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Phenotypic Characteristics of Red Maasai Sheep in Arumeru and Monduli Districts in Tanzania

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was aimed at describing the phenotypic characteristics and assessing the effects of sex and location on body measurements of Red Maasai Sheep found in Arusha region of Tanzania. Samples of 281 adult Red Maasai sheep (165 from Arumeru and 116 from Monduli district) were involved for quantitative characteristics while for qualitative traits 497 sheep were involved. The result indicated that sheep colour type varied though reddish brown dominated, whereas main colour patterns were patchy and spotted. In most cases backward curved horns were observed in both sexes. Ears were medium sized and droopy. Sheep tails were also characterized as fat tailed and fat rumped types. Generally, sex did not significantly affect body weight, withers height, ear length, ear width and tail thickness. Likewise, location did not significantly ($P > 0.05$) influence most linear body measurements (LBMs). Among the studied LBMs, heart girth was the best predictor of body weight with R^2 of 60 %. It was remarked that the breed is in danger of losing its identity as a result of dilution, which was mostly attributed to indiscriminate crossbreeding. Thus, further study on genetic diversity and adaptability of the breed is required. This will enable improvement, higher exploitation and conservation of the Red Maasai sheep pure lines for future.

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1. INTRODUCTION

Information on the phenotypic characteristics of indigenous animals' population in their habitat is a basic requirement for breed improvement under farmer level. These phenotypic features are useful in distinguishing the breed from one population to another [1]. Measuring animal body parts could aid as selection criteria during breeding. The body measurements are also necessary in evaluating animals' growth and performance [2]. In Africa, sheep have been described using morphological characteristics including tail types, coat cover, body size, body coat colour, horns, tassels, prolificacy and purpose [3,4]. Indigenous sheep in Tanzania are generally non-descript types possessing names of the tribes that keep them, like Red Maasai, Sukuma and Gogo sheep. These sheep may also be grouped on the basis of their tail characteristics into two major groups; namely fat tailed and long tailed sheep [3,5].

Inspite of a large number of livestock, knowledge on physical characteristics of local sheep and other livestock species in Tanzania are not well known, because characterization has been done to a very small extent [3,6]. Conservation of indigenous sheep is only possible if there is thorough characterization [4,7]. Despite the fact that the rate of substituting indigenous breeds with higher grade animals is increasing due to economic motives and changes in production systems, little effort has been done to conserve the remaining local breeds in the country. The Tanzania Red Maasai sheep have not been characterized in detail, unlike studies done in Kenya. A study by [8] suggested that Red Maasai sheep was an appropriate breed for farmers in semi-arid areas, followed by F1 Dopper-Red Maasai crosses. Another research in Tanzania concluded that Red Maasai sheep could be an animal of choice to smallholder farmers with limited resources who mostly raise their sheep flock in harsh environment [6]. This is due to the fact that Red Maasai sheep are trypanotolerant and resistant to *Haemonchus contortus* but also have high twinning rate [8-11]. A study by Tungu et al. [6] noted that Red Maasai sheep was superior to Black herd persion sheep in fertility (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.

Therefore, there was a need to characterize Red Maasai sheep breed. The information will help to better understand the indigenous Red Maasai sheep and find ways of improving their productivity. This study was intended to describe the phenotypic characteristics of Red Maasai sheep, to study the effects of sex and location on sheep body measurements and associations among quantitative body measurements of the Red Maasai sheep in Arusha region, Tanzania.

2. MATERIALS AND METHODS

The study was conducted in Arumeru and Monduli districts of Arusha region (Fig. 1). Arusha region is located in northern Tanzania at latitude 3° 22' 0 S and longitude 36° 40' 60 E. It is found at altitudes 900 to 1,600 meters above sea level. Annual temperatures range from 21^0C to 24^0C. Part of the region receives monomodal rainfall pattern, while others receive bimodal rainfall pattern ranging from 800 to 1,000 mm. Three wards were chosen from each of the districts and three villages from each ward were randomly selected. The study involved 281 adult Red Maasai sheep (165 from Arumeru and 116 from Monduli district), where quantitative body measurements were taken and qualitative traits were observed and recorded.

2.1 Description of External Morphological Characteristics of Sheep

Qualitative characters described were sheep sex, horn characteristics, ear type, coat colour types and patterns and tail types. Quantitative characters measured were body weights (BW) and linear body measurements (LBMs) including body length (BL), heart girth (HG), height at withers (WH), ear length (EL), ear width (EW), tail length (TL) and tail thickness (TT) for adult sheep. Age of sheep was determined based on dentition using charts described by Abegaz and Awgichew [12]. Body weight was measured by hanging an animal to a spring balance (Fig. 2). LBMs were measured by tailors tape. Body length was measured from tail base to in between the roots of horns. Heart girth was measured as chest circumference, just behind the fore limbs. Height at withers was measured on a standing sheep from ground base to the back at withers position using a special calibrated ruler bar. Horn length was measured by lining the tape from the base to the tip of the horn. Tail thickness was measured at the middle of the tail by measuring fat thickness, while tail length was measured from the base of the tail to the tip.

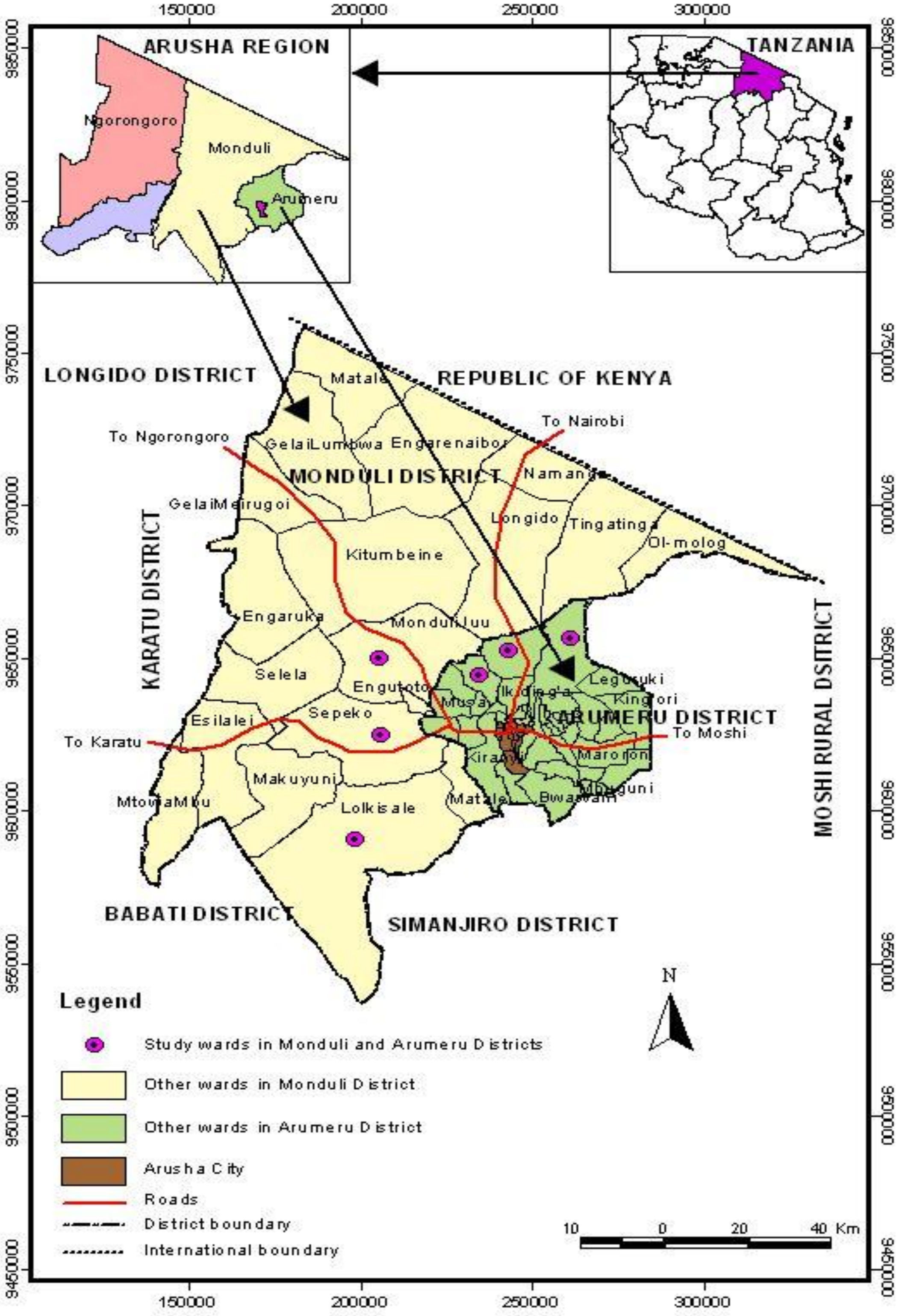

Fig. 1. Map of Arumeru and Monduli districts showing study areas

Fig. 2. Body weight measurement by spring balance at Mondulijuu village

2.2 Statistical Analyses

Data on weights and LBMs of adult sheep were analyzed using General Linear Models (GLM) procedures of Statistical Analytical System. Fixed effect of sex and location (districts) of sheep were fitted in the model when analyzing the physical body measurements.

$$Y_{ijk} = \mu + S_i + L_j + (SL)_k + \varepsilon_{ijk} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where, Yijk = an observation on k^{th} animal of i^{th} sex from j^{th} district
µ = general mean common to all observations,
Si = effect of the i^{th} sex (1 = male, 2 = female),
Lj = effect of the j^{th} district (1 = Arumeru, 2 = Monduli),
(SL) ij = interaction effect of sex and district,
Ɛijk = random error term.

Forward multiple linear regression model was used to see if there was improvement in predicting live weight by fitting the linear body measurements to predict live body weight of mature sheep.

$$Y = a + b1X1 + b2X2 + b3X3 + bnXn + \varepsilon \ldots\ldots (2)$$

Where, Y = the body weight of sheep,
a = the Y – intercept,
b1, b2, b3 = bn are the partial regression coefficients,
X1, X2, X3 = Xn are independent continuous variables of BL, HG, WH, HL, EL, EW, TL and TT, respectively,
Ɛ = random error term.

Survey responses and qualitative variables were analysed using Statistical Package for Social Sciences (SPSS, 2002) version 16.0 for windows and association between variables were tested by chi square.

3. RESULTS AND DISCUSSION

3.1 Effect of Sex and Location on Body Measurements of Adult Sheep

3.1.1 Body Weights (BW)

Results in Tables 1 and 2 show no significant difference (*P > 0.05*) in weights between males (27.6±0.73) and females (27.4±0.42). The similarity in weights among males and females observed in the current study might be because bigger rams were already sold. These findings are similar to those reported by Otoikhian et al. [13] who observed no significant difference between males and females among Ouda sheep. However, this finding is contrary to the publication by Mandal et al. [14] on Muzaffarnagari sheep who found that males were heavier than females. Arora et al. [15] also documented the effect of sex on the body weight (kg) in Ganjam sheep; males were heavier (27.0±0.96) than females (23.9±0.6). Regardless of the findings in this study, males are expected to be heavier due to their higher feed conversion efficiency as stated by Mandal et al. [14].

Analysis of variance on BW (Table 1) shows that location had no significant (*P > 0.05*) effect on sheep body weights. Sheep in Monduli were slightly heavier than those from Arumeru but their difference was insignificant. This is contrary to recent publication by Oke and Ogbonnaya [16] which has shown strong location effect on live body weight of WAD sheep in Nigeria. Location effect is often associated with feed resources available for the animals.

3.1.2 Body Length (BL)

Sex did not significantly (*P > 0.05*) influence body lengths for sheep although males had slightly longer body lengths than females. The slight difference between males and females could be due to biological variations between males and females. A study by Oke and Ogbonnaya [16] reported body length for adult WAD sheep to be 50.7±1.18 cm for males and 51.5±0.88 cm for females which are shorter than observations made in the current study (82.46±0.51 cm for females and 82.68±0.88 cm for males). The shorter in length for the WAD sheep could be attributed to inherent dwarfism traits.

Location on the other hand had no significant (*P > 0.05*) effect to body lengths although sheep from Monduli exhibited longer body lengths than those from Arumeru. The differences might be caused by environmental variations including feeding and diseases in the two districts. The study on WAD sheep by Oke and Ogbonnaya [16] reported location effect on LBMs, including body length such that adults in Umuhia zone measured 51.4±1.33 cm, Ohafia zone 52.1±1.52 cm and those from Aba zone 50.5±1.01 cm, which were shorter than body lengths for Red Maasai sheep (82.06±0.58 cm in Arumeru and 83.07±0.83 cm in Monduli).

3.1.3 Heart Girth (HG)

Sex differences were not important (*P > 0.05*) for the heart girth (Table 2) which is different from Kunene et al. [17] on Zulu sheep who found that sex had a strong effect on heart girth.

Table 3 shows that location had a significant (*P < 0.01*) effect on HG. Sheep in Monduli had a higher mean heart girth (72.04 cm) than those from Arumeru (69.48 cm). The study by Kunene et al. [17] on Zulu sheep, found that, location was among the highest contributing factor to the variation of heart girth. Variations in heart girth in the two locations could be due to body conformation differences.

3.1.4 Height at Withers (WH)

Height at withers was not significantly (*P > 0.05*) influenced by the sex of the animal (Tables 1 and 2). Kunene et al. [17] documented highly significant (*P > 0.001*) effect of sex on height at withers, which was opposing to the Red Maasai sheep in Arumeru and Monduli districts. The variation could be explained by biological differences in growth and mature size between males and females.

Similarly, location did not have effect on WH for adult sheep (Table 3). According to Oke and Ogbonnaya [16], there was location influence to the height at withers for WAD sheep in Nigeria, however, for WAD sheep their dwarfism could be a source of variation.

3.1.5 Ear length (EL) and ear width (EW)

Neither sex nor location was found to influence ear length and ear width of sheep (Tables 2 and 3). For both traits females had slightly longer and wider ears than males. The results are slightly higher than those of Otoikhian et al. [13] for Ouda sheep of Nigeria, with the ear length of 8.31±0.04 cm for male sheep and 7.75±0.01 cm for females. The variation could be explained by genetic differences between sexes with males having a larger number of growth cells than the females. Longer ear length has a positive implication in thermal regulation. Results on ear width obtained in this study were nearly similar to those observed by Otoikhian et al. [13] who reported males to have ear width of 4.21±0.06 cm and females of 4.16±0.17 cm. Current results conform to the cited observations that sex has no influence on ear width. This study, though not significant, females had longer and wider ears.

3.1.6 Tail Length (TL) and Tail Thickness (TT)

Results in Table 2 show that tail lengths were highly significantly influenced by sex (*P < 0.01*). The significant influence of sex on tail length observed in this study does not resemble those by Otoikhian et al. [13] who reported sex to have no effect on tail length. Their tail length values were 17.75±0.09 cm for males and 19.29±0.68 cm for females. The variation in tail length may be due to genetic differences between males and females [13]. Our findings are disagreeing to those by Mandal et al. [14] who found no significant difference between tail lengths of adult males and females among Muzaffarnagari sheep. In Tanzania, Msanga et al. [18] reported Red Maasai sheep as having long tails but no measurements were taken.

Table 1 shows that district was not an important source of variation on tail length among the sheep (*P > 0.05*). Sheep from Arumeru had longer tails (18.58 cm) than those from Monduli (17.40). Oke and Ogbonnaya [16] have observed significant effect of location on tail lengths of WAD sheep from two zones of Umuahia and Ohafia in Nigeria implying influence of environment on tail lengths. But for the case of Red Maasai the insignificant effect could be because they are raised in almost similar environments.

There was no significant (*P > 0.05*) influence of sex or location on tail thickness. Location differences were insignificant but sheep from Arumeru had slightly thicker tails than those from Monduli (Table 3). Little has been done on tail thickness; only one study [18] has reported Red Maasai sheep as having thick tails with *S* -shape, but no quantitative description was stated.

3.2 Prediction of Live Body Weight from Linear Body Measurements of Sheep

The best predictor of body weight (BW) in sheep was heart girth with coefficient of determination of 0.60 (Table 4). When withers height was included in the model R^2 improved to 0.62 and the prediction equation was BW = -27.92 + 0.57HG + 0.24WH. There was a slight improvement in prediction equation (R^2 = 0.63) when body length was included in the model as a third independent variable. When tail length was included in the model the prediction equation improved slightly (R^2 = 0.64). Further inclusion of other LBMs did not improve the prediction. So, the best model to predict body weight was: Body weight = -32.83 + 0.51HG + 0.21WH + 0.11BL - 0.09TL.

Table 1. ANOVA for various body measurements for adult sheep

Source of variation	Df	Mean Squares for variables							
		BW	BL	HG	WH	EL	EW	TL	TT
District (D)	1	0.60^{NS}	51.13^{NS}	325.00**	72.94^{NS}	0.97^{NS}	0.06^{NS}	63.27^{NS}	7.22^{NS}
Sex (S)	1	1.43^{NS}	2.39^{NS}	44.38^{NS}	0.44^{NS}	0.93^{NS}	14.68^{NS}	224.94**	0.12^{NS}
D*S	1	0.72^{NS}	85.01^{NS}	15.38^{NS}	66.29^{NS}	1.35^{NS}	0.22^{NS}	213.69**	0.42^{NS}
Residual	277	34.96	51.3	45.10	23.20	2.16	12.61	35.44	1.44

*NS= not significant, * p < 0.05, **p < 0.01, ***p < 0.001*

Table 2. Comparison of least squares means (±s.e.) for sex effect on various body measurements

Sex	BW (kg)	BL (cm)	HG (cm)	WH (cm)	EL (cm)	EW (cm)	TL (cm)	TT (cm)
F (202)	27.45±0.42	82.46±0.51	71.24±0.48	60.85 ±0.34	10.88 ±0.10	6.48 ±0.25	19.93±0.42^{a}	2.21 ±0.10
M (82)	27.62±0.73	82.68±0.88	70.29±0.83	60.75 ±0.59	10.74 ±0.18	5.93 ±0.44	19.06±0.73^{b}	2.26 ±0.17
Significance	NS	NS	NS	NS	NS	NS	**	NS

BW= body weight, BL=body length, HG=heart girth, WH=height at withers, EL=ear length, EW=ear width, TL=tail length, TT=tail thickness, F=female sheep, M=male sheep
*Along the column least square means with different superscripts differ significantly (P < 0.05), NS= not significant, * P < 0.05, ** P < 0.01, *** P < 0.001*
Numbers of observations are shown in brackets

Table 3. Comparison of least squares means (±s.e.) for location effect on various body measurements

Location	BW (kg)	BL (cm)	HG (cm)	WH (cm)	EL (cm)	EW (cm)	TL (cm)	TT (cm)
Arumeru(167)	27.47±0.48	82.06±0.58	69.48±0.55^{a}	61.41±0.39	10.73±0.12	6.20±0.29	18.58±0.49	2.43±0.11^{a}
Monduli (117)	27.59±0.69	83.07±0.83	72.04±0.78^{b}	60.19±0.56	10.88±0.17	6.18±0.41	17.40±0.70	2.05±0.16^{b}
Significance	NS	NS	**	NS	NS	NS	NS	*

BW=body weight, BL=body length, HG=heart girth, WH=height at withers, EL=ear length, EW=ear width, TL=tail length, TT=tail thickness, F=female sheep, M=male sheep
*Along the column least square means with different superscripts differ significantly (P < 0.05). NS= not significant, * P < 0.05, ** P < 0.01, *** P < 0.001*
Numbers of observations are shown in brackets

Table 4. Constants, regression coefficients (b±s.e.) and coefficients of determination (R^2) for linear relationship between body weight and linear body measurements

Y	Intercept (a)	BX	S.E.	R^2
BW	-19.07	0.66 HG	0.03	0.60
	-27.92	0.57 HG	0.04	0.62
		0.24 WH	0.05	
	-31.40	0.11 BL	0.04	0.63
		0.52 HG	0.04	
		0.21 WH	0.05	
	-32.83	0.11 BL	0.04	0.64
		0.51 HG	0.04	
		0.21 WH	0.04	
		-0.09 TL	0.03	
	-32.68	0.11 BL	0.04	0.64
		0.51 HG	0.04	
		0.22 WH	0.05	
		-0.09 EW	0.06	
		0.08 TL	0.03	

BW = Body weight, HG = Heart girth, BL = Body length, WH = Withers height, EL= Ear length, EW = Ear width, TL=Tail length

Since heart girths were found to have highest degree of accuracy with a higher R^2 of 0.60, therefore, heart girth can be the best predictor of sheep live body weight than height at withers and body length. On the other hand, ear length, tail length and ear width had very little contribution. A study by Otoikhian et al. [7] differs from the current result that, heart girth, had a low percentage of fitness. Oke and Ogbonnaya [16] reported similar findings to the current ones that heart girth was proven as the best singular predictor of body weight in both sexes of all age groups of WAD sheep. Another study by Kumar et al. [1] noticed that heart girth was the most important trait for estimating live body weight in sheep with R^2 of 0.78. The predictions can be used as a basis for the design of sheep housing, for example, through space allowances, and design of feeders or as a biological basis for space allowance [19]. Another research has supported our study and confirmed that HG, WH and LW can be used to evaluate growth in ruminants [17]. HG can estimate body weight, which is then used in drug administration during animals' treatments.

3.3 Description of Red Maasai Sheep Qualitative Traits

Red Maasai sheep were qualitatively described based on sex, horns, ears, coat colour types and patterns as well as tail fat position (Tables 5 and 6). Chi-square test results show that there is no significant (*P > 0.05*) association between districts and most qualitative traits with exception to sheep coat colour patterns. However, there was highly significant (*P > 0.001*) influence of sex on horn status.

3.3.1 Sex

Farmers in both districts retain fewer male sheep (36.7%) than females (63.3%). A few males are left in the farms for breeding and other social uses, while unsuitable rams are castrated. Females are retained for perpetuation of the flock size. A similar observation has been reported [16] on West African Dwarf (WAD) sheep, where 69% of the populations were females retained to maintain a constant flock size.

3.3.2 Presence of horns and orientation

The majority of Red Maasai sheep from the study area were found polled (80.0%), with few possessing horns (20.0%). Horn shape and orientation varied from curved backward, lateral and curved forward (Table 5). For those with horns; both males and females bear horns, although males exhibited a higher percentage (38.8%) of horns than females (8.9%, Table 6). In Red Maasai sheep, horns were observed in both sexes, but a larger number of females (91.1%) were polled as compared to males (61.2%). The variation in presence of horns with sex is because possession of horns in sheep is a sex-influenced trait which can occur in both sexes though there will be preponderance in one sex [20]. In some sheep breeds, horns appear in both sexes, but to some breeds only males are having horns while in others both sexes are polled. For example, in Muzaffarnagari sheep both males and females are polled [14]. Piras et al. [21] reported presence of horns in both males and females of Pecora Nera di Arbus breed of sheep in Sardinia, whereas, in Garole sheep males are horned. In Bhutan, only male Sapang sheep were reported to be horned [22].

Common horn orientation observed in Red Maasai sheep were curved backward (65.7%, Fig. 3), with few lateral or curved forward. Adult WAD ram sheep were reported to have horns with forward inclined spiral orientation [23]. The results are almost similar to Msanga et al. [18] that, horns in Red Maasai are curved with lateral orientation. They also reported Tanzania Blackhead sheep with short horns, curved with backward orientation, which also resembles Red Maasai.

3.3.3 Ear size and shape

All (100%) of Red Maasai sheep from the study area had medium ears, leafy shape with droopy elevation. This is due to genetic inheritance. Maasai sheep were observed with variation in ear size and shape from very small to medium, with long leafy shape. Carles [24] described Red Maasai sheep with medium and pendulous ears. Ear shape and size were nearly similar to findings for Mecheri sheep with medium-long, leafy like and pendulous (Karunanithi et al. [25]. A similar study [18] in Tanzanian environment, reported Blackhead Persian sheep with small dropping ears which is similar to ear orientation of Red Maasai sheep.

Table 5. Description of qualitative characteristics of Red Maasai sheep in Arumeru and Monduli districts

Trait	Arumeru		Monduli		Overall		Chi-Square	Significance
	n	%	n	%	n	%		
Sex								
Male	99	39.8	83	33.6	182	36.7		
Female	150	60.2	164	66.4	314	63.3		
							2.02	NS
Presence of horns								
Horned	46	18.5	53	21.5	99	20.0		
Polled	203	81.5	194	78.5	397	80.0		
							0.69	NS
Horn shape & orientation								
Curved backward	28	59.6	37	71.2	65	65.7		
Lateral	11	23.4	11	21.2	22	22.2		
Curved forward	8	17.0	4	7.6	12	12.1		
							2.34	NS
Colour type								
Brown and white	120	48.2	138	55.9	258	52.0		
Reddish brown	112	45.0	96	38.9	208	41.9		
Brown and black	2	0.8	-	-	2	0.4		
Black	15	6.0	13	5.2	28	5.65		
							3.63	NS
Colour pattern								
Patchy	120	48.2	137	55.5	257	51.8		
Spotted	92	36.9	61	24.7	153	30.9		
Plain	21	8.4	35	14.2	56	11.3		
Shaded	16	6.4	14	5.7	30	6.1		
							11.03	*
Tail fat position								
Fat tail	130	52.2	116	47.0	246	49.6		
Fat-rumped tail	119	47.8	131	53.0	250	50.4		
							1.36	NS

n is the number of observations in column
*Chi-square calculated at 5%, NS= not significant, * P < 0.05, **P < 0.01, ***P < 0.001*

Table 6. Influence of sex on horn status of Red Maasai sheep

Trait	Male		Females		Overall		Chi-Square	Significance
	n	%	n	%	n	%		
Horned	71	38.8	28	8.9	99	20.0		
Polled	112	61.2	285	91.1	397	80.01		
Total	183	100	313	100	496	100		
							64.4	***

n is the number of observations in the column
*Chi-square calculated at 5%, NS= not significant, * P < 0.05, **P < 0.01, ***P < 0.001*

Fig. 3. A red Maasai sheep with horns curved backward in Arumeru

3.3.4 Coat color type and pattern

About 52.0% of sheep had brown and white coloured coat while reddish brown coloured coat was exhibited by 41.9%, although other colour types were rarely observed. Plain, patchy, spotted, and shaded colour pattern were the main colour patterns, and of these patchy was the dominant (51.8%) pattern. These findings have confirmed the dominant coat colour for Red Maasai to be reddish brown with plain and some few had multicolours of reddish-brown and white or black with various patterns. The study agrees with Hyera et al. [11] and Msanga et al. [18] who documented the main colour for Red Maasai as red, but red/white pied and black was also reported as minority. In another study, Carles [24] reported Red Maasai with reddish-brown colour.

3.3.5 Tail fat position

Tails of Red Maasai sheep were found to have fat either deposited along the whole tail (fat tailed) or deposited at the rump (fat rumped tail). Fat tailed position sheep were represented by 49.6% while fat rumped tail was represented by 50.4% in both districts. The current results are in line with the one reported by Muigai et al. [9] which described Red Maasai sheep as fat-tailed sheep. Also, the result support those published by Hyera et al. [11] which described Red Maasai sheep with fat deposit in tail and hindquarters. Carles [24] documented the breed as a fat rumped tail sheep, while Gatenby [3] categorized it as a fat tailed type.

4. CONCLUSION

Although the majority of Red Maasai sheep are polled, a few possess horns which are curved backwards with high frequencies exhibited in males. The dominant coat colour for these sheep is reddish brown. Red Maasai sheep are medium size with their tails varying in length and fat position. Body weights and most LBMs were generally not influenced by sex nor by location. Since Heart girth was found to be the best predictor of sheep live weight, could be useful tool in measuring body weight in the absence of weighing scales. Genomic study of this breed is ought to be done to determine genetic diversity between and within breeds. As the population of Red Maasai sheep is declining, there is a need to conserve as gene bank for sustainable exploitation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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