survivorship to age five (1992:45). Pennington and Harpending (1988) report deaths as infants, and deaths as children. In demographic usage, infants are 0 to 1 year old, but these authors state that "children" means infancy to adulthood (1988:310). Our data on father effect among Hadza concerns survival through a five-year period by children age 0–5 at the beginning of the period. In most populations mortality declines sharply with age from birth to 1 year, rapidly from 1 to 5 years of age, and thereafter mortality is quite low. Hurtado and Hill's figures 1 and 2 show that the difference between survivorship of children with and without father continues to diverge slightly as the children grow beyond age 5. Thus comparing Ache survival to adulthood (age 15), !Kung survival to 1 or 15, Hiwi survival to 5, and Hadza survival from 0 to 5 and 5 to 10 combined may be less dangerous than at first appears. We discuss the vulnerability of our conclusions in the appendix to this chapter.

Fertility Units per Male

Hurtado and Hill (1992) took the number of females age 15–40, multiplied by the total fertility rate, and divided by the number of men age 20–55. Population age-sex structure for the !Kung from Howell (1979) and for the Hadza from Blurton Jones and coauthors (1992) allows us to compute the numbers of men age 20–55 and women age 15–40 (Table 4.2). In the appendix we show that the impact of altering the age groups included in this measure is slight.

Among the !Kung, the number of females can easily be extracted from Howell's table 12.1. Determining the number of males age 20–55 is not straightforward because Howell's table 12.2 gives 10-year age blocks with unusual starting ages. Inspection of the age pyramids diagrammed in her figure 2.6 suggests that the number within a block can be divided by the number of years to allow us to reconstitute numbers for our age blocks.

Marriage Stability

Hurtado and Hill report two measures of the stability of Ache and Hiwi marriages: (1) number of husbands reported by women of a given age and (2) proba-

Table 4.2. Fertility units per male (calculated as in Hurtado and Hill 1992: table 1).

Population	*Females 15–40 (N)*	*Males 20–55 (N)*	*Proportion of Females/Males*	*Total Fertility Rate*	*Fertility Units per Male*
Ache	122	108	1.129	7.8	8.81
Hiwi	18	25	0.720	5.4	3.89
!Kung	90	114	0.789	4.7	3.71
Hadza	138	134	1.029	6.2	6.385

Ache and Hiwi data from Hurtado and Hill 1992
!Kung female/male data from Howell 1979: tables 12.1 and 12.2
Hadza data from Blurton Jones et al. 1992.

bility of divorce by length of the marriage. Our aim is to examine marriage as the absence of desertion. The cost of desertion is in decreased fitness of offspring. Thus it makes most sense to examine rates of breakdown of marriages that have lasted long enough to produce a child. Consequently we prefer to ignore reported number of spouses, which is heavily influenced by the number of brief liaisons, usually early in adult life. Data on the number of husbands reported by Hadza women are not abundant, nor is their reliability impressive.

The data from the Hadza censuses are not directly comparable with the interview reports for the other populations. The Hadza data allow direct computation of crude annual divorce rates, which are very close to the rate reported by Woodburn (1968b) from his fieldwork in the early 1960s. Crude annual divorce rates are unsatisfactory for comparison across populations because they are strongly influenced by population age-structure. However, some approximations to probability of divorce by age of marriage can be obtained, and compared with figures from the !Kung, Ache, and Hiwi.

In Table 4.3 we show the divorce rate between 1990 and 1995 of Hadza couples who got married between 1985 and 1990 (marriages 0–4 years old), couples who were together in 1985 and still together in 1990 (marriages >5 years old), and couples who were listed in Lars Smith's 1977 census and were still together in 1990 (marriages >13 years old).

RESULTS

Is There a "Father Effect" among Hadza?

Blurton Jones and colleagues (1996) report no significant difference between survival of children whose fathers left after 1985 and those whose fathers were still with the mothers in 1991. There was a striking effect of loss of mother. The data in Table 4.1, for the periods 1985–1990 and 1990–1995, also give no significant indication of an effect of father's death or divorce upon young children's survival. No data on mother's death are shown because these are children whose life histories were obtained by interviewing their mothers in 1992 or 1995.

Is There a Father Effect among the !Kung?

Pennington and Harpending (1988) claim "The importance of male parental care for the survival of !Kung offspring is supported by the observation that i[n] mortality was significantly higher a[mong] offspring of women who had mo[re] one husband." They also report, "[in] Ngamiland the risk of death of an i[nfant] whose mother married more than [once] (24%) is almost double that of an i[nfant] whose mother married only once [(12%)] $p < .005$" (1988:312). They are suggesting a strong effect of fathers [on] offspring survival, "almost double," actually, as measured by Hurtado and Hill, the ratio of survivorship with father to

Table 4.3. Divorce rates of Hadza and !Kung.

	Hadza			
	Divorced 1990–1995	*Stayed Together 1990–1995*	*Probability of Divorce*	*Nearest !Kung Equivalent*
Got married between 1985 and 1990 (marriage 0–4 yrs)	11	17	.393 (11 of 28 marriages)	.373*
Married in 1985 and same spouse in 1990 (married > 5 yrs)	11	26	.297 (11 of 37 marriages)	.078 – .143†
Married in 1977 and same spouse in 1990 (married > 13 yrs)	8	25	.242 (8 of 33 marriages)	.030 – .080‡

* Probability of marriages less than 5 years old surviving the next 5 years. Howell's table 12.6 gives 323 marriages at risk, minus 15 deaths of husbands, for a total sample of 308. There were 115 divorces during the five-year period. 115/308 = .373.

† Probability of marriages that had lasted at least five years surviving the next five years: 150 marriages minus 10 husbands' deaths = 140. With 11 divorces, 11/140 = .078. Or, since the Hadza sample includes marriages that lasted much longer than 5 years, let us add in all subsequent !Kung divorces: with 19 divorces, 19/140 = .143

‡ Probability of divorce for marriages that had lasted 10 years (we bias the !Kung figures upward, to handicap our chance of showing a difference from the Hadza, in preference to choosing a limit of 15 years, which biases in favor of our expected result). 108 marriages minus 9 husbands' deaths = 99. With 3 divorces, 3/99 = .030. Or, adding in all subsequent divorces: 8/99 = .080.

survivorship without father is only a father effect of 1.14. Pennington and Harpending's table 2 allows us to calculate father effect on children as well as infants. Taking postmenopausal Ngamiland women who reported only one marriage we sum the number of offspring that died as infants and as children (57 + 81 = 138), and the number that survived childhood (194), to find 332 births of which 194/332 survived (.5843). For women who reported more than one marriage the figure is .4609. The ratio (father effect) is .5843 / .4609 = 1.27.

The survival of !Kung children to adulthood increases less with the presence of their father than the survival of Ache children increases when their father is present. But the effect of !Kung fathers on child survival is larger than the effect of Hiwi fathers. !Kung fathers' presence increases child survival to 1 year old slightly more than the presence of Hiwi fathers increases child survival to 5, and the effect of !Kung fathers on survival to adulthood is much higher than this. If the Hadza show no effect on survival of father's presence between 5 and 10, it is unlikely to appear between 10 and 15. We thus rank father effect as, highest to lowest effect: Ache > !Kung > Hiwi > Hadza.

Fertility Units per Male

Among the Hadza in our 1985 census there were 138 females age 15–40 and 134 males age 20–55. Hadza total fertility rate (TFR) was estimated at 6.2 (Blurton Jones et al. 1992). FU/male works out as 6.38 for the Hadza, about halfway between the figures calculated for the Hiwi and the Ache.

For the !Kung, Howell's table 12.1 gives 90 females age 15–40. We estimated 114 men age 20–55, for a ratio of .789 females per male. A TFR of 4.7 (Howell 1979) yields 3.71 FU/male. Using the TFR of 5.0 suggested by Blurton Jones (1994) for !Kung women living the forager lifestyle increases FU/male to 3.945, just higher than the figure for the Hiwi and substantially lower than those of the Ache and Hadza. These results are shown in Table 4.2.

Completing the Table: Parenting/Mating Index for the Hadza and !Kung

The !Kung and Hadza figures plus those from Hurtado and Hill's Table 1 are reported in Table 4.4. The fertility units/male (an index of mating opportunities), and the father effect (the factor by which a child's survival to adulthood increases with father's continued presence) are listed in the first two columns. The parenting/mating index is the ratio of these used by Hurtado and Hill to estimate the tradeoff men face between remaining married and providing a father effect, and leaving to seek another mate.

Predicting Stability of Marriages

We can use the first three columns of Table 4.4 to derive simple predictions about marriage stability in the four populations from different hypotheses about desertion. All the hypotheses share the assumption (quite provisional and questionable) that marriage breakups primarily reflect desertion by males, although we know that sometimes women leave, or expel their husband. But among each of these populations women very seldom desert their offspring when they leave, or throw out, their husband; women usually keep the children with them (sometimes Hadza children stayed with their mother's mother for a while when their mother

Table 4.4. Marital stability and possible predictors. Marital stability is shown both as "divorce rate" and "staying" rate.

Population	*Fertility Units per Male*	*Father Effect*	*Parenting / Mating Index*	*Divorce Rate (1 = highest, 4 = lowest)*	*Marital Stability (1 = most stable, 4 = least stable)*
Ache	[illegible]	1.62	0.184		4
Hiwi	[illegible]	1.09	0.282	4	1
!Kung	3.71	1.27	0.342	3	2
Hadza	6.38	1.0	0.157	2	3

remarried). If costs of desertion (assessed by father effect) are the best predictor of marriage stability, then Ache men should desert least often, !Kung men a little more, and Hadza and Hiwi men should desert most often. If the parenting/mating index is the best predictor, then the !Kung should have the most stable marriages, followed by Hiwi, then Ache, with Hadza showing the least stability.

Stability of Marriages

As in many populations (see summary in Fisher 1989), Ache, !Kung and Hadza marriages are most at risk in their early years. Howell (1979:figure 12.1) and Hill and Hurtado (1996:figure 7.12) show a rapid decline in probability of divorce during the first 5 years of marriage. Howell's table 12.6 shows that after 5 years, divorce rates level off at between .02 and .07 per year (see Table 4.4). Hill and Hurtado's figure for precontact Ache shows a decline that reaches .05 between 5 and 6 years and decreases to almost zero by the eighth year of a marriage. However, their figure presents the results of a fitted logistic regression model, which might give a distorted impression of the prospects for the few lengthy marriages. Hill (personal communication) finds that Ache marriages that had lasted 5 or more years nonetheless break up at a rate of 19% per year. This annual rate of attrition will result in 65% of a cohort of marriages that have lasted 5 years ending in divorce by the end of the next 5 years.

Table 4.3 shows the divorce rate between 1990 and 1995 of Hadza couples who got married between 1985 and 1990 (marriages 0–4 years old), couples who were together in 1985 and still together in 1990 (marriages >5 years old), and couples who were listed in Lars Smith's 1977 census and were still together in 1990 (marriages >13 years old). Probability of divorce among Hadza marriages seems to be similar to that of the !Kung in the early years but subsequently is much higher.

The rate at which marriages break up after having lasted five years or more allows us to rank the Ache above the Hadza and the Hadza above the !Kung in terms of marital instability. Although we dismissed the use of Hadza accounts of numbers of previous spouses, the researchers on Hiwi and !Kung express confidence in their reports. This measure, the average number of spouses by the end of a woman's child-bearing career, allows us to rank !Kung (2.45 from figures in Howell's table 12.3, 1979:235) above Hiwi (1.7 from Hurtado and Hill 1992). Since the !Kung fall below the Hadza and Ache on the other measure, we rank Hiwi also below Hadza and Ache. Thus from highest divorce rate to lowest: Ache > Hadza > !Kung > Hiwi.

What Is the Best Predictor of Stability of Marriages?

Table 4.4 shows the values for father effect, fertility units per male, and parenting/mating index alongside the ranking of marriage stability. The best candidate for predictor of marriage stability (probability of divorce for marriages that have lasted 5 years) is fertility units per male. Marriages are less stable when there are more fertility units per male. There are several technical reasons for regarding

this apparent relationship with caution and we discuss them in the appendix. There is no suggestion of support here for the importance of male parental care, and very weak support for prediction using the parenting/mating index of the tradeoff between care and mating opportunity.

DISCUSSION

We followed Hurtado and Hill 1992 (who in turn followed Maynard-Smith's mate desertion models) in examining (1) the effect of fathers upon offspring survival (parenting, cost of desertion), (2) opportunities for new matings (fertility units per male), and (3) the ratio of these two values, intended to display the relative balance of costs and benefits from desertion. Hurtado and Hill compared Ache and Hiwi and found that their parenting/mating index predicted divorce rate, whereas father effect did not. Here we added the Hadza and !Kung to the sample and showed that neither father effect nor parenting/mating index predicted divorce rate. Divorce rate was predicted by fertility units per male (and by both of its components—total fertility rate and reproductive adult sex ratio).

The view that higher costs of desertion lead to more enduring pair bonds received no support from this comparative analysis. Neither father effect, nor the ratio of father effect to mating opportunity (P/M index) predicted divorce rate. The results are difficult to reconcile with the widely accepted view that paternal provisioning favors pair bonding. This view fails to predict the observed association of higher divorce rates with higher numbers of "fertility units" per male. The measure "fertility units per male" is very close to the measures of "operational sex ratio," which biologists have found to be a good predictor of many features of mating systems (Kvarnemo and Ahnesjo 1996). It is regarded as a good measure of the strength of competition among males. This suggests we might consider monogamy as an outcome of male competition.

This result is surprising to those of us who have long believed in the unique importance of paternal care in the evolution of human pair bonding. We note, however, the many findings in the recent literature that cast doubt on the equally long assumed importance of paternal care in avian pair bonding. We note also that findings such as ours, and those of Hawkes (1990, in press), may open the way to much closer comparison with results of research on other primate breeding systems (Hrdy 1997; Manson 1997; Smuts and Gubernick 1992).

In the appendix we discuss many details of the measurements that could be thought to affect our conclusion. But we see one simple way to overturn our conclusion—adding more populations to the sample and showing that the association disappears. Other simple interpretations of our result are possible. (1) Perhaps ease of discovery of extramarital intercourse varies among these societies and the result reflects variation in ease of discovery and a constant rate of retribution by aggrieved spouses. (2) Perhaps FU/m reflects the opportunity for men to obtain matings outside marriage, and such matings carry a constant risk of discovery and retribution by wives. Our finding would then reflect merely variation in "temptations and discoveries"! But these interpretations require an explanation for a spouse's retribution.

Alternatives to Paternal Provisioning Theory

If we remove paternal provisioning as an explanation for pair bonding, we create many orphaned observations. Can other theories account for them, and do they generate additional, distinct predictions? What are the alternatives?

Models offered by Hawkes, Rogers, and Charnov (1995) suggest that expenditure on competition, or mate guarding, will be extensive and an even distribution of resources is likely to follow. An even distribution might result in ceaseless "wife swapping," or a more static system, with fewer risks, perhaps especially where lethal weaponry is widely available (see Woodburn 1979). This might be enough to produce some semblance of pair bonding.

Pair bonding as a solution to male contests (not a new idea; e.g., see Symons 1979) draws attention to the social nature of marriage more forcefully than paternal provisioning has done. The knowledge and interest of individuals outside the couple is an obvious feature of marriage. Everyone knows who is married to whom, and tries to keep their information up to date. Are the bystanders' interests part of the mechanism that solves the conflict and maintains monogamy? Could the interests of "bystanders" help account for the persistence of marriage across a variety of economic systems (in which male opportunities to offer resources to females may vary widely)? Why should bystanders care who is married and who is single, and whether a couple is getting divorced? Both paternal provisioning and male competition theories offer quick, but differing, suggestions—who will be burdened with the "orphans" (a problem for their kin), whose mate might be attracted to the newly single people (a problem for all adults of reproductive age, and for kin of offspring at risk of desertion)? Who might be set in renewed contest against whom?

Female Support for a Conventional Solution to Male Contests

Most of us find it difficult to envisage human mating systems without female preferences. Would women have an interest in supporting a conventional solution to male contests over sexual access? Recent literature has commented on the disruption, occasional injury, and loss of time incurred by females as a result of male attempts at mating and competition for sexual access (Clutton-Brock and Parker 1995). Females might gain from mating with the most effective competitors, but this gain is offset by costs in time and accidental injury, and ability to time conceptions optimally. When female time is valuable, the benefit of fewer time-consuming disruptions might exceed the value of mating with the winners of the disruptive competition. Can we link the occurrence of pair bonding among birds and among humans to the high value of female time spent caring for and provisioning offspring? Elsewhere (e.g., Hawkes et al., chapter 11, this volume) we have

pointed to the significance of food sharing between females and offspring as differentiating all human foragers from other primates. We linked this to a shift from exploiting resources which are easily exploited by juveniles to exploiting the abundant but hard-to-access roots, tubers, and nuts that human foragers use so much more than other primates. The woman's current infant, and to a greater or lesser extent all her previous offspring (her weaned pre-adult children), depend upon her foraging time. In this sense her foraging time, and her control over this time, may be much more reproductively valuable than that of other primate females. Interference thus becomes much more costly. Perhaps this makes female support of male mate-guarding conventions worthwhile. Our suggestion generates the expectation that women might prefer men who are better able to guard them and keep other men away (either by their ability in contests, or by their reputation and its effect on other men's readiness to concede to them). But these ideas imply that many females settle for lower-quality males than they might have obtained from continued competition. Our speculations call urgently for systematic modeling!

Female Preference for Providers

It has long been argued that females might prefer males who provide resources, and it has long been assumed that females are able to put this preference into effect. Males might then benefit from conforming to female preferences and, for example, compete for females by providing more resources. Does this lead us straight back to the paternal provisioning hypothesis? Would it give the same predictions as traditional assumptions about paternal provisioning? We think not, for two reasons. First, Hawkes's (1990) "showoff" model illustrates that it may pay males not to conform with female preferences for a provisioner where there are modest returns to effort seeking extra matings. Second, provisioning or child care given in competition for sexual access should vary with factors that affect the payoffs from effort to gain and maintain sexual access, such as female fertility, and the intensity of competition among males. Provisioning as paternal investment should vary with vulnerability of offspring and effectiveness of male care, and with male estimates of paternity. While paternal provisioning can account for the differences between stepfathers and biological fathers (Daly and Wilson 1987; and see Marlowe 1997 on Hadza stepfathers), it has difficulty accounting for the care that stepfathers do show. If childcare and/or provisioning is part of the bargain that maintains sexual access to a female, stepfathering is easily accounted for. Giving food or care in exchange for lasting sexual access may imply one kind of bargaining situation (perhaps similar to that described in Hewlett 1992). Giving food or care in proportion to its effect on offspring fitness suggests another, perhaps with more closely shared interests of males and females.

If marriages involve only mutual investment in offspring our options for accounting for the great number of marriages that break up before children are born are limited to guessing how long partners might wait to test fertility. If marriages involve a bargain over sexual access, then the early years of a marriage may

involve assessment of various aspects of the bargain and its prospects. We find this suggestion the more likely of the two to provoke investigation.

If marriage does incorporate complicity in a conventional solution to male contest and/or constitutes some kind of bargain, then both partners will be interested in the bargaining position of the other, and in signs that the other will keep the bargain. Can some of the mate preference criteria tapped by widely used questionnaires be seen as indicators of bargain-keeping? If so, we might better understand the similarity between the sexes in the mate preference criteria that some readers find to be the most striking finding in mate preference studies.

CONCLUSION

If we loosen the grip of paternal provisioning on our thinking, we can attend to a wider array of behavior associated with pair bonds or marriage, and to a richer array of ways to account for variation in human mating systems. Anthropologists have long told us that marriage is a social phenomenon (Bell 1997), and psychologists have long told us that marriage is an uneasy bargain (e.g., Schoeninger and Wood 1969). Armed only with paternal provisioning theory we have been quite restricted in our exploration of these (Kerber 1994), and often tempted to dismiss them as describing "trappings of modern civilization" or "socially imposed monogamy" and so forth. Freed from paternal provisioning, and by paying more attention to male competition, we may find it possible to understand, even predict or derive, more of the complexities that anthropologists and psychologists have observed.

SUMMARY

1. We added two more populations (Hadza and !Kung) to the comparison of divorce rates among Ache and Hiwi reported by Hurtado and Hill (1992).

2. Divorce rate is not predicted by father's cost of desertion, nor is it predicted by either of two versions of Hurtado and Hill's parenting/mating index.

3. Instead, in this very limited sample of four hunter-gatherer populations, divorce rate is found to be higher when there are more "fertility units per male," a measure of the strength of competition among males.

4. We suggest that pair bonding be examined again as a solution to male-male competition.

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NOTES

1. We use "pair bonding" to refer to lasting cohabitation of a man and a woman. We attend primarily to ideas about why men stay in such a relationship. We pay little attention to female choice, even though its existence is quite apparent.
2. Although the Ache father effect is apparently primarily due to infanticide following desertion or death of the father, Hill and Hurtado describe Ache informants linking infanticide to the cost of providing for orphans.

APPENDIX: HOW IMPORTANT ARE THE WEAKNESSES IN THE STUDY? DEFINITION OF MARRIAGE

Comparative studies have many problems and this study is no exception. Do "married" and "divorced" mean the same in each population? Would a couple recorded as married in one population be recorded as married by a different ethnographer in a different population? All evidently attend to coresidence, and all seem to imply consensual intercourse, and a social recognition of these two features. In each society there appears to be a view that couples can be recognized by other individuals. There is some variation in what informants say about extramarital sex and jealousy, but strong constancy in reports of violence between men over women. Concepts of "legitimacy" vary. Among the Ache "secondary fathers" are recognized and seem to influence an orphan's survival prospects. Among the Hadza a woman's children by a previous husband quickly become named as "children of" her current husband.

Sampling

While the data on each population result from an immense amount of work by each team of fieldworkers, a sample size of four populations is still dangerously small. Probably other populations could be added to this comparison with limited data analysis by other ethnographers. One problem with this sample warrants a special caution. The !Kung figures are very different from the other three. Do these differences have an underlying influence on the results the picture we get from the sample? Are divorce rates among hunters and gatherers really rather invariant, with the exception of the Ache? We cannot answer this question without a larger sample.

Measures of Marital Stability

Hurtado and Hill (1992) used two measures of marital stability, divorce rate and number of husbands reported by postreproductive women. There are problems with using number of husbands as a measure of marriage stability.

1. In 1996 Marlowe asked 17 women how many times they had been married. His impression was that, even more so with his larger sample of men, the older individuals omitted brief partnerships from long ago, which younger individuals seemed inclined to report. His data give no indication of an increase in number of husbands with a woman's age. Fifteen of these women were found in our census records. The record for ten of them showed the same number of spouses as they reported to Marlowe. Of the remaining five, four reported one less spouse than the record showed, and one reported more. These census records cover a period of 10 years, less than half a woman's reproductive career. Hadza women's reports of number of husbands appear to be substantial underestimates of the actual number.
2. A large proportion of Hadza women of postreproductive age remain unmarried after their husband dies or leaves them. If Hadza differ in this from other populations, then number of spouses reported will also be expected to be lower for Hadza women of postreproductive age.
3. Number of husbands includes those acquired by a widow. Thus the figure will be influenced by husband's mortality rates, and since these are associated with age, and with the age gap between husband and wife, it may also vary from one population to another.
4. Number of husbands is probably overweighted by the rate of dissolution early in a marriage. We argued that rate of divorce in marriages that had lasted long enough to produce children was the best test of a "costs of desertion" theory of divorce. Hadza and !Kung divorce rates differed more with respect to marriages that had lasted five years than they did among the "younger" marriages. Marriages tend to be at highest risk in their first to fourth year, and among younger individuals. Howell (1979) attributes some of the divorces among the !Kung to the tendency for women's first marriages to be at a very young age and to much older men. This is apparently not entirely at the girls' choice, and they frequently leave their older husband. We see little sign of social pressure on Hadza girls to marry a particular man (but in 1997 we witnessed two instances of girls being put under pressure to reach a decision between rival suitors "before violence broke out"), and age at first marriage appears to be greater for Hadza women than among the !Kung (although age at first birth seems to be very similar). These factors may account for the apparent lower tendency of Hadza marriages to break up in the first year or two.

If we had used women's interview reports of the number of husbands as our measure of stability we would have clustered the Hiwi (1.7 by end of reproductive career) and Hadza (1.5) very close together, with the !Kung (2.45 husbands reported by women over 45) a little higher, and the Ache (12.1 average of hus-

hands for postreproductive women) as a distant outlier. This ranking suggests higher divorce rates are associated with higher father effect, the opposite of the paternal provisioning prediction.

Father Effect

The effect of fathers on children's survival has been measured in slightly different ways, although the problems of comparison between them are quite limited. Pennington and Harpending's evidence about the effect of !Kung fathers is rather indirect. They compared the infant and child mortality of children borne to women who had lost a husband (usually through death, they report) with that of women who had not lost a husband. Some of the effect may reflect simultaneous strikes by epidemics (killing husband and children but sparing the woman to survive to be interviewed!). Nor do we know whether the infant deaths preceded or followed the paternal deaths, or whether less healthy men get less able wives.

The link between father effect and paternal provisioning is not established for any of these populations. The Ache, with their pattern of food sharing and their high incidence of infanticide, might appear to offer a particularly poor example. However, Hill and Hurtado (1996) offer emic evidence that Ache men resented giving food to "orphans," and that the infanticide represented removal of the fitness loss that would result from feeding a dead man's children.

Father effect might underestimate the economic value of husbands because women must be presumed to allocate resources optimally between care and fertility. Thus when the father leaves, she may delay the next birth, and any shortfall in resources will then have less effect on current offspring than if she had continued bearing new offspring at her previous rate. This does not weaken the usefulness of father effect as a measure of desertion costs, but it does imply that resources she may have obtained from the father could have more effect on her fitness than our measure might be taken to indicate. If females allocate resources under their control between fertility and care, then, if we follow Smith and Fretwell's venerable (1974) model, a male who transfers resources to a female can have no effect on offspring survival, only on their number.

Hill (personal communication) suggested that father effect measured by absolute number of children lost would better reflect costs of desertion. If we make this recalculation, ranking on father effect does not change but parenting/mating index does, in a direction that counters the Hurtado and Hill (1992) finding: Hiwi

Table 4.5. Recalculating father effect as number of offspring lost by desertion.

Population	*Survivorship with Father*	*Survivorship without Father*	*Fertility*	*Father Effect (N of C.)*	*P/M Index*
Ache	.86	.53	7.8	2.5*	.29
Hiwi	.57	.52	5.4	0.27	.07
!Kung	.58	.46	4.7	0.58	.16
Hadza	.48	.44	6.2	0.25	.04

(.07) have a lower parenting/mating index than Ache (.29) and should desert more readily, which they do not (Table 4.5).

Fertility Units per Male

Is fertility units per male a good measure of benefit from desertion? It measures the number of units of paternity available per male, and thus opportunity to gain paternity. This should be a good measure of opportunity and probability of returns from pursuing matings outside the marriage. But first, it does not directly measure the reproductive benefit to be gained by giving up the continuing fertility of the current wife for the fertility of a new wife. On average, over a span of, say, five years, these would be the same, unless men only leave their wife for a woman of higher fertility. This could happen on two time scales—he might desert a pregnant or lactating wife for one who is neither (the mirror image of the strategy suggested by Fisher [1989] in which a man is predicted to leave his wife just as she returns to fecundability). He might desert a wife who is nearing the end of her reproductive career for one who is at peak fertility, or has much of her career ahead of her (Lockhard and Adams 1981). Because we are dealing with populations that have broad-based age pyramids, with many more younger people than older, FU/m will tend to correlate with the number of younger females per male, so failure to specifically measure the benefit of new matings may not have greatly distorted the picture.

Second, TFR (total fertility rate) is a component of FU/m. If infant and child mortality rate varied among these populations, mortality might account for some of the variance in TFR and FU/m. Ache infant mortality appears to be lower than the Hiwi, !Kung, or Hadza rates, which are very similar to each other. If Ache infant mortality increased, replacement births would increase and raise TFR and thus Ache FU/m would be raised, and our correlation would remain.

Third, FU/m may be a good measure of the operational sex ratio (OSR) and male-male competition. OSR has often been measured by reproductive "downtime"—how much less of the time are females available for reproduction (fertility units, conceptions, not copulations) than males? For noncontracepting human females, in cultures where babies are suckled for two years or more, and where lactational infertility is found, high TFR must accompany a greater number of opportunities for fertilization. In such populations it seems reasonable to note the parallel between Hurtado and Hill's FU/m and Clutton-Brock and Parker's OSR.

Fourth, FU/m depends on the reproductive age span. We use Hurtado and Hill's span of 15–40 for women, but Hazda women's reproductive career would be better represented as 18–45. For the !Kung should we use the average age at last birth reported by Howell (age 34), or the much higher modified figure obtained by Blurton Jones (1994) for bush-living women who may have avoided the highest incidence of secondary sterility due to disease?

Finally, the answer to the question of determining reproductive age span is even less obvious for men. If the measure is supposed to reflect competition, should it reflect the ages during which men are actually trying to compete? How do we determine this? Hurtado and Hill comment on age variation in men's ability as

hunters, implying that this influences their competitive ability. Should we limit the age range to those producing viable sperm? This measure is difficult to obtain! If we determine it by the ages at which men are married, or at which they still have a prospect of getting married, this seems in danger of getting circular—we end up using the proportion that competed successfully as part of a measure of intensity of competition. We note that the evolution of menopause increased the number of men competing for each woman of reproductive age compared to when the reproductive spans of the two sexes were similar.

Would our results be different if we changed the age ranges? Most of the Hadza men age 55–65 were married. If FU/m is intended to measure the degree of competition for paternity among men "in the market," then perhaps we should include these men. There were 23 men age 55–65 (80% of them married). Adding these to our sample yields 157 men and an FU/m of 5.88. Although this is a substantial reduction, it leaves the ranking unchanged. Hadza FU/m still lies about halfway between the !Kung and Ache rates; this actually makes the relationship between divorce rate and FU/m more nearly linear.

Among the !Kung, Howell reported that men first marry in their late twenties. If we remove men age 20–25 (say 13 of the 25 men estimated to be age 20–29) then we have 90 women, 101 men, and a TFR of 4.7 results in a !Kung FU/m of 4.19. Then the association between FU/m and divorce rank would be perfect.

And finally, why does "fertility units per male" vary so much among these populations? Total fertility rate and reproductive age spans both contribute to this variation, and so does adult sex ratio. Are adult sex ratios in these small populations stable enough to affect reproductive strategies? Hurtado and Hill argue that the Ache and Hiwi figures have a time depth of at least 30 years but offer no explanation for them.

REFERENCES

Bell, D. 1997. Defining marriage and legitimacy. *Current Anthropology* 38:237–254.

Blurton Jones, N. G. 1994. A reply to Dr. Harpending. *American Journal of Physical Anthropology* 93:391–397.

Blurton Jones, N. G., K. Hawkes, and P. Draper. 1994. Foraging returns of !Kung adults and children: Why didn't !Kung children forage? *Journal of Anthropological Research* 50:217–248.

Blurton Jones, N. G., K. Hawkes, and J. F. O'Connell. 1996. The global process, and local ecology: How should we explain differences between the Hadza and the !Kung? In *Cultural Diversity Among Twentieth Century Foragers,* Susan Kent, ed. Pp. 159–187. Cambridge: Cambridge University Press.

Blurton Jones, N. G., J. F. Smith, J. F. O'Connell, K. Hawkes, and C. L. Kamuzora. 1992. Demography of the Hadza, an increasing high density population of savanna foragers. *American Journal of Physical Anthropology* 89:159–181.

Borgerhoff Mulder, M. 1988. The relevance of the polygyny threshold model to humans. In *Mating Patterns,* C. N. Mascie-Taylor and J. Boyce, eds. Pp. 84–102. Cambridge: Cambridge University Press.

Buckle, L., G. G. Gallup, and Z. Road. 1996. Marriage as a reproductive contract: Patterns of marriage, divorce, and remarriage. *Ethology and Sociobiology* 17:363–378.

Clutton-Brock, T. H., and G. A. Parker. 1992. Potential reproductive rates and the operation of sexual selection. *Quarterly Review of Biology* 67:437–456.

———. 1995. Sexual coercion in animal societies. *Animal Behavior* 49:1345–1365.

Cronk, L. 1991. Wealth, status, and reproductive success among the Mukogodo of Kenya. *American Anthropologist* 93:345–360.

Daly, M., and M. Wilson. 1987. Child abuse and other risks of not living with both parents. *Ethology and Sociobiology* 6:197–210.

Fisher, H. 1989. Evolution of human serial pair bonding. *American Journal of Physical Anthropology* 78:331–354.

Hames, R. 1996. Costs and benefits of monogamy and polygyny for Yanomamö women. *Ethology and Sociobiology* 17:181–200.

Hawkes, K. 1990. Why do men hunt? Benefits for risky choices. In *Risk and Uncertainty in Tribal and Peasant Economies,* E. Cashdan, ed. Pp. 145–166. Boulder: Westview Press.

———. 1991. Showing off: Tests of an hypothesis about men's foraging goals. *Ethology and Sociobiology* 12:29–54.

———. 1993. Why hunters work: An ancient version of the problem of public goods. *Current Anthropology* 34:341–361.

———. 2000. Big game hunting and the evolution of egalitarian societies. In *Hierarchies in Action: Cui Bono?* Center for Archaeological Investigations, Occasional Paper No. 27:59–83. Michael W. Diehl, ed. Southern Illinois University.

Hawkes, K., J. F. O'Connell, and N. G. Blurton Jones. 1991. Hunting income patterns among the Hadza: Big game, common goods, foraging goals and the evolution of the human diet. *Philosophical Transactions of the Royal Society of London* B 334:243–251.

———. 1995. Hadza children's foraging: Juvenile dependency, social arrangements, and mobility among hunter-gatherers. *Current Anthropology* 36:688–700

———. 1997. Hadza women's time allocation, offspring provisioning, and the evolution of long post-menopausal lifespans. *Current Anthropology* 38:551–577.

Hawkes, K., A. R. Rogers, and E. L. Charnov. 1995. The male's dilemma: Increased offspring production is more paternity to steal. *Evolutionary Ecology* 9:662–677.

Hewlett, B. S. 1992. Husband-wife reciprocity and the Father-infant relationship among Aka Pygmies. In *Father-Child Relations: Cultural and Biosocial Contexts,* B. S. Hewlett, ed. Pp. 153–176. New York: Aldine de Gruyter.

Hill, K. and A. M. Hurtado. 1996. *Ache Life History: The Ecology and Demography of a Foraging People.* New York: Aldine de Gruyter.

Hill, K. and H. Kaplan. 1993. On why males foragers hunt and share food. *Current Anthropology* 34:701–706.

Howell, N. 1979. *Demography of the Dobe Area !Kung.* New York: Academic Press.

Hrdy, S. 1997. Raising Darwin's consciousness; female sexuality and the prehominid origins of patriarchy. *Human Nature* 8:1–49.

Hurtado, A. M., and K. R. Hill. 1992. Paternal effect on offspring survivorship among Ache and Hiwi hunter-gatherers: Implications for modeling pair-bond stability. In *Father-Child Relations: Cultural and Biosocial Contexts,* B. S. Hewlett, ed. Pp. 31–55. New York: Aldine de Gruyter.

Kaplan, K. B. 1994. The marital balance of power and quid pro quo: An evolutionary perspective. *Ethology and Sociobiology* 15:283–298.

Kvarnemo, C., and I. Ahnesjo. 1996. The dynamics of operational sex ratios and competition for mates. *Trends in Ecology and Evolution* 11:404–408.

Lancaster, J. B. 1997. The evolutionary history of human parental investment in relation to

population growth and social stratification. In *Feminism and Evolutionary Biology*, P. A. Gowaty, ed. Pp. 466–488. New York: Chapman and Hall.
Lancaster, J. B., and C. S. Lancaster. 1983. Parental investment: The hominid adaptation. In *How Humans Adapt: A Biocultural Odyssey*, D. J. Ortner, ed. Pp. 33–69. Washington, D.C.: Smithsonian Institution Press.
Lee, R. B. 1979. *The !Kung San*. Cambridge: Cambridge University Press.
Lockhard, J., and R. M. Adams. 1981. Human serial polygyny: Observations and demographic evidence? *Ethology and Sociobiology* 2:177–186.
Mabulla, A. Z. P. 1996. Middle and later stone age land-use and lithic technology in the Evasi Basin, Tanzania. Ph.D. dissertation, University of Florida.
Marlowe, F. 1999a. Showoffs or providers?: The parenting effort of Hadza men. *Evolution and Human Behavior* 20 (6):391–404.
———. 1999b. Male care and mating effort among Hadza foragers. *Behavioral Ecology and Sociobiology* 46:57–64.
Manson, J. H. 1997. Primate consortships: A critical review. *Current Anthropology* 38:353–374.
McDowell, W. 1981. A brief history of the Mangola Hadza. Ms. prepared for The Rift Valley Project, Ministry of Information and Culture, Dar es Salaam, Tanzania.
Mehlman, M. 1988. Later Quaternary Archaeological Sequences in Northern Tanzania. Unpublished Ph.D. dissertation, Department of Anthropology, University of Illinois, Champaign-Urbana.
Obst, E. 1912. Von Mkalama ins Land der Wakindiga. *Mitteilungen der Geographischen Geselleschaft in Hamburg* 26:3–45.
O'Connell, J. F., K. Hawkes, and N. G. Blurton Jones. 1992. Patterns in the distribution, site structure and assemblage composition of Hadza kill-butchering sites. *Journal of Archaeological Science* 19:319–345.
Pennington, R., and H. Harpending. 1988. Fitness and fertility among Kalahari !Kung. *American Journal of Physical Anthropology* 77:303–319.
Sands, B. 1995. Evaluating Claims of Distant Linguistic Relationships: The Case of Khoisan. Ph.D. dissertation, University of California, Los Angeles.
Sands, B., I. Maddieson, and P. Ladefoged. 1993. The phonetic structures of Hadza. *UCLA Working Papers in Phonetics* 84:67–88.
Schoeninger, D. W., and W. D. Wood. 1969. Comparison of married and ad hoc mixed-sex dyads negotiating the division of a reward. *Journal of Experimental Social Psychology* 5:483–499.
Smith, C. C., and S. D. Fretwell. 1974. The optimal balance between size and number of offspring. *American Naturalist* 108:499–506.
Smuts, B. B., and D. J. Gubernick. 1992. Male-infant relationships in nonhuman primates: Paternal investment or mating effort? In *Father-Child Relations: Cultural and Biosocial Contexts*, B. S. Hewlett, ed. Pp. 1–30. New York: Aldine de Gruyter.
Symons, D. 1979. *The Evolution of Human Sexuality*. Oxford: Oxford University Press.
Woodburn, J. C. 1968a. An introduction to Hadza ecology. In *Man the Hunter*, R. B. Lee and I. DeVore, eds. Pp. 49–55. Chicago: Aldine.
———. 1968b. Stability and Flexibility in Hadza residential groupings. In *Man the Hunter*, R. B. Lee and I. DeVore, eds. Pp. 103–110. Chicago: Aldine.
———. 1979. Minimal politics: the political organization of the Hadza of north Tanzania. In *Politics and Leadership: A Comparative Perspective*, W. Snack and P. Cohen, eds. Pp. 244–266. Clarendon Press, Oxford.
———. 1988. African hunter-gatherer social organization: Is it best understood as a product of encapsulation? In *Hunters and Gatherers*, T. Ingold, D. Riches, and J. Woodburn, eds. Vol. 1, pp. 31–64. Oxford: Berg.

5

Fertility, Offspring Quality, and Wealth in Datoga Pastoralists

Testing Evolutionary Models of Intersexual Selection

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One of the greatest challenges for evolutionary anthropology is to account for the wide variation in human marriage and mating practices using Darwinian logic. Early studies of human marriage systems were strongly influenced by Emlen and Oring's (1977) theoretical model linking mating systems and resource distributions. Thus the strong associations of polygyny with marked differences in wealth and power among men (e.g., Betzig 1986; Chagnon and Irons 1979; Irons 1979) were seen as evidence that men commonly use their resource-holding power to monopolize women and render them unavailable to other men (e.g., Flinn and Low 1986). Over the years behavioral ecological models have broadened considerably. Recently, the potential for conflict between the sexes has been emphasized (Gowaty 1995; Smuts and Smuts 1993; Westneat and Sargent 1996). The notion of mating systems has also become problematic since sexual relations may take place beyond the so-called breeding pair. This chapter explores the impact of polygynous marriage on a variety of fitness indices in the Datoga of Tanzania and attempts to delineate some of the dynamics of sexual conflict in their marriage system.

Polygyny has been a topic of enormous interest to sociocultural anthropologists. Comparativists have elucidated many of the conditions in which polygyny obtains, but they have focused almost exclusively on men's strategies. Thus White and Burton (1988) attribute the causes of polygyny worldwide primarily to expansionary external interest groups that capture women and bride-wealth through warfare. Similarly Spencer (1980) views polygyny in Africa as the consequence of men's attempt to differentiate themselves in wealth and power, often through gerontocratic processes. There are problems with such male-biased sociocultural approaches (Borgerhoff Mulder 1992b). Most notably, they do not look at how the