Testosterone and Marriage among Ariaal Men of Northern Kenya

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Recent studies suggest that differential human male investment in mating (male-male competition and mate-seeking behavior) and parenting effort may be associated with variation in testosterone levels. The Ariaal present an interesting test case because marital relations tend to be aloof and direct paternal care minimal by cross-cultural standards. Polygyny is prevalent and increases with age, and the age-set system highly structures the transition to marriage. A test of the effect of marital status on testosterone levels among the Ariaal involved 205 men aged 20 and older from a settled agropastoral community and nomadic populations. Each participant provided morning and afternoon saliva samples in which testosterone levels were measured, provided demographic background during interviews, and had anthropometrics taken. As predicted, during the dynamic ages (20–39) of transition from life as a bachelor and warrior to monogamous marriage, men with one wife had significantly lower testosterone levels than unmarried men. Contrary to prediction, however, polygynously married men did not have higher testosterone levels than their monogamously married counterparts. While variation in testosterone may be associated with mating effort in young Ariaal men, political networks and wealth may be better predictors of marital status in older men.

Humans are among the approximately 5% of mammals that exhibit pair bonding and high levels of paternal care (Reichard and Boesch 2003; Clutton-Brock 1991). Consequently, males may experience a trade-off between mating effort (male-male competition and mate seeking), on one hand, and investment in affiliative interactions with a mate and direct paternal care, on the other (Kaplan and Lancaster 2003). Recent theoretical and empirical studies suggest that differential investment in mating and parenting effort may be associated with variation in male testosterone levels (Archer 2006; Oliveira 2004; Gray et al. 2002; Muller and Wrangham 2001; Wingfield et al. 1990).

More specifically, men involved in affiliative relationships with a female partner and direct paternal care may have lower testosterone levels, either because of reduced mating effort or because of interactions with a long-term partner or direct child care. Indeed, a growing body of research among North American subjects has shown that men’s involvement in committed, romantic relationships such as marriage and/or involvement in paternal care are associated with lower testosterone levels (Van Anders and Watson 2006; McIntyre et al. 2006; Gray et al. 2004a; 2004b; Burnham et al. 2003; Gray et al. 2002; Fleming et al. 2002; Berg and Wynne-Edwards 2001; Storey et al. 2000; Mazur and Michalek 1998; Booth and Dabbs 1993).

Current cross-cultural findings on this topic have yielded mixed results. In a study of Kenyan Swahili men, Gray (2003a) found no differences in salivary testosterone levels between unmarried men and monogamously married men, but men with two wives had higher testosterone levels than others. Research on Beijing men in a university community showed that fathers had lower testosterone levels than married men without children and unmarried men (Gray, Yang, and Pope 2006). The different outcomes of these studies may reflect several factors including the nature of extended kinship networks, spousal relationships, and the validity of using relationship status (e.g., marital status) as a proxy for mating and parenting effort (Gray and Campbell n.d.).

Here, we extend the cross-cultural scope of this research by testing predictions regarding variation in male testosterone levels in relation to marriage among Ariaal men of northern Kenya (Fratkin 1998). Cross-cultural data on human marriage and parenting behaviors suggest that pastoralists like the Ariaal fall at the “aloof” extreme of an aloof-affiliative husband-wife bonding scheme (Gray 2003b; Whiting and Whiting 1975). Moreover, pastoralists like the Ariaal tend to invest considerably in forms of indirect care such as providing livestock to sons for bridewealth but invest relatively little in direct child care (Lamb 2004; Marlowe 2000). Some of the reasons for the aloof marital relationships and low investment in direct paternal care include the relatively high prevalence of polygynous marriages and the value placed on male-male bonds to assist in livestock defense at the expense of husband-wife relationships.

On the basis of the theoretical link between testosterone and human mating and parenting effort and the specifics of the Ariaal sociocultural context, we derived and tested two predictions:

1. Among men aged 20–39, monogamously married men will have lower testosterone levels than unmarried men. This age-range represents the period in which Ariaal men typically transition from investing in mating effort as warriors (particularly solidifying male-male bonds with age-mates and seeking short-term mates) to investing in both mating and parenting effort as reproductive, married adults. We bracket this age-range because the average age of first marriage among Ariaal men is around 30 years and men remaining unmarried beyond age 40 may not be suitable as mates.

2. Polygynously married men will have higher testosterone
levels than monogamously married men. The basis for this prediction is that men with multiple wives are investing in greater mating effort than those with one wife. To maintain successful relationships with multiple wives, polygynously married men may invest in additional mate guarding or experience a modified version of the so-called Coolidge effect (elevations in libido associated with different sexual partners).

Notably, we do not test any predictions regarding male testosterone and paternal status among the Ariaal. Ariaal men, by cross-cultural standards, invest little in forms of child care (e.g., holding an infant) that might be associated with lower testosterone levels or draw men away from mating effort. Consequently, we do not expect male testosterone levels in this population to be obviously related to paternal behavior.

Methods

The Ariaal are pastoralists inhabiting both upland and lowland regions in Marsabit District, Kenya. First appearing in oral history in the 1880s, they are derived from poor Rendille and Samburu groups that banded together to build up their herds in the mountains. Culturally, they still exhibit features of both Rendille and Samburu, including Samburu age-set rituals and Rendille annual camel blessings (Fratkin 1998). Ariaal derive their subsistence from the herding of camels, cattle, goats, and sheep, which they depend on for nutrition in the form of milk, blood, and meat. Especially in the settled agro-pastoral community of Songa, maize and other foodstuffs make important contributions to the diet (Fratkin 1998).

Ariaal participants were recruited from two venues: 103 men from the settled agro-pastoral community of Songa and 102 nomadic males from the nomadic settlement of Lowegosa on the Kasuit Plateau. Potential subjects were identified by a scattershot method in the settled community. In the nomadic community, all eligible men were asked to participate.

Interviews, assisted by trained translators in the appropriate language (Samburu or Rendille), were conducted with all participants. They focused on demographic background, marital and reproductive history, social support, and age-related quality-of-life outcomes. Participants’ ages were estimated with reference to an event calendar and age-set membership and ambiguities checked with local assistants (see Gray and Campbell 2005 for further details). Marital status was recorded as the current number of wives. All polygynously married men (N = 44 with two wives, N = 7 with three wives, N = 1 with four wives, and N = 1 with five wives) were collapsed into a single category of polygynously married men. Anthropometric measures, including height, weight, and suprailliac skinfolds, were taken by an experienced human biologist (BCC).

One morning (within 15 minutes of 0900 hours) and one afternoon (within 15 minutes of 1600 hours) saliva sample were obtained from each subject. Morning testosterone levels are thought to reflect the magnitude of the sleep-related rise in testosterone while afternoon levels are thought to reflect influences on testosterone due to activities and interactions throughout the day. Therefore morning levels may be indicative of endogenous physiological differences between subjects whereas afternoon levels may be more indicative of behavioral and short-term ecological effects. Samples were collected with the use of sugar-free Trident gum as a stimulant and sodium azide to inhibit microbial growth (Lipson and Ellison 1989). Samples were stored at ambient temperature for approximately one month and then frozen until assayed in the Reproductive Ecology Laboratory at Harvard University. Testosterone levels have been shown to remain stable under these collection and handling conditions (Lipson and Ellison 1989). Assay procedures relied on standard techniques based on modifications of a commercially available kit obtained from Diagnostic Systems Laboratories (see methods in Campbell, O’Rourke, and Lipson 2003). The interassay coefficient of variation was 15% and the intraassay coefficient 7%.

We considered several variables as potential confounders. Age-related declines in testosterone levels have been almost universally observed, though population differences exist in the rate of decline—the slope being steepest among developed, Western populations and nonsignificant among some traditional, non-Western populations (Ellison et al. 2002). Among these Ariaal samples, there was no significant age-related decline in testosterone (Campbell, Ellison, and Gray 2006). Separate analyses showed that several measures of body composition (suprailiac skinfolds and the sum of three skinfolds) were positively related to testosterone levels. Residential status (settled agropastoralists versus pastoral nomads) was considered in light of residential differences in activity patterns, diet, and testosterone levels (Campbell, Ellison, and Gray 2006).

In order to test our predictions, an analysis of covariance was used with sum of skinfolds and age-group entered as covariates, marital status and residential status entered as independent variables, an interaction term between marital status and residential status entered as an independent variable (because of the residential differences in marital status noted below), and morning and afternoon testosterone levels used, respectively, as dependent variables. P values reflect two-tailed tests with alpha set at 0.05.

Results

Table 1 displays Ariaal marital status according to age-group. Only four men aged 40 or older were unmarried, and no man under 40 had more than one wife. These data reflect the processes of marriage, with men marrying their first wife soon
after leaving the warrior stage and acquiring more wives with age. Marital patterns also differed according to residential status ($t = 2.85; p = 0.005$); nomadic men were less likely to be unmarried and more likely to be polygynously married.

Four morning and one afternoon testosterone concentrations fell more than three standard deviations above the mean. When these samples were excluded, mean ($\pm$ 1 SE) testosterone levels were 87.6 (4.0) pmol/L in morning samples and 86.7 (3.9) pmol/L in afternoon samples. These testosterone levels are low by comparison with Western populations, consistent with observations of population variation in male testosterone levels (Bribiescas 2001). Morning testosterone levels did not show the typical circadian pattern of testosterone ($t = 0.28; p = 0.595$) variation, in which higher levels are observed around the time of waking in the morning and generally decline across the day. The lack of circadian rhythms in these testosterone levels mirrors earlier Ariaal results reported by Campbell, O’Rourke, and Lipson (2003) on a smaller Ariaal sample and may reflect Ariaal men’s waking several hours before morning samples were collected as well as various behavioral effects on afternoon levels (Campbell, Ellison, and Gray 2006). Table 2 displays raw testosterone data according to age-group and residential status.

Prediction 1 was upheld. Among men aged 20–39, a significant overall analysis-of-covariance model emerged for both morning ($F[3,62] = 5.12; p = 0.001; R^2 = .292$) and afternoon ($F[3,65] = 2.54; p = 0.037; R^2 = .164$) testosterone levels. Marital status (unmarried versus monogamously married) was a significant predictor of both morning ($F = 4.42; p = 0.040$) and afternoon ($F = 4.77; p = 0.033$) levels. Residential status was also a significant predictor of testosterone levels (morning $F = 18.87; p < 0.0005$; afternoon $F = 5.30; p = 0.025$), but skinfolds (morning $F = 0.03; p = 0.858$; afternoon $F = 0.04; p = 0.841$), age-group (morning $F = 0.38; p = 0.542$; afternoon $F = 0.49; p = 0.845$), and the interaction term between marital status and residential status (morning $F = 0.01; p = 0.542$; afternoon $F = 0.82; p = 0.367$) were not. The marriage-related differences in testosterone levels among men aged 20–39 were also confirmed in univariate analyses (morning $F = 4.13; p = 0.046$; afternoon $F = 4.83; p = 0.031$). Results are shown in figure 1.

Prediction 2 was not upheld. Mean ($\pm$ 1 SE) testosterone levels of monogamously married (morning 88.4 ± 5.4 pmol/L; afternoon 84.2 ± 5.1 pmol/L) and polygynously married (morning 71.7 ± 6.0 pmol/L; afternoon 80.1 ± 7.4 pmol/L) men did not differ significantly. Across men of all ages, a significant analysis-of-covariance model emerged for both morning ($F[5,163] = 9.45; p < 0.0005; R^2 = .225$) and afternoon ($F[5,162] = 5.60; p < 0.0005; R^2 = .147$) testosterone levels. Marital status (monogamously versus polygynously married) was not a significant predictor (morning $F = 2.08; p = 0.151$; afternoon $F = 3.31; p = 0.071$). Residential status (morning $F = 13.88; p < 0.0005$; afternoon $F = 2.41; p = 0.122$) and skinfolds (morning $F = 0.53$;

Figure 1. Testosterone levels of Ariaal aged 20–39 by marital status and time of day. Monogamously married men ($N = 42$) have 37% lower morning (black bars) testosterone levels than unmarried men ($N = 26$). Monogamously married men ($N = 43$) have 36% lower afternoon (white bars) testosterone levels than unmarried men ($N = 28$).

Table 2. Ariaal Male Testosterone Levels (mean ± SE) according to Age and Residence

<table>
<thead>
<tr>
<th>Age-Group</th>
<th>20s</th>
<th>30s</th>
<th>40s</th>
<th>50s</th>
<th>60+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Settlement</td>
<td></td>
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<tr>
<td>Mornings</td>
<td>137.9 (16.0)</td>
<td>113.5 (13.9)</td>
<td>111.1 (16.0)</td>
<td>95.9 (16.4)</td>
<td>102.6 (9.7)</td>
</tr>
<tr>
<td>Afternoons</td>
<td>109.4 (12.2)</td>
<td>108.8 (15.2)</td>
<td>85.6 (13.7)</td>
<td>102.2 (16.1)</td>
<td>99.0 (9.4)</td>
</tr>
<tr>
<td>Nomadic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mornings</td>
<td>58.4 (9.7)</td>
<td>72.9 (10.4)</td>
<td>58.9 (6.2)</td>
<td>61.3 (10.3)</td>
<td>67.7 (7.8)</td>
</tr>
<tr>
<td>Afternoons</td>
<td>84.1 (13.0)</td>
<td>70.2 (10.8)</td>
<td>60.8 (8.6)</td>
<td>66.9 (9.7)</td>
<td>92.2 (14.3)</td>
</tr>
</tbody>
</table>
afternoon $F = 8.19; \ p = 0.005$) showed mixed ability to predict testosterone levels, while age-group was not a significant predictor (morning $F = 0.04; \ p = 0.840$; afternoon $F = 3.32; \ p = 0.070$). The interaction term between marital status and residential status was significant (morning $F = 8.58; \ p = 0.004$; afternoon $F = 5.27; \ p = 0.023$), which suggests that the relationship between polygynous marriage and testosterone levels differs according to residence; lower levels associated with polygynous marriage appear primarily among settled men.

To determine how sensitive these results might be to confounding variables, including age, we performed additional analyses. When we conducted the same analyses as before but across all men aged 20 and older, testosterone differences between unmarried and monogamously married men were no longer significant (morning $F = 2.12; \ p = 0.147$; afternoon $F = 3.82; \ p = 0.052$). However, if we performed similar analyses over the 20-plus age-range while including an interaction term between marital status and age-group, this interaction was significant (morning $F = 2.99; \ p = 0.021$; afternoon $F = 2.57; \ p = 0.041$), suggesting that the relationship between testosterone and marital status changes with age. In fact, differences in testosterone levels according to marital status diminish with age. Because these analyses include few unmarried men aged 40 and older ($N = 4$), however, these results should be viewed cautiously.

Another question we considered was whether contrasts between monogamously and polygynously married men should be age-restricted. Since no men in this sample marry polygynously until their 40s, we performed analyses similar to the above but restricted to monogamously and polygynously married men aged 40 and older. This age restriction did not meaningfully alter results for analyses of morning testosterone but did have effects on results for afternoon testosterone. The model for afternoon testosterone was significant ($F[5, 119] = 6.00; \ p < 0.0005; R^2 = .201$). Marital status ($F = 4.73; \ p = 0.032$), age-group ($F = 6.78; \ p = 0.010$), skinfolds ($F = 12.54; \ p = 0.001$), and the interaction between marital and residential status ($F = 5.07; \ p = 0.026$) were significant predictors of afternoon testosterone levels. Residential status was not a significant predictor ($F = 4.73; \ p = 0.319$).

These analyses indicate that polygynously married men had lower afternoon testosterone levels than monogamously married men aged 40 and older and that an interaction between residential status and marital status on testosterone levels remained significant in this group. Since the difference in afternoon testosterone levels according to marital status was no longer significant in univariate analysis ($F = 0.65; \ p = 0.421$), these results implicate confounding effects of age and skinfolds.

**Discussion and Conclusion**

As predicted, monogamously married Ariaal men had significantly lower testosterone levels than their unmarried counterparts during the period (20–39) in which men undergo the transition to marriage. These differences in testosterone levels were not due to confounded effects of age, body composition, or residential status. Polygynously married Ariaal men, however, did not have higher testosterone levels than their monogamously married counterparts in this age-range, which was counter to our expectation. A significant interaction between residential status and marital status suggests different relationships between testosterone levels and polygynous marriage (lower levels among polygynously married men are largely due to their living in settlements rather than as nomads). Afternoon testosterone levels were lower among polygynously married Ariaal men aged 40 and older than among their monogamously married counterparts. This result may reflect the fact that it is older men who are capable of obtaining additional wives.

Ariaal marriage and fatherhood must be understood from the standpoint of the age-grade system common among East African pastoralists (Spencer 1993, 1973; Edgerton 1973). Males serve as herd boys until reaching puberty, when they are initiated, and become warriors who attempt to accumulate the livestock required for bridewealth and marriage. As warriors, they may be sexually active with peripubescent girls but are not allowed to marry ( McCluskey, Roth, and Van den Driessche 2005). Traditionally, warriors served important functions of livestock defense against predators and other pastoralists. This is a time when males develop strong social bonds with their male cohort members. As a result of this age-graded system, men do not transition from warriors into adulthood, when they are allowed to marry and soon after have children, until approximately 30 years of age.

Our interviews with Ariaal men suggested that marriages should be characterized as aloof. When asked to list individuals from whom they received material and emotional support, on average they reported receiving material support from 2.3 friends and 1.4 family members and emotional support from 1.8 friends and 2.6 family members. Only 3 of 203 men listed their wives as sources of emotional support. While one might ask how well the concept of material and emotional support translates to an Ariaal context, this pattern of responses suggests that men were able to specify such support, and replies were consistent with the recognized importance of male-male bonds and more distant, commonly polygynous marriages.

At least two factors may be relevant in interpreting our findings. First, divorce is not formally recognized, meaning that some older men declaring marriage to multiple wives may in fact spend little time with some of their wives. Consequently, some of the men considered polygynously married may, de facto, be living with one wife. Second, it may be that the role of testosterone in regulating social relationships matters more among young adults. The competitive interactions and mate seeking facilitated by testosterone predominate in young adulthood, after which different types of social strategies (e.g., political maneuvering) take precedence (Daly and...
Wilson 1988). Indeed, this idea gains support from the interaction effect between age-group and marriage on testosterone levels observed among unmarried and monogamously married men.

Polygynously married men tend to be older than monogamously married men. As we saw in age-restricted analyses (men aged 40 and older), polygynously married men had lower afternoon testosterone levels than monogamously married men. Examination of interaction effects showed that these results were largely due to factors associated with settlement life. First, settled men have higher testosterone levels than nomadic men (Campbell, Ellison, and Gray 2006), and thus their testosterone levels are capable of greater decline with age and changing social interactions. Second, the negative relationship between polygyny and testosterone among older men may speak to the greater importance of political networks and land and livestock holdings than of testosterone-related behavior as predictors of polygynous marriage.

These unexpected results regarding Ariaal polygyny and testosterone differ from earlier findings among Kenyan Swahili, in which polygynously married men had higher testosterone levels than other men. Differences in age distribution between the populations may play a role. The Kenyan Swahili men studied were aged 29–52, whereas this Ariaal sample encompasses a broader, older age-span, particularly for polygynously married men. The Swahili and the Ariaal also show socioeconomic differences; the urban Swahili display a wider range of occupations and socioeconomic variation. Furthermore, in contrast to the Ariaal, some of the unmarried Kenyan Swahili men were divorced and had previously fathered children.

The results of this study are subject to methodological limitations. Because of the pulsatile release of testosterone, it would be preferable to obtain multiple samples from subjects rather than single morning and single afternoon samples; our study design focused on a larger sample rather than within-individual variation. The testosterone data presented here may be viewed as representing baseline levels; however, it would be interesting to investigate differences in testosterone responses to social challenges (see Archer 2006). Furthermore, the measure of marital status used in this study may be imperfect. Marital status may not encompass divorce, as noted above, and we have seen that polygynous marital status may serve as a poor proxy for testosterone-related mating effort.

In summary, these findings add to the cross-cultural scope of published data on the topic of human pair bonding, parenting and testosterone. While a number of North American studies (see Booth and Dabbs 1993) had shown lower testosterone levels among monogamously married men compared with their single counterparts, no study outside North America had observed this. Contrary to earlier findings among the Swahili, polygynously married Ariaal men did not show higher testosterone levels. In fact, follow-up analyses among Ariaal men aged 40 and older revealed lower testosterone levels among polygynously married men compared with monogamously married men. Thus, these results lend further support to arguments that male testosterone levels reflect, in part, variation in male mating effort. However, the negative relationship between polygynous marriage and testosterone level suggests that among older men other factors (such as political networks and wealth) may be more important. Future research may adopt a biocultural perspective on human behavior to begin exploring the role of other hormones such as oxytocin, vasopressin, and prolactin (Carter 1998) in human male pair bonding and parenting in cross-cultural settings.

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