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Effect of genetic and non-genetic factors on growth and reproduction performance of Black Head Persian and Red Masai Sheep in Tanzania

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Abstract
The aim of this study was to evaluate the effect of genetic and environmental factors on growth and reproduction performance of Red Masai (RM) and Black Head Persian (BHP) sheep in Tanzania. Data on weights at birth, weaning, 32, 48 and 72 weeks of age were analysed using Generalized Linear Models procedure of SAS. Breed, birth type, year, season and sex significantly (P<0.05) affected growth performance at all ages. BHP was superior to RM in all growth parameters and lambing interval (270 vs 275 days), while RM was superior to BHP in fertility rate (72 vs 70.8%), conception rate (72.9 vs 71.5%), age at first lambing (553 vs 620 days), litter size (1.03 vs 1.02) and low mortality rate (28.7 vs 35.8%) respectively. It was suggested to correct records for environmental factors before comparing lambs for selection. RM could be comparable to BHP on production for international markets

Keywords: BHP, RM, Growth performance, reproduction, sex, birth type

1. Introduction

A well planned sheep improvement programme is an important aspect for increasing and sustaining the productivity of any sheep flock (Rashid *et al.*, 2008) [15]. A successful sheep genetic improvement can be achieved only when there is a good understanding of the sheep environment and genetic information (Baker and Gray, 2004) [2]. It has been assumed that poor growth and reproduction performance of sheep in Tanzania could be the cause of low contribution of the sheep sub sector to the country's economy (Tungu *et al.*, 2016) [20]. This is because these factors are important indicators of flock productivity (Berhanu and Haile, 2009)[3]. Fast growth rate allows the sheep to reach breeding age early and therefore allows the animals to produce more lambs in their lifetime (Berhanu and Haile, 2009) [3]. This allows animals reaching market weight early and therefore quicker income to the farmer. Furthermore if one wants to produce more mutton, there should be more animals for slaughter. However, few studies have been conducted on factors affecting the growth and reproduction in most of the Tanzanian sheep farms. In Tanzania scanty information on genetic and non-genetic factors affecting growth and reproduction performance of BHP and RM has been documented. This study was therefore conducted to compare the effects of genetic and non-genetic factors contemporarily on BHP and RM breeds. This is due to the fact that if one wants to produce more mutton, there should be more animals for slaughter.

2. Materials and methods

The experiment was conducted at TALIRI West Kilimanjaro located at latitude 3^{o} south and longitude 37^{o} east. According to TALIRI (2014) [19], the area has an annual rainfall ranging between 450 – 750 mm, which occurs in two seasons; i.e. long rains occurring during late March to May and short rains during November to December (Figure 1). Desiccating winds blow during the dry season with wind speed reaching up to 25 km/hr which result into higher evaporation rates. Temperatures lie between 12 – 28 ^{o}C. Dominant soils are dark brown and silt loam without any major soil nutrient deficiency. The sheep flock used in this study involved the Blackhead Persian (BHP) as an improved breed and the Red Masai as a breed indigenous to Tanzania, which were collected from farmers and managed under on-station condition.

Both breeds are a genetic pool being conserved and closely monitored under Tanzanian Farm Animal Genetic Resources Program (FAnGRP). Feeding was based on pasture grazing mainly dominated by *Cenchrus ciliaris, Chloris gayana* and *Panicum maximum* as established pasture species and *Themeda triandra, Eragrostis rizidion, Hyparrhenia rufa, Bothriochloa insculpta* and *Aristida spp*. as natural pastures.

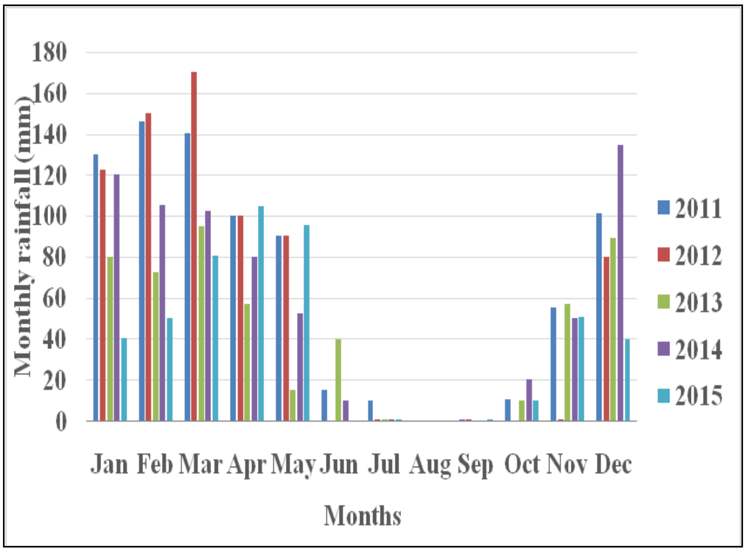

Fig 1: West Kilimanjaro monthly rainfall pattern from 2011 to 2015

The recommended disease control, feeding and other husbandry practices were maintained during the study period. Upon lambing, lambs were monitored for their growth through a planned weighings at birth (Bwt), weaning at 120 days (Wwt), then at 32 (32wwt), 48 (48wwt) and 72 weeks (72wwt) of age. Mortality status up to 72 weeks of age from year 2011 to 2015 was monitored and recorded.

Collected growth data were fitted for analysis using the following model:
Yijklm = μ + Bi + Sji + Tki + Yl + Xm + eijklm;

Where Yijklm = weight of individual lamb.
μ = Overall mean
Bi = Fixed effect of i^{th} breed within season (i: 1=BHP, 2=RM)
Sji = Fixed effect of the j^{th} sex of lamb within breed (j: 1=male, 2=female)
Tki = Fixed effect of k^{th} birth type of lamb within breed (k: 1=single, 2=twins)
Yl = Fixed effect of the l^{th} year of birth (l: 1=2012, 2=2013, and 3=2014)
Xm = Fixed effect of the m^{th} season between breeds (m: 1=wet, 2=dry)
eijklm = Random error.
Weaning weight at 120 days and subsequent weights at 32, 48 and 72 weeks were adjusted for age before analysis because lambs were measured in groups of the same mating season. Adjustments were done using formulae (1) to (4).

$$AWw = \frac{Act.\ Ww - BW}{Act.\ Wa} \times 120 + BW \quad (1)$$

Where: AWw = Adjusted weaning weight (kg)
BW = Birth weight
Act. Ww = Actual weaning weight (kg)
Act. Wa = Actual weaning age (days)

$$AW_{32} = \frac{Act.\ W_{32} - AWw}{Act.\ Am_{32}} \times 104 + AWw \quad (2)$$

Where: AW_{32} = Adjusted weight at 32 weeks (kg)
Act. W_{32} = Actual weight at 32 weeks (kg)
Act. Am_{32} = Actual age when weighing at 32 weeks (days)

$$AW_{48} = \frac{Act.\ W_{48} - AW_{32}}{Act.\ Am_{48}} \times 224 + AW_{32} \quad (3)$$

Where: AW_{48} = Adjusted weight at 48 weeks (kg)
Act. W_{48} = Actual weight at 48 weeks (kg)
Act. Am_{48} = Actual age when weighing at 48 weeks (days)

$$AW_{72} = \frac{Act.\ W_{72} - AW_{48}}{Act.\ Am_{72}} \times 336 + AW_{48} \quad (4)$$

Where: AW_{72} = Adjusted weight at 72 weeks (kg)
Act. W_{72} = Actual weight at 72 weeks (kg)
Act. Am_{72} = Actual age when weighing at 72 weeks (days)

Average daily gain (ADG) at a particular period e.g. Pre-weaning ADG (PrwADG) which was birth to weaning age at 120 days; and post-weaning ADG (PoswADG), which was from 120 days of age to 72 weeks of age (i.e. 384 days post weaning) were calculated using formulae 5 and 6 as follows:

$$PrwADG = \frac{AWw - BW}{120\ days} \quad (5)$$

$$PoswADG = \frac{AW72 - AWw}{384\ days} \quad (6)$$

Data obtained was analysed using the GLM procedures of SAS (2008) [16]. The number of ewes mated and lambed and the numbers of lambs born and weaned per breed were recorded. Fertility was based on ability of ewes to produce lambs annually. Fertility rate (FR) was generally expressed as the number of births per 100 mated ewes in a breed at their mature age. Analysis of lamb mortality was carried out by investigating the effect of year, genotype and sex using Chi-square test by using PROC FREQ (Chisq expected of SAS) basing on the following Chi-square formula

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

Where: χ^2 = the value of Chi-Square statistics
O = Observed values of frequencies for lamb mortality incidences
E = Expected values of frequencies for lamb mortality incidences

BHP and RM reproductive performance was analysed using ANOVA procedures of SAS to compare the two breeds in two seasons (wet and dry) from 2011 to 2016. Traits analysed were fertility rate (FR), conception rate (CR), age at first lambing (AFL), lambing interval (LI), litter size (LS) and mortality rate (MR). CR was obtained as the distribution of 963 conceptions in respect of ewes mated and calculated from the lambing records obtained between years 2012 and 2016 on annual basis. AFL was determined by calculating the mean age at first lambing for 530 females born from 2011 to 2015. LI was determined as mean lambing interval from 854 records obtained from 2013 to 2016, whereas LS were obtained from 963 parturitions recorded from 2012 to 2016, which was calculated as the mean litter size on breed basis. FR, CR and MR were analysed using chi-square to determine breed, season and year effects. AFL and LI were analysed to determine breed, season and year effects.

3. Results and discussion

The mean weights of BHP and RM lambs at birth, weaning, 32, 48 and 72 weeks of age at West Kilimanjaro is shown in Table 1. There was no significant (P>0.05) difference in birth weight between BHP and RM lambs. The two breeds differed significantly (*P*<0.05) in weights at weaning, 32, 48 and 72 weeks of age.

Table 1: Least squares means (LSM±se) for effect of breed, sex and birth type on weights at different ages

Factor	Levels	Bwt	Wwt	32wwt	48wwt	72wwt
Overall	-	3.47±0.07	11.43±0.27	13.43±0.31	18.61±0.46	20.76±0.43
Genotype	BHP	3.55±0.10	12.93±0.35^a	16.03±0.39^a	20.64±0.53^a	21.84±0.55^a
	(n=93) RM (n=94)	3.39±0.06	10.78±0.21^b	12.83±0.24^b	17.53±0.32^b	19.82±0.33^b
Sex	BHP Females	3.56±0.09	12.07±0.50	14.38±0.25	18.76±0.42^a	21.58±0.48^a
	(n=52) BHP Males (n=41)	3.58±0.07	12.24±0.25	15.47±0.28	20.40±0.38^b	23.08±0.40^b
	RM Females (n=52)	3.25±0.05	11.05±0.30	12.45±0.33	16.79±0.41^a	18.03±0.37^a
	RM Males (n=42)	3.36±0.08	11.47±0.30	13.38±0.33	17.76±0.45^b	18.58±0.46^b
Birth type	BHP Singles (n=89) BHP Twins (n=4) RM Singles (n=82) RM Twins (n=12)	3.59±0.07^a 3.43±0.06^b 3.05±0.11^b 2.50±0.14^a	13.14±0.24^a 10.89±0.30^b 9.60±0.27^b 8.75±0.36^a	16.40±0.24^a 13.12±0.34^b 11.78±0.29^b 9.67±0.30^a	21.23±0.45^a 17.85±0.38^b 14.00±0.55^b 12.35±0.51^a	22.56±0.35^a 20.31±0.32^b 14.75±0.55^b 14.20±0.52^a
R^2		0.31	0.15	0.30	0.21	0.29

^{a,b} Means with different superscripts within a factor and breed rows are significantly different at *P*<0.05
Bwt=birth weight, Wwt=weaning weight, 32wwt=32 weeks of age weight, 48wwt=48 weeks of age weight, 72wwt=72 weeks of age weight.

Mean weights of BHP were significantly (*P*<0.05) higher than those of RM by 2.15, 3.20, 3.11 and 2.02 kg at weaning, 32, 48 and 72 weeks of age, respectively. Within breeds, males were significantly (*P*<0.05) heavier than females at 48 and 72 weeks of age. At 48 weeks of age BHP ram lambs were 1.64 kg heavier than ewe lambs. Their weight difference at 72 weeks of age was 1.5 kg. Results are further presented graphically which indicate that both BHP and RM were comparable at birth, but thereafter at weaning, 32, 48 and 72 weeks BHP were superior to their counterparts (Figure 2).

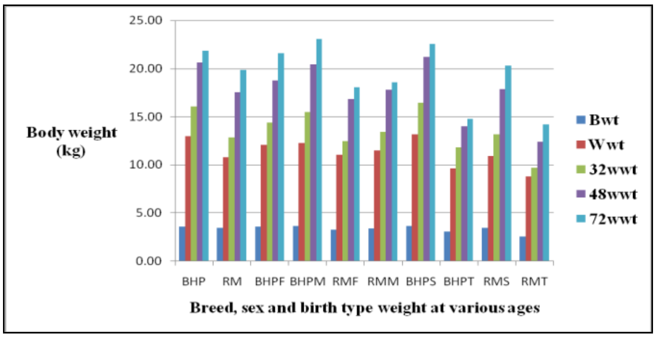

Fig 2: Effect of breed, sex and birth type on BHP and RM growth performance

Key: BHP-Blackhead Persian, RM-Red Masai, BHPF-BHP female, BHPM-BHP male, RMF-RM female, RMM-RM male, BHPS-BHP single, BHPT-BHP twin, RMS-RM single and RMT-RM twin.

RM males weights were superior to females with a difference of 110 g, 420 g, 930 g, 970 g and 550 g at birth, weaning, 32, 48 and 72 weeks of age, respectively. The phenomenon which was observed with the BHP sex comparison applied also to RM but the difference at birth was smaller and increased at weaning, 32 and 48 weeks of age, but decreased at 72 weeks. It has been reported elsewhere (Momoh *et al.*, 2013) [14] that differences in sex chromosomes, in the position of genes related to growth, physiological characteristics, difference in endocrinal system (i.e. type and measure of hormone secretion especially sexual hormones) lead to difference in animal growth. According to Rashidi *et al.* (2008) [15], in relation to endocrinal system, estrogen hormone has a limited effect on the growth of long bones in females and that could be one of the reasons in which females have always been lighter than males. Birth type as another factor was found to have an influence on growth performance in both breeds.

BHP singles were heavier than RM singles at all ages except at birth. BHP singles' weights surpassed those of RM singles by 3.54, 4.62, 7.23 and 7.81 kg, at weaning, 32, 48 and 72 weeks of age, respectively. Singles from the two breeds coincided only at birth, but thereafter differed significantly (P<0.05) in the successive ages. The difference could be due to the natural genetic potential of BHP by virtue of having been improved through selection to a medium size breed while RM is among the small East Africa breeds (Das, 2010) [7]. Twins and singles from the two breeds differed significantly (P<0.05) by within breeds. BHP singles were heavier than BHP twins at all ages. The mean weights difference being 2.14, 3.45, 5.50 and 6.11 kg at weaning, 32, 48 and 72 weeks of age, respectively. Maternal influence could be an important cause of the twins' underperformance as the milk supply from ewes in bad years and seasons could affect milk production because of inadequate pasture and hence low milk supply to meet the high milk demand of the twins. This calls for the need to supplement twins. Although the difference between singles and twins at birth was relatively small, the magnitude of difference increased with age thus having a larger difference at 72 weeks of age. The same scenario was shown by RM. Singles and twins for RM were small only at birth, but thereafter singles became superior by increasing their difference at each stage. Singles were superior to twins with a gap of 0.93, 2.14, 3.45, 5.50 and 6.11 kg at birth, weaning, 32, 48 and 72 weeks of age, respectively. The difference in weights between singles and twins at all ages is in agreement with the findings reported by Kuchtik *et al.* (2011) [13] who noted better performance of singles than multiple lambs. They finally recommended for a proper nutrition to ewes with twins to allow the twin lambs to express their full genetic potential. It is therefore important to be more careful in lamb management especially with twins to ensure good growth rate and survival.

The effect of season of birth on BHP and RM growth performance is presented in Table 2. In both breeds, lambs born and raised in wet season were heavier than those born and raised in the dry season. For instance BHP and RM lambs born and raised in wet season were heavier than BHP and RM lambs born and raised in dry season. BHP lambs born and raised in wet season weighed 3.67±0.15 kg, 12.89±0.27 kg, 16.76±0.39 kg, 21.33±0.50 kg and 23.22±0.45 kg for birth, weaning, 32, 48 and 72 weeks of age, respectively which were higher than the dry season lambs which weighed 2.56±0.15 kg, 11.12±0.30 kg, 15.65±0.36 kg, 20.41±0.43 kg and 20.81±0.45 kg respectively. For the RM the wet season lambs surpassed the dry season ones by weighing 3.55±0.11 kg, 11.53±0.24 kg, 13.72±0.30 kg, 18.95±0.40 kg and 20.67±0.39 kg at birth, weaning, 32, 48 and 72 weeks of age, respectively, against dry season weights of 2.47±0.13 kg, 10.10±0.28 kg, 12.50±0.30 kg, 17.68±0.48 kg and 19.53±0.35 kg for birth, weaning, 32, 48 and 72 weeks of age, respectively. These observations are in agreement with observations reported by Kuchtik *et al.* (2011) [13] who noted better performance of lambs born and reared in wet season than their counterparts which were born and reared in dry season. They recommended that lactating ewes should be provided proper nutrition in dry seasons to allow them to improve their maternal environment to support their lambs to express their full genetic potential. According to Kuchtik *et al.* (2011) [13], the effects of the complexes of season, management and the patterns of compensatory growth are the aspects which warrant particular attention. Further, results have shown that BHP weights in both seasons were superior to weights of RM lambs. At birth and at weaning, mean weights of the two breeds were comparable, but differed significantly (P<0.05) at 32, 48 and 72 weeks where BHP weights became superior.

Table 2: Least squares means (LSM±se) for effect of season on weights of BHP and RM lambs under on station conditions

Factor	Levels	Bwt	Wwt	32wwt	48wwt	72wwt
Overall	-	3.47±0.07	11.43±0.27	13.42±0.31	18.61±0.46	20.76±0.43
Wet season	BHP	3.67±0.15 (n=177)	12.89±0.27 (n=165)	16.76±0.39^a (n=157)	21.33±0.50^a (n=143)	23.22±0.45^a (n=139)
	RM	3.55±0.11 (n=200)	11.53±0.24 (n=182)	13.72±0.30^b (n=171)	18.95±0.40^b (n=162)	20.67±0.39^b (n=145)
Dry season	BHP	2.56±0.15 (n=175)	11.12±0.30 (n=160)	15.65±0.36^a (n=145)	20.41±0.43^a (n=136)	20.81±0.45^a (n=122)
	RM	2.47±0.13 (n=187)	10.10±0.28 (n=179)	12.50±0.30^b (n=168)	17.68±0.48^b (n=160)	19.53±0.35^b (n=155)
R^2		0.31	0.15	0.30	0.21	0.29

^{a,b} Means with different superscripts within a factor and row are significantly different at P<0.05

This phenomenon could be interpreted in the light of adaptation potential to the environment of the RM over BHP during the early stages of life at birth and weaning age, but the genetic potential of the BHP allowed it to achieve its superiority at mature age.

Table 3 displays the results on the effect of years on weights of BHP and RM lambs. The BHP breed was superior to RM in almost all weights for all the three years, except at birth and 72 weeks of age in 2013. For both breeds the worst performance was in year 2013. This could be due to the fact that years 2012 and 2014 were good years in terms of rainfall which could have enough pastures to support feeding requirements for ewes and consequently produce enough milk for their lambs. Such conducive weather could also ensure enough pastures for the weaned lambs. RM weighed almost equal to their counterparts BHP at 72 weeks (19.63 vs 20.91 kg, respectively) in year 2013. This could be a sign of adaptation of the RM as has been mentioned before. The weights recorded in this study differ a little bit with those reported by Sendalo *et al.* (2010) [18] who recorded BHP birth, weaning, 48 and 72 weeks of age weight of 2.68, 15.15, 22.93 and 33.24 kg, respectively. In this study mean mature weights of BHP male and females were 55 and 45 kg respectively which is a little bit higher than those reported by Charles (2007) [5].

Table 3: Least squares means (LSM±se) for effect of years on weights of BHP and RM lambs

Factor	Levels	Bwt	Wwt	32wwt	48wwt	72wwt
2012	Overall	3.63±0.14	12.10±0.32	13.47±0.26	17.80±0.43	21.36±0.34
	BHP	3.77±0.15 (n=120)	13.89±0.27[a] (n=114)	15.76±0.39[a] (n=110)	20.30±0.50[a] (n=93)	23.52±0.45[a] (n=90)
	RM	3.58±0.11 (n=132)	11.53±0.24[b] (n=125)	12.72±0.30[b] (n=116)	16.95±0.40[b] (n=109)	20.67±0.39[b] (n=102)
2013	Overall	3.08±0.15	10.01±0.25	13.48±0.33	18.98±0.45	19.55±0.55
	BHP	3.37±0.16 (n=117)	12.10±0.30[a] (n=109)	16.65±0.36[a] (n=102)	21.41±0.43[a] (n=91)	20.91±0.45 (n=86)
	RM	3.08±0.14 (n=130)	10.10±0.28[b] (n=119)	13.50±0.30[b] (n=113)	18.98±0.48[b] (n=108)	19.63±0.35 (n=100)
2014	Overall	3.54±0.09	9.56±0.33	13.10±0.29	18.41±0.37	19.68±0.57
	BHP	3.65±0.12 (n=115)	13.53±0.37[a] (n=100)	16.50±0.54[a] (n=90)	20.84±0.39[a] (=89)	22.59±0.56[a] (n=85)
	RM	3.54±0.08 (n=125)	9.56±0.40[b] (n=117)	13.10±0.49[b] (n=110)	18.42±0.36[b] (n=105)	19.68±0.51[b] (n=98)
R^2		0.31	0.15	0.30	0.21	0.29

[a,b] Means with different superscripts within factor and breed rows are significantly different at $P<0.05$

The mean birth weight in this study was a little bit higher (3.55 vs 2.68 kg) than that recorded by Sendalo *et al.* (2010) [18]. Other BHP mean weights in subsequent ages were lower than those recorded by Sendalo *et al.* (2010) [18]. Weaning weight, 48 and 72 weeks of age weights from this study are lower than those recorded by Sendalo *et al.* (2010) [18] by 2.22, 5.40 and 11.40 kg respectively. The most interesting thing is that the current study was conducted on the same farm where Sendalo *et al.* (2010) [18] conducted their study. Their study was made from the same genetic pool raised from 1972 to 1990 at TALIRI West Kilimanjaro. The flock used in this study were the descendants from the 1990s flock. Continuous selection for birth and subsequent age weights has been conducted within the flock for many years. The birth weight from Sendalo *et al.* (2010) [18] of 2.68 kg and higher mean weight from this study (3.55 kg) could be due to continuous selection for birth and subsequent age weights trait within this flock. This is in line with the findings reported by Assan *et al.* (2002) [1] who noted a response to selection of 0.8 and 0.14 kg in two generations for birth and weaning weight, respectively. In their findings (Assan *et al.*, 2002) [1], heritability was moderate (0.38), thus making the results of selection successful. In course of this study West Kilimanjaro farm complained about management problems due to inadequate funds to address several husbandry issues like feed supplementation, especially during dry seasons which could be the possible cause for poor performance of lambs. Factors like inadequate nutrition and diseases can obscure animals' growth potential (Charles, 2007) [5].

BHP weaning and 32 weeks weights significantly correlated positively (r=0.52) and (r=0.66) respectively with weight at 72 weeks. Similarly RM weaning and 32 weeks weights correlated well (r=0.56) with weight at 72 weeks. Further, dam weight significantly correlated well with birth weight (r=0.51 for BHP; r=0.59 for RM). It has been specified that when two growth traits are highly correlated, then breeders can select lambs as parents for a future generation for the growth trait of weight at 72 weeks basing on 32 weeks weight and this is an opportunity of making selection earlier to reducing the generation interval (Falconer and Mackay, 1996) [8]. The positive correlation between dam weight and birth weight is in agreement with the findings by Hussain *et al.* (2000) [10] who reported a significant association between them of r=0.3. It is therefore important to select well managed dams as parents by basing on their body weights. It has been reported that phenotypic weight of mature ewes from a representative sample of sheep in African environments range from 30 to 45 kg (Charles, 2007) [5]. It has been reported by DAD-IS (2005) [6] that in South Africa rams can potentially grow up to 68 kg of ram mature weight and 52 kg of ewe mature weights. In East Africa most farms have maintained mean weight of 55 and 45 kg of mature ram and ewe respectively.

Table 4: Correlation of weights at different ages of BHP (above diagonal) and RM (below diagonal)

	Bwt	Wwt	32 wwt	48 wwt	72 wwt	Dam wt
Bwt		0.365**	0.233NS	0.293*	0.367*	0.509**
Wwt	0.351**		0.801**	0.581**	0.563**	0.206NS
32 wwt	0.291**	0.694**		0.673**	0.561**	0.181NS

48 wwt	0.140^{NS}	0.497**	0.847**		0.758**	0.308*
72 wwt	0.337**	0.516**	0.663**	0.706**		0.069^{NS}
Dam wt	0.592**	0.242*	0.219*	0.193*	0.290**	

Bwt = lamb birth weight
Wwt = lamb weaning weight
32wwt = lamb weight at 32 weeks of age
48wwt = lamb weight at 48 weeks of age
72wwt = lamb weight at 72 weeks of age
Dam wt = Dam weight at mating
NS = Not significant, * Significant $P<0.05$, ** Significant $P<0.01$

Furthermore this study recorded ADG birth to weaning at 120 days among RM lambs of 61.6 g/day and ADG from weaning to 72 weeks of age of 23.5 g/day. Therefore ADG for RM from weaning to 72 weeks of age was comparable to that of BHP. It must be borne in mind that BHP is a breed which was developed in South Africa but was adopted to East Africa. Better environment and selection for bigger size can improve the flock performance as well (Sendalo *et al.,* 2010) [18]. On the side of weights of RM lambs, the flock followed the same trend as for BHP. Birth weights of RM lambs were higher than those reported by Sendalo *et al.* (2010) [18] and Das (2010) [7] i.e. 3.39 vs 2.7 kg respectively. These authors worked with RM at West Kilimanjaro and Malya farms in Tanzania respectively. Their reported mean lamb birth weights were also lower to that reported by Kiriro (1994) [12] of 3.2 kg in Kenya. All the other subsequent weights by Sendalo *et al.* (2010) [18] were higher than those recorded in this study. For instance weaning weight by Sendalo *et al.* (2010) [18] was 15 kg in comparison with 10.78 kg in this study. However weaning weight reported by Sendalo *et al.* (2010) [18] and the one in this study are lower than that reported by Kiriro (1994) [12] which was 15.56 kg. RM mature weight recorded in this study is almost same as that recorded by Sendalo *et al.* (2010) [18] and Kiriro (1994) [12] which were 40 kg for males and 30 kg for females. DAD-IS (2005) [6] reported male and female sheep mature weight for RM in East Africa of 41 and 32 kg respectively. The range of weights among males in this study were 38 to 42 kg with a mean of 40.54 kg and for females ranged from 36 to 39 kg with a mean of 37.5 kg. The rate of growth in this study and the time of reaching that particular mature weight were a little bit longer than those in other workers (Sendalo *et al.,* 2010; DAD-IS, 2005; Kiriro, 1994) [18, 6, 12]. The differences could be due to variation in environment and periods of trials. Despite the flock management problems raised before, these findings could raise a concern to issues pertaining to climate change which could promote some adaptation mechanisms to it as been reported by Sejian *et al*. (2016) [17]. Animals exposed to heat stress normally reduce feed intake and increase water intake, and there are changes in the endocrine status which in turn increases the maintenance requirements leading to a reduced performance (Gaughan and Cawsell-Smith, 2015) [9]. Such environmental stressors can lead to reduced body weight, average daily gain and body condition of livestock.

Comparison between BHP and RM in terms of fertility rate (FR), conception rate (CR), age at first lambing (AFL), lambing interval (LI), litter size (LS) and mortality rate (MR) traits is presented in Table 5. In this study RM has shown to be better than BHP in aspects of conception rate (CR) by 1.4% units, fertility rate (FR) by1.2% units, litter size (LS) by 0.01 and mortality rate (MR) lower by 7.1%. However, BHP performed better (shorter by 34 days) in lambing interval (LI).

Table 5: Performance of BHP and RM on fertility, conception, mortality rate, age at first lambing, lambing interval and litter size

Trait	P levels	BHP	RM	Difference/ superiority*
FR (%)	X^2 (df=1, 0.002)=9.84	70.8	72.0	1.2 (RM)
CR (%)	X^2(df=1, 0.001)=12.56	71.5	72.9	1.4 (RM)
MR (%)	X^2 (df=1, 0.01)=7.78	35.8	28.7	7.1 (RM)
AFL (days)	($P<0.05$)	620±8.04	553±4.90	67 (RM)
LI (days)	($P<0.05$)	275±2.89	309±7.13	34 (BHP)
LS (mean litter size)	($P>0.05$)	1.02	1.03	0.01 (RM)

FR=Fertility rate, CR=Conception rate, MR=Mortality rate, AFL=Age at first lambing, LI=Lambing interval, LS=Litter size. *(RM was superior with higher FR, CR and LS; but low MR and earlier AFL, while BHP was superior to RM for having shorter LI.

All these were noted to be influenced by genetics and seasons as has been reported by Jones *et al.* (2013) [11]. This was in conformity with the findings by Berhan and Van Arendonk (2006) [4] who reported that lambs born per mated ewes, LI and LS are normally impacted by breed.

4. Conclusion and recommendations

Comparison between the two breeds has indicated that BHP is superior to RM in most body weights. The genetic potential of BHP as a medium sized and improved sheep breed has contributed to such superiority. However RM has competed well in weights during harsh climate. Sex effect has shown that the entire males performed better weights than females. Both breeds have the prospects for improvement and production for both local and export markets. This could be an advantage for crossbreeding programs where potential of each breed can be taped for the complementary situation of good traits from each breed. RM could be an animal of choice to smallholder farmers with limited resources who mostly raise their sheep flock in harsh environment. On the other side of the coin for the BHP, the animal could be an animal of choice to those well-off farmers with enough resources with well-established pasture farms, other supplementary feeds and good veterinary services. Sheep sub sector stakeholders are urged to intervene in the genetic improvement and exploitation of the potential of both breeds.

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