Original Research Article

Genetic Parameters for Growth Traits of Malya Goats and Heterosis from Crossbreds of Malya and Sukuma Goats

.**ABSTRACT**

The study estimated heterosis of growth traits from crossbred progeny of MalyaxSukuma goats and heritability, genetic correlation and phenotypic correlation for growth traits of Malya goats in Maswa, Tanzania. The objective was to explore strategies for crossbreeding Malya goats with the Sukuma goats. Growth performance data recorded during the implementation of a crossbreeding project for parent breeds and crossbred off-springs were used to estimate the parameters. Positive heterosis was observed for birth weight (8.19%), yearling weight (9.59%), post-weaning growth rate (19.26%) and birth to yearling growth rate (9.62%), while negative heterosis was found for weaning weight (-10.92%), 32-weeks weight (-6.66%) and pre-weaning growth rate (-9.50%). Heritability estimates from sire variance components were 0.43±0.040 for birth weight, 0.23±0.028 for weaning weight, 0.11±0.020 for 32 weeks weight, 0.18±0.025 for yearling weight, 0.18±0.025 for pre-weaning growth rate,0.17±0.024 for post-weaning growth rate and 0.17±0.024 for birth to yearling growth rate. Genetic correlations between body weights ranged from 0.17±0.062 to 0.49±0.055, while the corresponding phenotypic correlations ranged from 0.10 to 0.61. Genetic correlations between growth rates for the different stages ranged from 0.39 to 0.90, whereas the phenotypic correlations ranged from -0.38 to 0.89. Genetic and phenotypic correlations (-0.39±0.058 and -0.38, respectively) between pre-weaning growth rate and post-weaning growth rate were negative. Genetic and phenotypic correlations between body weights at different ages, pre-weaning growth rate and birth to yearling growth rate, and post-weaning growth rate and birth to yearling growth rate were all positive. In conclusion, heterosis results showed that, birth weight, yearling weight and post-weaning growth traits benefited from the crossbreeding program. Heritability results showed birth weight and weaning weight were considerably controlled by additive genes and thus, in inferiorly performing breeds the traits can potentially be improved by breeding. Correlations among growth traits indicated promising correlated responses to selection.

Keywords: Heritability, correlation, heterosis, body weight, growth rate

1. INTRODUCTION

Malya goat, which is also known as Blended goat is a dual-purpose goat breed which was developed in Tanzania during the second half of the 20th Century [1]. It was developed as a composite breed by crossing three breeds namely Kamorai, Boer and the indigenous Small East African (SEA) goat [2]. It has a large body size of the Kamorai, high twinning rate, fast growth rate and good carcass quality of the Boer goats from South Africa, and sound adaptation to the semi-arid tropical climate of the indigenous SEA [3,4]. It was developed as an alternative breed to the indigenous SEA goats, which generally have low genetic potential for growth and mature body size. As it is well known, goats constitute an important tool for poverty alleviation in rural areas of the developing world [5]. Goats are preferred from their high reproductive prolificacy (i.e. twinning ability and short gestation period) and small size, which make them easily disposable compared to large ruminants.

Despite having beneficial characteristics to the goat keepers, there is limited information on Malya goats regarding genetic parameters particularly heritability, genetic and phenotypic correlations, and heterosis among crossbred progenies of Malya goats and other indigenous goats. Genetic parameters are important because genetic improvement is largely dependent on the heritability of the trait and its genetic relationship with other traits of economic importance, upon which some selection pressure may be applied. Information on heritability is essential for planning efficient breeding programs, and for predicting response to selection [6]. Genetic correlation measures the association between an animal's genetic value for one trait and the same animal's genetic value for another trait. Phenotypic correlation, on the other hand, is the association between records of two traits on the same animal measured at different times. Genetic correlation between different traits is important in indirect selection to estimate correlated response to selection, while phenotypic correlation can be used to predict full records from partial records or lifetime performance from early life records.

This paper presents heterosis estimated from crossbred (MalyaxSukuma) goats. In addition, it presents estimates of genetic parameters i.e. heritability, genetic and phenotypic correlations for body weights at various stages of growth from birth to fifty-two weeks of age and growth rate traits for Malya goats. The parameters are envisaged to consolidate a base for planning genetic improvement of the SEA goats for growth performance by crossbreeding with Malya goats.

2. MATERIAL AND METHODS

2.1 Description of the study area

The study was undertaken in Maswa District of Tanzania located in the Lake zone area. The district is one of the five districts of Simiyu Region. The district is at an altitude of 1,250 m above sea level and lies between Latitude 2.75˚S and 3.25˚S, and Longitude 33˚E and 34˚E [7]. Maswa District has a land area size of 3,398 km^2 of which 2,475 km^2 are under farming activities [7]. The district has an average temperature of 22.1°C and receives an annual average rainfall of 878.8 mm, raining from October to April (Figure 1). Agro-ecologically, Maswa is a semi-arid area of steppes with thorny species. Rangelands are extensive comprising widely spread seasonal grasses and bushes. Trees are mainly of thorny *Acacia* species. Two villages namely Senani and Mwabayanda, were selected purposively because have large number of goats and were sites of a MalyaxSukuma goat crossbreeding program which was implemented from 2008 to 2011 by Tanzania Livestock Research Institute (TALIRI)- Mabuki. The villages have the same type of land terrain and vegetation type, where the land is covered by grass and shrubs.

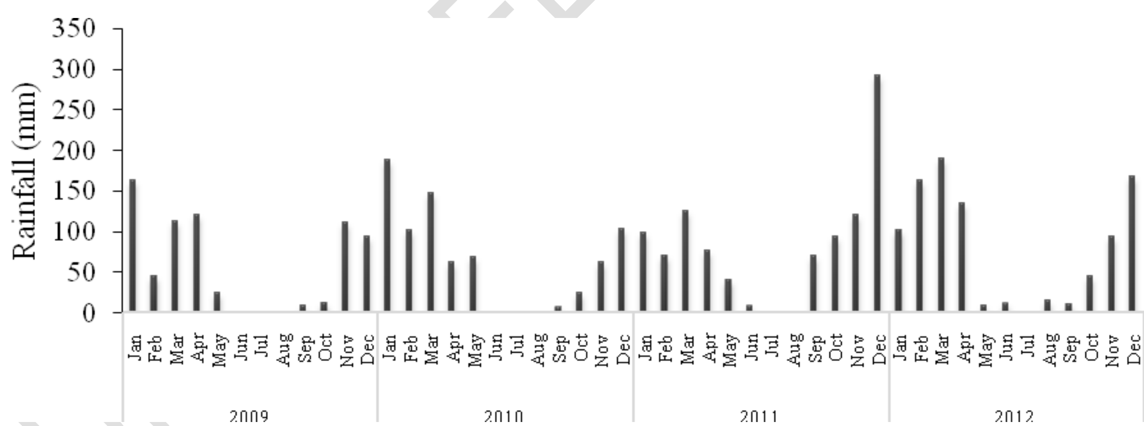

Figure 1: Histogram for rainfall pattern between years 2009 and 2012

2.2 Study animals

The study animals were Malya goats (Figure 2) and Sukuma goats (Figure 3). As was indicated previously, Malya goats is a composite breed considered to have potential for use as a germplasm for improving growth performance of dwarf goat breeds like SEA goats [2].

Figure 2: Malya goats

Malya goats are well known to have superiority over SEA goats in terms of mature size and twinning rate but have almost the same capability for tolerance of environmental and managerial stress commonly encountered in low input goat rearing systems [2]. In this trial, improvement of one SEA strain namely Sukuma through crossbreeding with Malya was piloted.

Figure 3: Sukuma goats

2.3 Data Collection

This study used secondary data which were collected under a community-based cross-breeding project to improve the performance of Sukuma goats using Malya goat bucks. Project document indicated that all goats were managed uniformly under an extensive system throughout the breeding project implementation. The goats were released for free grazing on natural vegetation within each household's farmland each day from around 10:00 hrs in the morning to around 17:00 hrs in the evening. Standard housing in roofed houses was provided as night shelters at each household. No supplementary feeds were provided to these animals but they were routinely sprayed and de-wormed for ecto-parasite and endo-parasite control, respectively.

For each village, 3 progressive farmers who were nominated by the participating farmers' groups in respective villages were trained on group dynamics, basic goat husbandry practices and basic animal health, so as to provide services as paravets to participating members with easy reach and at affordable cost. The paravet-farmers were charged with the responsibility to guide the management and mating of goats in all involved flocks and also recording data. They were meant to supplement technical services of the local livestock extension staff. All bucks which were not intended for mating in the involved flocks were castrated. Malya goat's (dams and bucks) were then distributed to farmers in both of the study villages, where some farmers were selected to act as control by continuing to use Sukuma bucks for siring does. The distributed bucks were shared among participating farmers in the study villages. Growth data were collected from 255 kids which were produced from 11 sires and 160 dams along three mating pathways (Figure 4): Malya - Malya which produced pure Malya, Sukuma - Sukuma which produced pure Sukuma (control), and Malya - Sukuma which produced crossbreds (Malya x Sukuma). All the three pathways were implemented in both of the study villages. Primary data which were recorded were birth weight, weaning weight (at 16 weeks), weight at 32 weeks and yearling weight. These were used to estimate pre-weaning growth rate, post-weaning growth rate and birth to yearling growth rate. The variables were recorded during the wet and dry seasons, from the year 2010 to the year 2011. Data were classified according to breed, sex, season, year, type of birth and dam weight. Then performance means for the growth traits of each genetic group (Malya, Sukuma and F1 crossbreds) were computed.

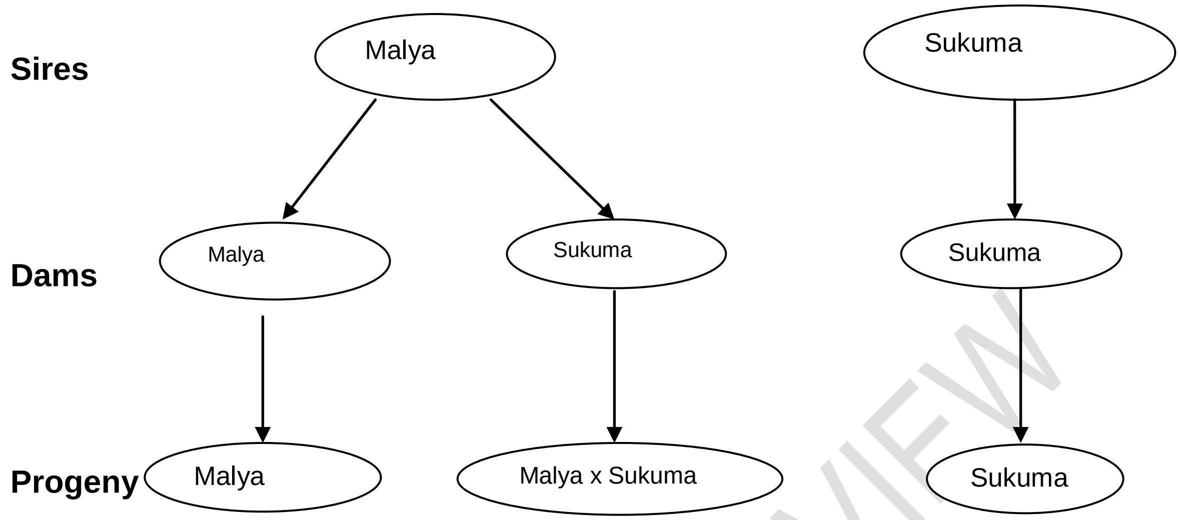

Figure 4: Schematic presentation of the mating plan that was used in

2.4 Data analysis

Calculation of heterosis

Heterosis was expressed both by the trait unit and as percentage for birth weight, weaning weight, 32 weeks weight, yearling weight, pre weaning growth rate, post weaning growth rate and birth to yearling growth rate. The F1 were not represented by reciprocal crosses but by Malya bucks x Sukuma does. Heterosis was calculated using formula expressed in Equation 1[8].

$$Heterosis = [(F1\ mean - \left(\frac{Malya + Sukuma}{2}\right))/(Malya + Sukuma)/2] * 100 \ldots..(1)$$

Calculation of heritability (h^2)

Data from offspring and their parents were used to estimate heritability (h^2) for weights at birth, weaning (16 weeks), 32 weeks and yearling and for growth rates from birth to weaning, weaning to yearling and birth to yearling. Initially, the variance components for calculating heritability were estimated using Restricted Maximum-Likelihood (REML) method from VARCOMP procedures [9]. The linear model that was used is expressed in equation 2.

$$Z_{ijklmno} = \mu + T_i + Y_j + C_k + B_l + S_m + D_{mn} + \varepsilon_{ijklmno} \ldots \ldots \ldots \ldots..(2)$$

where:

$Z_{ijklmno}$ =record of oth individual from ith season of birth, jth year of birth, kth sex, lth birth type and nth dam mated to mth sire

μ = General mean;
T_i = Fixed effect of i^{th} season of birth
Y_j = Fixed effect of j^{th} year of birth
C_k = Fixed effect of k^{th} sex
B_l = Fixed effect of l^{th} birth type
S_m = Random effect of m^{th} sire
D_{mn} = Random effect of n^{th} dam mated to m^{th} sire
$\varepsilon_{ijklmno}$= Random effect peculiar to each individual (N,O,σ^2)

Then, heritability was estimated from sire variance components according to [10] as shown in equation 3 and their standard errors were approximated according to [11].

$$Heritability = \left(\frac{\delta^2 s}{\delta^2 s + \delta^2 d + \delta^2 w}\right) \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where:
$\delta^2 s$ = Sire variance component
$\delta^2 d$ = Dam variance component
$\delta^2 w$ = Error variance component

Calculation of Correlations

Genetic and phenotypic correlations between the growth traits were calculated from variance and covariance components. The variance components were estimated using the REML method of the VARCOMP procedures of [9] by using model in equation 4. Covariance components of two traits (a and b) were calculated by using the formula expressed in equation 4.

$$\text{cov}_{ab} = \frac{\text{var}_{a+b} - \text{var}_a - \text{var}_b}{2} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where:
var_{a+b} = Variance of the sums of the two individual traits
var_a = Variance of trait a
var_b = Variance of trait b

Genetic correlation (r_g) of growth traits at different ages were estimated from variance and covariance components using formulae expressed in equations 5 as described by [10].

$$r_g = \delta^2 Sxy / \sqrt{\delta^2 Sxx * \delta^2 Syy} \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where:
$\delta^2 Sxy$ = Sire covariance of traits x and y

$\delta^2 Sxx$ = Sire variance of trait x
$\delta^2 Syy$ = Sire variance of trait y

Phenotypic correlation (r_p) of growth traits at different ages were estimated from variance and covariance components using formulae expressed in equations 6 as described by [10].

$$r_p = \delta^2 Pxy / \sqrt{\delta^2 Sxx * \delta^2 Syy} \quad \ldots\ldots(6)$$

where:
$\delta^2 Pxy$ = Phenotypic covariance of traits x and y
$\delta^2 Pxx$ = Phenotypic variance of trait x
$\delta^2 Pyy$ = Phenotypic variance of trait y

3. RESULTS

3.1 Heterosis for growth traits in MalyaxSukuma goats

Heterosis estimates for birth weight, weaning weight, weight at 32 weeks, weight at 52 weeks of age, pre-weaning growth rate, post-weaning growth rate and growth from birth to yearling were as shown in Table 1. There were positive heterosis for birth weight (8.19%), yearling weight (9.59%), post-weaning growth rate (19.26%) and growth rate from birth to yearling (9.62%). Negative heterosis estimates were observed for weaning weight (-10.92%), weight at 32 weeks of age (-6.66%) and pre-weaning growth rate (-9.50%).

Table 1. Heterosis estimates for growth traits of MalyaxSukuma crossbred goats

Trait	Heterosis estimate (%)
Birth weight	8.19%
Weight at weaning age (16 weeks)	-10.92%
Weight at 32 weeks age	-6.66%
Yearling weight	9.59%
Pre-weaning growth rate (Birth to weaning)	-9.50%
Post-weaning growth rate (Weaning to Yearling)	19.26%
Growth rate from birth to yearling	9.62%

3.2 Heritability for growth traits in Malya goats

Heritability estimates for investigated body weights and growth rates were as presented in Table 2. For body weights, the heritability estimates varied from low (0.11±0.020) to moderate (0.43±0.040). Moderate heritability was shown by birth weight and weaning weight which were estimated at 0.43±0.040 and 0.23±0.028, respectively. Low heritability estimates among growth traits were found in weight at 32 weeks (0.11±0.020) and yearling weight (0.18±0.025). All Growth rates i.e. pre-weaning, post weaning and birth to yearling growth rates had low heritability values, which were 0.18±0.025, 0.17±0.024 and 0.17±0.024, respectively.

Table 2. Heritability estimates for growth traits in Malya goats

Traits	**Heritability value**
Birth weight	0.43±0.040
Weight at weaning age (16 weeks)	0.23±0.028
Weight at 32 weeks age	0.11±0.020
Yearling weight	0.18±0.025
Pre-weaning growth rate (Birth to weaning)	0.18±0.025
Post-weaning growth rate (Weaning to Yearling)	0.17±0.024
Growth rate from birth to yearling	0.17±0.024

3.3 Correlations among growth traits in Malya goats

Results on genetic and phenotypic correlations for the studied growth traits were as summarized in Tables 3 and 4, respectively. Generally, both genetic and phenotypic correlations between the weights at different ages were positive and ranged from low to moderate. The values of genetic correlations between birth weight and weaning weight, birth weight and weight at 32 weeks of age, weaning weight and weight at 32 weeks of age, and weight at 32 weeks of age and weight at 52 weeks of age were 0.48±0.055, 0.43±0.057, 0.49±0.055 and 0.44±0.056, respectively. The corresponding values for phenotypic correlations ranged from 0.10 for birth weight and weaning weight to 0.61 for 32 weeks' weight and 52 weeks weight.

Table 3. Estimates for genetic (below diagonal) and phenotypic (above diagonal) correlation between growth traits (weights) in Malya goats

Traits	Birth weight	Weaning weight	32 weeks weight	52 weeks weight
Birth weight	-	0.10	0.17	0.14
Weight at weaning age (16 weeks)	0.48±0.055	-	0.37	0.11
Weight at 32 weeks age	0.43±0.057	0.49±0.055	-	0.61
Weight at 52 weeks age	0.32±0.060	0.17±0.062	0.44±0.056	-

There were negative genetic and phenotypic correlations between pre-weaning growth rate and post-weaning growth rate (-0.39±0.058 and -0.38, respectively). Respective genetic correlations between post-weaning and birth to yearling growth rate, and between pre-weaning growth rate and birth to yearling growth rate were 0.90±0.027 and 0.14±0.062. The corresponding phenotypic correlations between the parameters were 0.89 and 0.09, respectively.

Table 4. Estimates of genetic (below diagonal) and phenotypic (above diagonal) correlation between growth traits (growth rate) in Malya goats

Traits	Pre-weaning growth rate	Post-weaning growth rate	Birth to yearling growth rate
Pre-weaning growth rate	-	-0.38	0.09
Post-weaning growth rate	-0.39±0.058	-	0.89
Birth to yearling growth rate	0.14±0.062	0.90±0.027	-

4. DISCUSSION

The positive estimates of heterosis for birth weight, yearling weight, post-weaning and birth to yearling growth rate and negative estimates of heterosis for weaning weight, 32 weeks weight and pre-weaning growth rates found in this study are similar to those reported by [12] for crossbred kids between SEA goats and improved breed of goats. The work reported positive heterosis estimates for birth weight and yearling weight, and negative heterosis estimates for weaning weight and pre-weaning growth rate in crossbred kids between SEA goats and improved breeds (Toggenburg, Anglo-Nubia and Galla). Heterosis estimate for birth weight was lower compared to 10.6%, 17.1%, 15.3% and 23.1% heterosis for birth weight of crossbreds of Nubia, Saanen, Toggenburg and Alpine sires with local goat does from Northern Mexico, respectively [13] and lower to 46.67% heterosis estimate of crossbred kids of Boer and PE goat [14]. Heterosis values observed in this study are also lower than those estimated for birth weight, weaning weight and pre-weaning growth rate in crossbred kids between Aradi Saudi goats and Syrian Damascus goats which ranged from 7.8% to 14.5% [15]. Heterosis estimates for weaning weight (6.28%) and (5.66%) in crossbreds of Boer and Kiko goats and in crossbred of Boer and Spanish goats, respectively, were higher than those observed in this study [16]. In addition, the obtained heterosis values for birth weight and weaning weight were lower than heterosis values of crosses between two indigenous Moroccan breeds reported by [17]. The reason for lower estimates of heterosis in this study might be due to loss of co-adaptive gene combinations in the crossbreds between different breeds, or due to environmental conditions where the animals were reared as explained by [12]. Another reason for negative heterosis in pre-weaning growth rate can be explained by the permanent maternal environmental and genetic effects. Dam weight and size affect the amount of milk available for a kid, which in turn affects kids' growth rates. This is likely to hold also in this case because Sukuma dams, which were the mothers for the crossbred goats had small body size and are low milk yielders.

Heritability estimates for growth traits in this study ranged widely. For those traits with low heritability estimates, this indicated that, environmental factors played a significant role in the performance of goats in the study area. The moderate estimates of heritability suggest that additive gene action was moderate for individual selection and that crossbreeding would improve birth weight and weaning weight. For the remaining traits, the results suggest that, improvement of environment in terms of feeding and diseases control will help to improve goats' performance. The heritability estimate recorded for birth weight was higher than 0.15 which was reported by [2] for the same breed. The value was also higher than 0.05 reported by [5] for Black Bengal goats, higher than 0.13 reported by [12] for Kenya Dual Purpose goats, little higher than 0.32 reported by [18] for Jamunapari goats and higher than 0.15 reported by [19] for Ardi goats. However, current heritability for birth weight is comparable to 0.42, 0.43, 0.44, 0.47 and 0.41 reported by [20] for Crossbred goats [21] for Boer goats, [22] for local goats raised for meat in Thailand, [23] for indigenous Nigerian goats, and [19] for Damascus goats, respectively. The heritability estimates for weaning weight obtained in the current study was moderate. The value is comparable to 0.22 estimated for Boer goats, 0.28 estimated for Black Bengal goats and 0.26 estimated for Ardi goats by [24], [5] and [19], respectively. The current estimate is higher than 0.16 estimated by [12] for Kenya Dual Purpose goats, 0.18 estimated by [25] for Toggenburg goats in Kenya, 0.04 observed by [23] for indigenous Nigeria goats, 0.18 shown by [26] for Adani goats and 0.06 observed by [27] for Sudan desert goats. However, it was also lower than 0.4 estimated for SEA goats by [11], 0.04 estimated by [28] for Sudanese Nubian goats and 0.35 estimated by [19] for Damascus goats. Weight at 32 weeks of age, yearling weight, pre-weaning growth rate, post-weaning growth rate and birth to yearling growth rate were generally poorly heritable. The obtained values fall within the range of 0.10 to 0.15 for post-weaning weight and growth rate of Malya goats reported by [2]. However, heritability for yearling weight observed in this study was similar to 0.18 for Black Bengal goats [5], but lower than 0.44 for SEA goats and 0.33 for Nigeria crossbreed goats reported by [11] and [29], respectively. Estimated values of heritability for growth rate in this study were within the range of 0.03 to 0.39 for local goats of Nigeria observed by [23] and within range of 0.23 to 0.35 for Jamunapari goats [18]. Currently estimated values for growth rate were also below the range of 0.22 to 0.59 reported for Sudanese Nubian goats by [28]. Therefore, there was reasonable conformity between results of the current and past goat studies. Encountered differences may be due to the fact that heritability varies between breeds, places, sample size and method of estimation.

Genetic correlations between body weights at different ages were positive and moderate. They were lower than those reported by [30] for Hainan Black goats of southern China, which ranged from 0.35 to 0.91. But they fell within the range (from 0.29 to 0.61) of genetic correlations between body weights reported for Teddy goats by [31]. According to [32] and [33], genetic correlation between birth weight and weaning weight in Naeini goats and Boer x Central Highland goats of Ethiopia was higher (0.61 and 0.60) respectively than the corresponding genetic correlation in this study. However, [34] found a similar (r_g=0.45) genetic correlation between birth weight and weaning weight in Emirati goats as the one found in this study. The moderate positive genetic correlation between these weights indicates that the traits are somehow influenced by same genes and that selection for higher birth weight will result in higher weaning weight as a correlated response. Phenotypic correlations between weights at different ages estimated in this study are also within the range from 0.12 to 0.72 reported by [35] for Arsi-Bale goats of Ethiopia, but lower than that reported by [36] for Teddy goats, which ranged from 0.52 to 0.65. Phenotypic correlations between birth and yearling weights and that of 32 weeks weights and yearling weights found in the study were comparable to the respective values of 0.12 and 0.62 estimated for Markhoz goats by [37].

The genetic and phenotypic correlations between the studied growth rates at different stages of growth showed positive and negative values. Similarly, [23] and [38] found positive and negative genetic and phenotypic correlations between pre-weaning and post-weaning growth rates for Nigerian indigenous goats. However, the estimated genetic correlation between pre-weaning and post-weaning growth rate in the current study is lower than 0.73 reported by [28] for Sudanese Nubian goat breed. Negative genetic correlation between pre-weaning growth rate and post-weaning growth rate is an indication that, a faster pre-weaning growth rate which might be due to maternal influence tended to be followed by a slower post-weaning growth. This implies that, the advantage of maternal influence on kids decreases as age advances and hence after weaning growth rate was low. This might be due to high weaning stress for fast growers during pre-weaning stage and compensatory growth for slow pre-weaning growers. Positive genetic correlations between birth to yearling growth rate and post-weaning growth rate indicates that fast growing kids after weaning contributed much to the higher birth to yearling growth rate because the latter period is longer than the former. Thus, selection for post-weaning growth rate would have a positive impact on birth to yearling growth rate.

5. CONCLUSION

In conclusion, birth weight, yearling weight and post-weaning growth rate, which showed positive heterosis, benefited from crossbreeding program involving Malya sires and Sukuma does. Negative heterosis manifested in weaning weight and pre-weaning growth rate were due to poor maternal influence of Sukuma does, which supplied low milk for crossbred kids, and thereby lowered weaning weight and pre-weaning growth rate compared to their genetic potential. Malya goats displayed moderate heritability for birth weight and weaning weight. This implied that, any crossbreeding program that will involve Malya goats with an inferiorly performing breed will result into improvement of birth and weaning weight. Heritability estimates for other growth traits were low thus indicating the need for manipulation of environmental factors to improve performance of those traits. Genetic correlations among growth traits were moderate to high indicating that selection for the traits will lead to realization of favourable correlated responses. For traits which displayed negative genetic correlation, it is recommended to improve them from management manipulation side.

ETHICAL APPROVAL

This study was approved by the Research Ethical Committee of Sokoine University of Agriculture.

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