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Phenotypic Correlates of Fitness among the Turkana in North-Western, Kenya

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Abstract:
The impact of various phenotypic features to fitness attributes in some human populations has been shown. Height, grip strength and even skin colour do in some human populations correlate positively with the individual's reproductive success. While most of the reported results have been from studies based on industrialised populations, the situation especially in various African countries isn't obvious.
By using several Kenya populations, this study reports that the universality of these phenotypic correlates on a population's fitness cannot be guaranteed. Among the Turkana, for example, height and skin colour do not in any way impact on the population's fitness. This we hypothesise could be due to the different factors that determine success based on the different environments, culture as well as subsistence mechanisms.

Keywords: *Phenotype, fitness, culture, environment*

1. Phenotypic Attributes and Reproductive Success among Populations

The impact that various phenotypic attributes like height etc. have on individuals' reproductive success has been documented in several populations. However, studies especially in pre-industrial populations have shown that factors like height aren't such critical during mate choice after all. How such attributes vary across most African populations is not obvious and thus this study sets out to among other things establish the impact of several phenotypic features like height, Melanin index etc. on the eventual individuals' reproductive success. It also does investigate how the various cultural systems, with respect to marriage, impact on the eventual male and females' procreation ability.

Natural selection and sexual selection can lead to the increase in the frequency of a particular phenotype but the mechanisms behind each are disparate. Being tall for example in certain environmental conditions could be advantageous and thus favoured leading to an increased frequency of the genetic variants associated with tallness in populations thriving in such niches. However, there are other cases in which taller mates (especially males) are preferred more than their shorter counterparts thence leading to the eventual rise in the frequency of the genetic variants associated with increased height. While being tall in the former case possibly confers a survival advantage, in the latter scenario being tall only increases one's chances to accessing a mate and possibly procreating too.

This study therefore set out to assess which phenotypic attributes among the various Kenyan populations underline their (populations') fitness.

2. Materials and methods

2.1. Collection of the Phenotypic Data

Several Kenyan populations were targeted during this study (see Figures 1, 2 and Table 1 below for more information).

Questionnaires were administered and the total number of wives (for the male participants) and children (both for male and female participants) recorded.

A number of anthropometric measurements were as well taken for each individual in order to characterise the average population body phenotype. Such measurements are:

- Height which was recorded using the Harpenden® Anthropometer,
- Skin pigmentation was recorded as the Melanin index (M) *via* reflectance spectroscopy was captured using the Derma Spectrometer® (Cortex Technologies, Denmark). Numeric values on a scale from 0 (white) to >200 (black) measured the melanin index on a fixed portion of skin from the medial aspect of each upper arm (on the inferior part of the armpit), representing the area of the body less exposed to direct sunlight that may be measured non-intrusively, so as to avoid the confounding effect of exposure to the sunlight and the accompanying tanning

variability. Readings obtained from both arms were averaged and used as the representative Melanin index (M) value for each participant. Shriver and Parra (2000) defined the Melanin index (M) as $100\times \log_{10}$ (1/proportion red reflectance at 655nm).

2.2. The Turkana Sample

Phenotypic information from various sampling sites among the Turkana in north-western Kenya were obtained as shown in Figure 1 and Table 1 below.

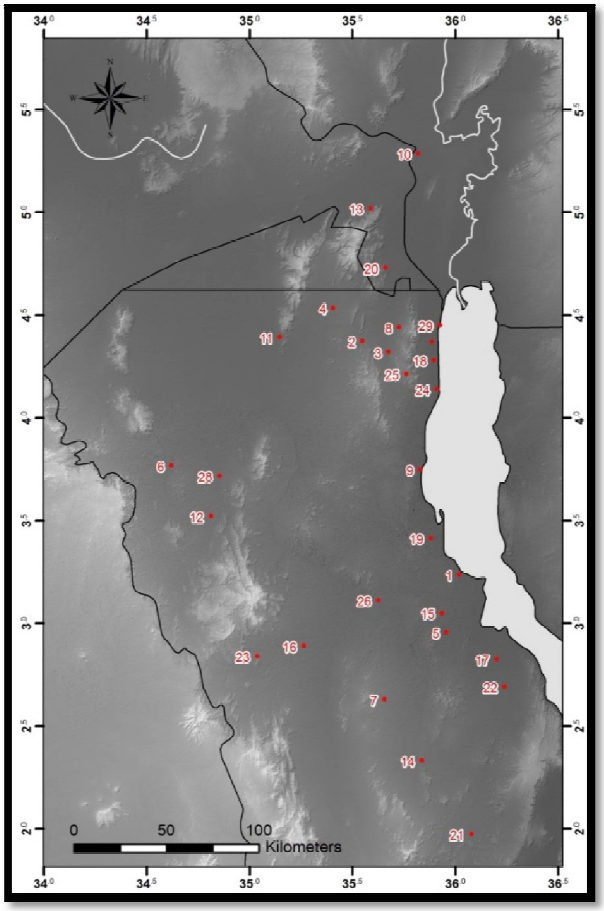

Figure 1: Map Showing the Sampling Sites within the Turkana Region
Background Elevation Map from ASTER GDEM V2 (By METI & NASA)

KEY: 1 -Eliye; 2 – Kaalem; 3-Kachoda; 4- Kokuro; 5-Kakimat; 6-Kalobeyei; 7-Kaputir; 8-Karebur; 9-Kataboi; 10-Kibish; 11-Kaikor; 12-Letia; 13-Lokamarinyang'; 14-Loperot; 15-Loreng'elup; 16-Lorugum; 17-Louwe; 18-Lowareng'ak; 19-Loyoro; 20-Meyen; 21-Morulem; 22-Nakoret; 23-Namorupus; 24-Nariokotome; 25-Natoo; 26-Nawoitorong; 27-Piringan; 28-Songot; 29-Todonyang'.

A total of 879 individuals (478 women and 401 men) from 29 different localities were included in the study (see Table1 below).

# on map (Fig 1)	Sampling site	Women	Men	Total	Livelihood zone
10	Kibish	11	20	31	Pastoralists in the Ilemi; extreme north of the Province
20	Meyen	11	10	21	Pastoralists in the Ilemi; extreme north of the Province
13	Lokamarinyang'	7	5	12	Pastoralists in the Ilemi; extreme north of the Province
4	Kokuro	15	15	30	Pastoralists in the Ilemi; extreme north of the Province
27	Piringan,	19	7	26	Fishermen-herders close to Lowarengak
9	Kataboi	7	17	29	Fishermen-herders along the Western shores of Lake Turkana
24	Nariokotome	13	18	31	Fishermen-herders along the Western shores of Lake Turkana
1	Eliye	21	8	29	Fishermen-herders close to Kalokol
19	Loyoro	9	17	26	Fishermen-herders close to Kalokol

# on map (Fig 1)	Sampling site	Women	Men	Total	Livelihood zone
7	Kaputir	10	15	25	Agro pastoralists and food gatherers along the southern reaches of the Turkwell River
	Tiya	5	20	25	Agro pastoralists along the northern reaches of the Turkwell River
21	Morulem	13	15	28	Agro pastoralists and the Kerio River (close to Lokori)
26	Nawoitorong	25	13	38	Agro pastoralists and the Kerio River (close to Lodwar)
28	Songot	19	6	25	Pastoralists to the SW of Lokichoggio
6	Kalobeyei	15	10	25	Pastoralists to the NE of Kakuma
8	Karebur				Pastoralists to the NE of Kakuma
	Abune	18	6	24	Pastoralists to the NW of Kakuma
12	Letia	10	15	25	Pastoralists to the NW of Kakuma
3	Kachoda	7	9	16	Pastoralists near Lokitaung
2	Kaalem	10	11	21	Pastoralists to the W of Lokitaung
11	Kaikor	10	13	23	Pastoralists to the NW of Lokitaung
25	Natoo	23	6	29	Pastoralists to the SE of Lokitaung
14	Loperot	20	5	25	Pastoralists to the NE of Lokichar
	Locher Akwan	14	9	23	Pastoralists to the SE of Lodwar
	Lotukumo	22	8	30	Pastoralists to the SE of Lodwar
17	Louwe	25	18	43	Pastoralists to the SE of Lodwar
22	Nakoret	30	18	48	Pastoralists to the SE of Lodwar
15	Loreng'elup	3	8	11	Pastoralists to the E of Lodwar
5	Kakimat	9	13	22	Pastoralists to the E of Lodwar
16	Lorugum	7	15	22	Pastoralists to the W of Lodwar
23	Namorupus	17	21	38	Pastoralists to the W of Lodwar
	Karchur	22	7	29	Pastoralists to the W of Lodwar
	Sasame	12	9	21	Pastoralists to the NW of Lokitaung
	Monti	16	11	27	Pastoralists to the W of Lodwar

Table 1: Communities Included in the Turkana Study, Organised According to Livelihood and Zone

2.3. Comparative Sample

In addition we collected phenotype information from a small group of populations within Kenya, which have different subsistence strategies and linguistic diversity. Figure 2 shows the other populations in Kenya included as comparative samples, listed in Table 2.

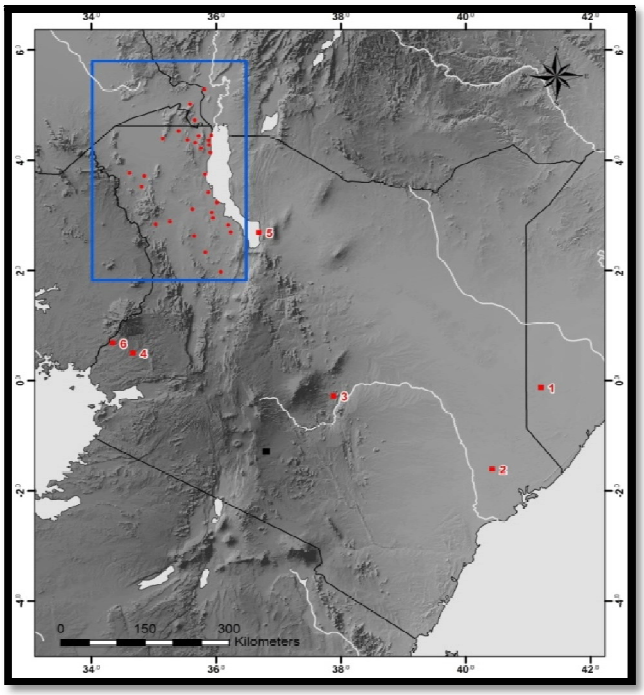

Figure 2: A Map Showing the Various Sampling Sites from Kenya with Those from the Turkana Region Enclosed in the Blue Rectangle

Background elevation data is based on GMTED2010 7.5 arcsec (by USGS & EROS).
KEY: 1-Boni/Aweer; 2-Dahalo/Sanye; 3-Tharaka; 4-Luhya; 5-El Molo; 6-Teso.

# on map (Fig 2)	Population	Sampled From	Linguistic Affiliation	Socio-Economic Activities	Samplesize
	Turkana	Turkana County	Nilo-Saharan	Pastoralism, Fishing and Agro-pastoralism	873
6	Teso	Kakapel-Busia	Nilo-Saharan	Agriculture	65
2	Dahalo (Sanye)	Witu and Kipini	Afro-Asiatic	Hunter gathering	29
1	Boni (Aweer)	Milimani-Lamu	Afro-Asiatic	Hunter gathering and Agriculture	41
5	El Molo	Loyiangalani	Afro-Asiatic	Fishing	57
4	Luhya	Bungoma	Niger-Congo (Bantu)	Agriculture	42
3	Tharaka	Chiakariga in Tharaka Nithi	Niger-Congo (Bantu)	Hunter gathering and Agriculture	21
	Total				1128

Table 2: Summary of the Populations Used in This Study

3. Results and Discussion

3.1. Family Demographic Parameters among the Turkana

In most African populations both patrilocality and polygyny are the predominant form of kinship structure (Murdoch, 1967). Kinship systems can be complex, but two basic forms of organisation form the majority of kinship structures in human societies (~60%, Murdoch & White, 1969) – matriliny and patriliny. Matrilineal societies are characterised by emphasis on kin and relatedness through the female line, so that group membership by descent is traced through mothers, rather than fathers, and it is the kin network of the women that benefit from residence norms, as well as inheritance of property and political power (Schneider & Gough, 1961; Flinn, 1981). Patrilineal societies show the opposite kinship structure, in which emphasis is on relatedness, inheritance and rights along male descent lines. Holden & Mace (2003) investigated the phylogenetic history of descent structure among Bantu- and Bantoid-speaking societies of southern and central Africa. In that study, that included 54.4% (37/68) societies that were patrilineal, 32.3% (24/68) matrilineal, with the remaining ones having either a dual descent system, or bilateral or ambilineal (10.3%), they show that patrilineality is strongly associated with Pastoralism, and argue that Bantu speakers were matrilineal prior to the introduction of domestic cattle (Holden & Mace, 2003). In fact, most if not all African Pastoralist societies are patrilineal (Aberle, 1961; Murdoch, 1967; Mesoudi, 2011).

As typical Nilotic Pastoralists, Turkana society is strongly patrilineal and they are also polygamous, although the number of wives is extremely variable. Historically, chiefs would have had a very large number of wives (the late chief Eporon had 18 wives, Marta Mirazón Lahr, *pers. comm*.), but no man interviewed in the course of this study had more than five wives (see Table3 below).

Number of wives per Turkana man	Number of men	Total number of children	Average Number of children per man	Average Number of children per woman
1	183	930	5.1	5.1
2	152	1657	10.8	5.4
3	42	760	17.5	5.8
4	10	262	26.2	6.6
5	6	138	23.0	4.6

Table 3: Distribution of Number of Wives per Turkana Men Sampled and the Corresponding Average Number of Children for Both Gendersin Additions to the Total Number of Children

The Turkana are known to practice polygyny and this is best exemplified in Table 3above, where almost half of the men sampled (183) reported being married to one wife with the remainder (210) having more than one wife. The highest number of wives reported in our current sample is 5 but we had initially met a Turkana man (now deceased) who had eighteen (18) wives.

Even though we sampled slightly more women (505) than men (422), the total number of children that was given birth to by men was relatively higher than that by women (Table 2).

Number of Females/Males	Total Number of Children
Males: 422	3981
Females: 505	2596

Table 4: The Number of Children Born of the Turkana Men and Women Sampled

In our non-Turkana sample which was made up of the Boni/Aweer, the Sanye/Dahalo, the Teso, the Tharaka, the El Molo, the Bongomek and the Luhya from Bungoma, the incidences of polygamy were most common among the Tharaka. Even though we had a very small sample of Tharaka men (10), six of them were married to more than one wife; one of which had 3 wives whereas the other five had two wives each. The Luhya from Bungoma had five men out of nineteen being polygamous with all of them having two wives each. Among the Bongomek, only one man out of fifteen was polygamous having three wives. The Boni too had two cases of polygamy out of the twenty one men sampled with one having three wives whereas the other one had two wives. Although we only had a limited sample of men from the Dahalo (seven), none of them was polygamous.

As shown in Table 5 below, the number of children that the men and women in the various populations have differs although the common trend, apart from what is seen among the Dahalo and the Boni, is that men end up having more children than women do. This as mentioned above leads to the reduction not only of the genetic diversity of the paternal lineages in the ensuing genepool but also does reduce the effective population size of the paternal lineages. The Tharaka can be a good case in point; even though the number of men (10) and women (11) sampled are almost equal, the number of children given birth to by the two genders differs significantly i.e. the eleven (11) women have forty-four (44) whereas the ten (10) men brought forth a massive ninety-three (93) children.

Population	Number of females sampled	Total number of children given birth to by the sampled females	Number of males sampled	Total number of children given birth to by the sampled males
Teso	50	289	15	89
El Molo	32	130	25	134
Luhya	23	106	19	106
Tharaka	11	44	10	93
Boni	20	111	21	97
Dahalo	22	87	7	20
Bongomek	22	85	15	72

Table 5: The Number of Children Given Birth to by the Men and Women Sampled from the Non-Turkana Populations

Two unique cases worth mentioning among the Teso from Kakapel and the Luhya from Bungoma were where some women (one in each of these sampling locations) had 'wives' and more interestingly the woman from Bungoma was polygamous- she had two 'wives'. Such cases usually occur when women get married and they cannot for some reason give birth to their 'own' children mostly because they are barren. Culturally, they are then allowed to get women to whose parents they pay bride price and then these 'wives' can have children with the barren woman's husband although the children now belong to the woman who paid the bride price.

The net result of all the cases highlighted above is that slightly fewer men seem to be siring children compared to the number of women. As much as this scenario is expected in a polygynous society, it is thought to potentially result into the reduction of the male effective population size relative to the females'. This can among other things lead to a reduction in the eventual genetic diversity of the paternal lineages within a given population since any given man is more likely to end up having more children compared to the number that any given woman can. Using the Turkana dataset, we estimate that on average one Turkana man can have close to nine (nine) children compared to five (5) children that a woman in the same population is likely to bear. This can be attributed to the widespread polygynous culture and now the current situation that is seen among the Luhya from Bungoma and the Teso where women can also have 'wives' who then bear for them children complicates matters even more.

3.2. Is There Any Relationship between Phenotypic Variation in Height and Skin Colour With Reproductive Success among the Turkana?

Several studies have shown that mate choice is influenced, among other factors, by phenotypic traits such as height, especially in the case of a man, and skin colour. We therefore set out to establish if there was a relationship between the standing height and skin pigmentation of Turkana men and the number of wives each has.

With the help of R statistical software (*R Development Core Team, 2013)*, the Pearson's product-moment correlation between the standing height of the men and the number of wives one had was determined. The Pearson's product-moment correlation coefficient obtained was -0.0745. This implies the presence of a very weak negative correlation between these two factors i.e. the number of wives that a Turkana man might marry based on his height.

Another interesting finding especially from populations studied in the developed world has been that the parental height tends to impact on the mortality of the children that one gives birth to. We then set out to test if there was any correlation whatsoever between the number of children that a parent (both male and female) has and the height of the parents. It has been argued that a positive correlation between these two factors exists and thus could explain the apparent increase in the global average height of the modern human population. Our findings from the Turkana indicate

the presence of very weak negative correlation coefficients both for males and females, -0.004 and -0.008, respectively with respect to the number of children.

Populations known to be generally short i.e. the pygmy and other hunter-gatherer groups e.g. the Khoisan are associated with averagely fairer skin pigmentation (Weiner *et al.,* 1964; Martin *et al.,* 2014). This was the basis upon which we set out to test if there was any association between the height and Melanin index among the Turkana or not. First, we considered the entire Turkana population sample together, irrespective of their gender, and the Pearson's product-moment correlation coefficient that we obtained, using the R Statistical software (*R Development Core Team, 2013)*, was -0.118. This suggests the presence again of a weak negative correlation between the standing height and the Melanin index among the Turkana. The same comparison of standing height *versus* Melanin index was again done in the Turkana men and women separately. Among the women, the Pearson's product-moment correlation coefficient obtained was -0.077. This as well shows how weak the negative correlation that exists between the standing height and the Melanin index among the Turkana women is. A similar test among the Turkana men too did reveal a very weak negative Pearson's product-moment correlation coefficient, -0.075.

3.3. Why the Negative Correlation between the Height and Skin Colour with the Reproductive Success?

Height has been shown to correlate with many achievements in one's life for example the number of children and even the probability of getting a life partner among others (Higgins *et al.,* 2002; Nettle, 2002; Pawlowski and Koziel, 2002; Sear, 2006; Stulp *et al.,* 2015). Since most of these studies have been done in post-industrial societies, there have been questions surrounding the global replicability of their findings. Among the Hadza for example, the significance of size i.e. height and weight towards mate choice has been downplayed but it has been shown instead that the man's foraging ability and intelligence are highly valued by the Hadza women while the Hadza men on the other hand rate fertility and hard work very highly among the women even more than looks (Marlowe, 2004; Sear and Marlowe, 2009). Research on how one's height affects his or her reproductive success has not been reported so far in any Kenyan population and thus assessing how the height of the Turkana varies with both the number of wives (in the case of the men) and children (in the case of both men and women) would help provide vital indications towards this end.

The negative weak correlation that was reported between the height of the Turkana men both with the number of wives and children they have is a possible indicator that indeed it (height) might not be a measure of the reproductive success among men within this population. Being a population that is heavily reliant on pastoralism for subsistence, I argue that the 'success' of a man and thus his attractiveness as a marriage partner is most likely to be judged on the basis of the size of the animal herd that he owns which indirectly signifies his ability to provide for his family rather than on the size of the man himself. Although it can be argued that the man's size might translate into his ability to protect his family from external aggression and thus making stronger men more attractive especially in a population that has raiding as part of its tradition. However, we are of the opinion that since most of the raiding is presently done while armed with guns, fighting sticks and even knives it is possible that how successful one can be in a raid is determined more by the skills employed and not necessarily the actual participant's body size.

Based on our data, Turkana men on average have more children than the women do; an observation which might be expected in a society practising polygyny. For a man to have more children especially within such a polygynous society he in a way is expected to have married more wives to begin with. This then means that it is a wealthy man who has 'enough' animals (to be able to pay the significant amount of bride-wealth in form of livestock and still remain with enough to enable him provide for the family) that is likely to end up having more wives and thence more children too by extension. This again emphasizes that it is not the size of the man *per se* that influences his reproductive success (i.e. marrying more wives and eventually bearing more children) but rather it is the size of his flock that potentially plays a critical role in this. This supposition derives more support from the fact that on average, Turkana men delay marriage until in their mid-thirties since most of them do not have 'enough' animals to cater for the dowry requirements during their earlier ages (Dyson-Hudson and Meekers, 1996). Among the Nyangatom, a pastoralist community that is closely related to the Turkana inhabiting a remote region along the southern border of Ethiopia and South Sudan, the raiding potential of a man eventually translates into increased reproductive success i.e. having more wives and children (Glowacki and Wrangham, 2015). This plausibly results from the man cumulatively benefiting from the animals captured during the raids he participated in and which in most cases might not come immediately but later on in life. The influence of the flock size to the children's upbringing can as well not be underestimated since it is on the abundance of the livestock products (especially milk) in a family setting, which is directly proportional to the number of animals one has, that the nourishment of the entire family and especially that of the children relies. In previous studies among Turkana children, those from nomadic families have been reported as being healthier than their counterparts in settled farming families although this situation seems to change post-weaning. The plenty of protein intake from the animals' milk that benefits the children in nomadic families was suggested as the reason for the health disparity with the post-weaning changes that happen in their growth pattern thought to emanate from the state of constant food supply associated with the farming families coupled with the institutional food support like the school feeding programs which most settled children attend compared to those in nomadic families (Little and Gray, 1990; Campbell *et al.,* 1999).

The relationship between the women height and their reproductive success has been established (Sear, 2006) with indications that taller women tend to have more of their children surviving. However, for the case of the Turkana we found a weak negative correlation between these two variables i.e. the height of the Turkana women and the number of children that they (Turkana women) have; this could serve to bolster the suggestion that the human reproductive behaviour might be affected by the environment that they dwell in. In a typical case of the 'male-taller norm' for the case of

marriage partners, Chu and Geary (2005) found that shorter women were more preferred as marriage partners than taller ones thus conferring to them (shorter women) higher reproductive success in return. Although it is possible that the weak negative correlation could be indicative of the existence of such a preference for shorter women by the Turkana men hence increasing their reproductive success in return, we however recommend more research especially to gather information on what exactly the Turkana consider when choosing their spouses and why.

The evident phenotypic differences among the Turkana reflect the possible assimilation of various other non-Turkana people (Dundas, 1910; Gulliver, 1951). Since the Turkana, like many other African pastoralist communities, are generally taken to be a tall people, majority of the short persons within the Turkana populace might be a representative of the stock brought in *via* assimilations. If at all this assumption is true, then the negative correlation, that we report in our data, between the height of the Turkana women and the number of children that they bear could potentially signal the effect of varied genetic origins of these women. The tall ones possibly representing the women from the original Turkana stock population could have the lower fertility levels that are generally associated with pastoralist populations while the higher number of children that the shorter ones tend to have could be courtesy of their disparate source from non-pastoralist populations and hence higher fertility levels.

3.4. Does Culture Affect The Diversity of Uniparental Markers?

Most studies have indicated that the patrilocal nature of many marriages could explain the high levels of matrilineal diversity relative to the observed patrilineal diversity (Seielstad *et al.,* 1998; Lippold *et al.,* 2014). However, other researchers have suggested the possible role played by polygyny not only in the reduction of patrilineal diversity levels but also in lowering the male effective population sizes (Barbieri *et al.,* 2015). Interestingly, the majority of African human populations are not only patrilocal but also polygynous with the hunter gatherers being the only probable exception since they practice uxorilocality (Walker *et al.,* 2011).

In our current study, the effect of polygyny is clear with most men bearing more children compared to their female counterparts; in our dataset the men from Turkana and Tharaka, for example, had almost twice as many children compared to females within the same populations. Given the patrilocal nature of most marriages in this region, we submit that although the perennial relocation of wives into their husband's homes after marriage might result in increased matrilineal heterogeneity, the possible effect that polygyny has not only on the diversity of the population but also the effective population size of the paternal lineages should not be under-estimated.

According to the polygyny threshold model, polygynous mating is costly to females and thus for it to thrive they (females) must get superior territories and or males (Orians, 1969; Pribil, 2000). Among the costs that secondary females (i.e. those that choose already mated males) pay include getting less help from these males in raising the young ones compared to the monogamous ones (Orians 1969; Ptak and Lachmann 2003). This in a way lessens the reproductive success of these secondary females compared to other monogamous and primary females. Among the among the Turkana, as seen from Table 4, the highest number of wives that a man can have and still be able to provide for the polygynous marriage without adversely affecting the reproductive success of his wives is apparently four (4).

3.5. Acknowledgements

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