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ON-FARM PHENOTYPIC CHARACTERIZATION OF HOLLA SHEEP TYPES IN SOUTH WOLLO ZONE EASTERN AMHARA ETHIOPIA

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ABSTRACT: The study was conducted from purposively selected districts of Kalu and Worebabu districts in South Wollo administrative zone to describe the physical characteristics. Confirmatory and purposive sampling techniques were employed to select the target farmers. Following that semi-structured questionnaire, focused group discussions, secondary data source analysis and field observations were used to generate the required information. In addition, simple random sampling technique was used to select 450 sheep. The study was performed based on field measurements and body measurements were taken from 450 sheep of both sexes. Majority of the Holla sheep have brown, coat color (59.2%) female and (49.5%) male and white coat color type (27.4%) for females and (31.8%) for males were observed and they are short, smooth coat cover and polled type. Whereas, about 4.4% of ewes had wattle while the rams had no wattle which was strongly influenced (P < 0.01) by pelvic width, tail width and ear length. Similarly body weight and chest depth were also influenced (P<0.05) by district. Age group had significant effect (P<0.05) on body weight and other body measurements. Average ±SE body weight age at 0PPI, 1PPI, 2PPI, 3PPI and 4PPI was recorded as 18.21±0.23 kg, 20.34±0.26 kg, 22.14±0.25 kg, 23.41±0.56 kg and 26.33±0.65kg, respectively. Sex was strong and significant (P<0.01) effect on wither height, tail length and tail width. The interaction of sex and age is significantly (P<0.05) influenced the liner body measurements except ear length of sheep. The highest relationship (r=0.74) between heart girth and body weight were recorded in Worebabu and Kalu district of female age groups at 2PPI. So, chest girth is the first variable to enter in to stepwise regression model in both male and female sheep type. Present phenotypic information could be complemented with genetic analysis, and serve as a basis or designing appropriate conservation, breeding and selection strategies 'for Holla sheep.

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INTRODUCTION

Ethiopia is endowed with huge livestock resources of varied and diversified genetic pools with specific adaptations to a wide range of agro-ecologies. Farm animals as a whole are an integral part of the country's agricultural system and are raised both in the highland and lowland areas. In developing countries, livestock production is mostly subsistence oriented and fulfills multiple functions that contribute more for food security (Roessler et al., 2008; Duguma et al., 2010). The demand for livestock products is increasing due to the growing urban population, while farm areas are shrinking considerably as a result of an increase in the rural population (Siegmund Schultze et al., 2009). Ethiopia's estimated livestock population is often said to be the largest in Africa. There were approximately 50.8 million cattle, 25.5 million sheep, 22.78 million goats, 2.0 million horses, 0.38 million mules, 6.2 million donkeys, 1.1 million camels and 49.3 million poultry excluding the Afar and Somali Regions (CSA, 2010). The Amhara National Regional State has 9 million heads of sheep which is about 35% of the national sheep population (CSA, 2010).

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So far, some attempts have been made to identify and characterize indigenous sheep breeds (Sisay, 2002; Kassahun and Solomon, 2008). Similarly, local names and general areas of distribution for few of the sheep types of Ethiopia have been mentioned by various authors in their effort to categorize and describe African sheep types (Epstein, 1971; Wilson, 1991). Sisay (2002) made the first comprehensive phenotypic characterization of sheep in the Amhara National Regional State. On farm characterization can serve as basis for the sustainable improvement and conservation of indigenous animal genetic resources, and has received increasing attention in determining the variation between and within pure breeds (Rege, 2003). Thus, more comprehensive information specific to on-farm phenotypic characterization of Holla sheep breeding should be made available. Hence, this study was attempted to phenotypic characterize Holla sheep types both Kalu and Worebabo districts in South Wollo zone, North Eastern Ethiopia.

MATERIALS AND METHODS

Study Areas

The study was conducted in two districts (Worebabo and Kalu) of South Wollo zone of the Amhara National Regional state. Worebabo is situated an altitude ranging from 1480-2900 m.a.s.l at 39^0.40 -41'E longitude and 11^{0}6'20'N latitude in the semi-arid tropical belt of north- eastern Ethiopia (Figure 1). Its average annual temperatures were 21°C, where as the mean annual rainfall of the district were 1040mm. Kalu is located an altitude range of 1400 to 1850 m.a.s.l at 37° 41' 48''E longitude and 11^0.58'44'' N latitude in north west highlands of Ethiopia. The mean annual maximum and minimum temperatures recorded in Kalu were 28°C and 12°C, respectively while the mean annual rainfall of the study areas varied from 500 to 1200 mm.

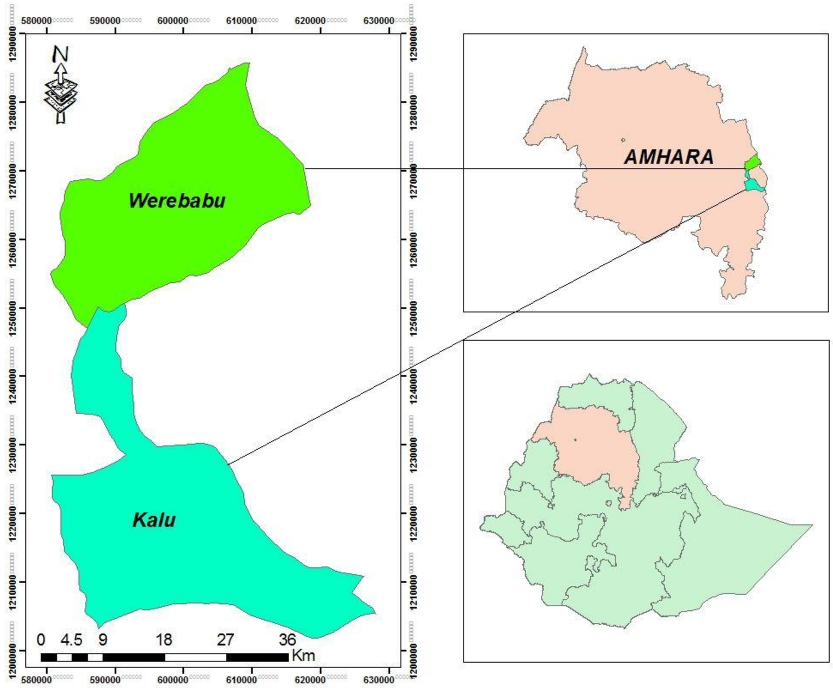

Figure 1 - Map of the Study area in South Wollo Zone

Sampling procedures

For body measurements and qualitative trait descriptions, a total of 450 sheep of both sexes which, were kept under natural pastures grazing conditions, were randomly taken from the surveyed households in four peasant associations. The Peasant Associations selected for this work were 01, 013 in Worebabo district, 04 and 08 in Kalu district. Since there was variation in sheep population among these peasant associations, different sample sizes of sheep of both sexes were taken. So, a total of 115 from 01, 110 from 013, 125 from 04 and 100 from 08 in Kalu district were randomly sampled.

Data collection procedures

The standard breed descriptor lists for sheep developed by FAO (2011) were closely followed to list both qualitative and quantitative morphological characteristics. Quantitative traits including; heart girth (HG), height at wither (WH), body length (BL), hair length (HL), ear length (EL), tail length (TL), rump height (RH)] and scrotal circumference (SC) were measured using measuring tape, while live body weight (LBW) was measured using portable weighing scale. All the measurements were made in the morning before the animals left for grazing and

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after restraining and holding the animals in an unforced position. The age of the animals were estimated by dentition and information taken from sheep owners. To assess effect of age on the parameters measured, the animals were grouped into five age groups: no pair of permanent incisor (0PPI), (1PPI), (2PPI), (3PPI), and (4PPI). The qualitative traits observed were coat color pattern, coat color type, head profile, rump profile, wattle, ruff, horn, horn orientation, horn shape, ear orientation, coat hair type, body skin color, hair length, tail type and shape.

Statistical data analysis

Both qualitative and quantitative data were analyzed using SPSS (Version 20). For adult animals, sex and age group of the sheep were fitted as independent variables while body weight and linear body measurements except scrotum circumference were fitted as dependent variables. A general linear model procedure (PROC GLM) of the SPSS was used for quantitative variables to detect statistical differences among sample sheep populations. Least square means with their corresponding standard errors were calculated for each body trait over location, sex, age and age by sex interaction.

RESULTS AND DISCUSSION

Phenotypic Characterization of *Holla* Sheep

The proportion of each level of the 15 qualitative traits recorded for each district is given in (Table 1). Out of 343 ewes and 107 rams of Holla sheep 59.2 % were plain, 27.1% patchy and 3.1% had spotted coat pattern. Plain brown (29.4%), brown and white (27.4%) coat color patterns were the dominant colors. Brown and red with red dominant (7.3%), black with white (7.0%), and Reddish brown and black (6.7%) coat were also observed in plain pattern and mixed in patchy or spotted patterns. Major colors like brown, brown and white and white and black were also frequently observed in samples population of Gumuz ewes (Solomon, 2007).The present study was similar from pervious reported for Bonga and Horro ewes coat color pattern (Zewdu, 2008) and indigenous sheep Tocha rams (Amelmal, 2011). Similarly the mixtures of red and white *('sendama')*, dark grey locally known as 'jibma'.This study results are in agreement with those of Mulata et al. (2014) reported that the sheep population found in Atsbiwonberta is characterized as dominant coat color of red brown. Coat color and presence of horn are among the qualitative body traits used as a criterion to select individual sheep for breeding purpose (Bosenu et al., 2014). Another author reported similar findings that coat color is among the qualitative body characteristics, the local community selects breeding rams and ewes based on the coat color (Dhaba et al., 2012).

The predominant hair types were short and coarse (71.4 %) and rest of short and smooth (28.6%). Coat pattern is more or less similar between the two sexes in *Holla* sheep type. The coat patterns of male sheep were 49.5% plain, 33.6% patchy and 16.9% were spotted. Plain brown (24.2%), brown and white (31.8%) coat color patterns were the dominant colors. Brown and red with red dominant (7.5%), black with white (8.4%), and Reddish brown and black (8.4%)) were the major colors frequently observed in the male sample population (Table 1). Other kinds of plain, patchy, and spotted coat patterns with different colors were also observed. The head profile was Straight (50.5%) or very slightly concave head profile (42.1%). Convex head profile was rarely observed (7.5%). They had short and rudimentary ears and all the sampled sheep are hornless. No wattle (Table 1).

Body weight and other linear body measurements

The least squares means and standard errors for the effect of sex, age group, location and their interaction on body weight and other body measurements are presented in Tables 2.

The overall least square means of body weight, body length, height at wither, heart girth, rump height, tail length, tail width, pelvic width, scrotal circumference, ear length and width of *Holla* sheep were 22.09 (kg), 52.4 , 58.4, 69.95, 61.31, 23.37, 15.54, 13.78, 23.52, 4.12, and 2.25 (cm), respectively.

Location (district) effect. Location was found to strongly influence ($P < 0.01$) on pelvic width, tail width and ear length. Similarly, body weight and chest depth were influenced ($p<0.05$) by location. However, body length, heart girth, height at wither, rump height, tail width and scrotal circumference were not significantly influenced ($p>0.05$) by location. Kalu sheep (22.45±0.20kg) were significantly ($p<0.05$) heavier than Worebabu sheep (21.72±0.23kg). The present study dis agreement with the pervious reported for Afar sheep (Tesfaye, 2008) and Nedjo sheep of west Wollega (Kedjela, 2010).

Age effect. Age group exerted strong significant effect ($p<0.01$) on body weight, body length, height at wither, heart girth, rump height, tail length, scrotal circumference, chest depth. Similarly, tail width and ear length were significantly ($p<0.05$) affected by age group. Body weight, body length, height at wither, heart girth rump height and scrotal circumference were in the current study body weight had significant difference in all age (dentition) groups and the same was true for all linear body measurements (Table 2). Where body weight and these linear body measurements increases when the animal gets older (increase in age).The above variables (BW, BL. HW, HG, RH, SC) are reached their maximum value in the oldest age (4PPI) of the sheep and dentition group 3 and 4 had higher

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values than those between 1 and 2 dentition groups. There was wide variability as the age of the animals increased for body measurements such as BW, BL, HG, and WH. This implies that these variables might be best explaining the growth pattern of the animals. The finding of this result of body weight and other body liner measurements is in agreement with the report of (Amelmal, 2011) who reported that matured body weight of the animal almost fully attains at older age. As age increased the size of un-castrated scrotal circumference also increased. The matured (age group 4) sheep had higher ($p<0.05$) scrotal circumference than the other age groups. The scrotal circumference of matured Kalu and Worebabu sheep (26.25± 1.86 cm) is greater than matured Menz (24.5±0.58cm) sheep and less than matured Afar (27.5±0.67cm) sheep (Tesfaye, 2008). Similar result was observed in Afar sheep (Tesfaye, 2008). Zewdu (2008) also reported that animals at older age group had larger scrotal circumference than animals at younger age groups. SC is a sex dependent character and it was affected by the age of the male sheep. Body weight of males in age group 0PPI (25.7 ± 0.3kg), age group 1PPI (31.9 ± 0.8kg) and age group 2PPI (38.2 ± 2.0kg) in the current study was higher than body weight of Menz males 18.0 ± 0.28kg, (22.9 ± 0.39kg) and 24.9 ± 0.67 in the same age group.

Sex effect. The least squares means and standard errors for the effect of sex, age group and their interaction on body weight and other body measurements are presented in Tables (2). Sex of the sheep had strong significant ($p<0.01$) effect on wither height, tail length and tail width. Similarly, rump height were significantly ($p<0.05$) affected by sex of the sheep. Scrotal circumference, ear length, chest depth, body weight, body length hart girth and pelvic width of Holla sheep were not affected ($p>0.05$) by sex. Holla sheep and its body weight (kg) 22.20±0.20 of males were higher 21.97±0.12 ($p<0.05$) than females in the study area. Differences in live weight and most of the body measurements between sexes observed in *Holla* sheep showed that these parameters are sex dependent. The effect of sex on body weight and other measurements obtained in this study is in agreement with previous results (Kassahun, 2000; Markos *et al.,* 2004: Tesfaye, 2008). The current report is in line to the previous findings of Mengistie *et al*. (2010) reported that a significant effect of sex on body weight, heart girth, body length and height at wither in Washera sheep. However; previous findings of Mulata et al. (2014) reported that sex has no significantly ($p>0.05$) effect on body weight, heart girth, body length and height at wither in highland sheep found in Atsbiwonberta.

Sex by age group. The interaction between sex and age group had a significant ($p<0.05$) effect on BW, BL, HW, HG, TL, TW, and SC. The interaction between sex and age group had no a significantly ($p>0.05$) effect on ear length of the sheep. Both females and males in age group (0PPI) had the same ($p>0.05$) body weight value but males in age group (0PPI) and up to 4PPI were heavier ($p<0.05$) than females in the same age group. Body weights of male and female sheep in the oldest age group (4PPI) were 27.45±1.28 kg and 25.21±0.28 kg, respectively Both females and males in age group (0PPI), age group (1PPI), age group (2PPI) and age group (3PPI) had almost the same ($p>0.05$) body weight value but males in age group 4(4PPI) were heavier ($p<0.05$) than females in age group 4(4pp) (Table 2). Differences in live weight and most of the body measurements between sexes observed in both Kalu and Worebabu showed that these parameters are sex dependent. Ewes have slower rate of growth and reach maturity at smaller size due to the effect of estrogen in restricting the growth of the long bones of the body (Sowande and Sobola, 2007).

Body weight and other linear body measurements

The correlation coefficient indicating the relationship between live weight and other body measurements in Holla sheep are shown in Table 3. Body weight most independent parameters depicted positive and highly significant ($P<0.01$) correlation. The highest relationship between chest girth and body weight were observed in female of dentition one ($r= 0.74$) and in male of the dentition two ($r=0.71$) the linear body measurements, chest girth with the highest correlation with body weight at various ages and in both sexes. The high, positive and significant correlation between body weight and chest girth suggest that this variables could provide a 'good estimate for predicting live weight of these breeds type (Table 3). This highest correlation of heart girth with body weight than other body measurements was in agreement with other results (Afolayan, et al., 2006; Fasae et al., 2006; Solomon, 2008; Tesfaye, 2008) and would imply that hart girth was the best variable for predicting live weight than other measurements. Scrotum circumference (SC) had positive and strong correlation with body weight at most age groups with correlation coefficient of 0.34 to 0.96 for both rams. The strong correlation of SC with body weight is in agreement with previous reports of Horro sheep breed (Kedjela, 2010). Males with large SC tend to sire daughters that reach puberty at an earlier age and ovulate more ova during each estrus period (Söderquist and Hultén, 2006). Decrease in SC resulted in increase in morphologically abnormal sperm (Söderquist and Hultén, 2006) and SC strongly correlated with age at first puberty of females, semen traits and libido (Toe et al*.,* 2000). Higher heritability of SC was observed by (Toe et al*.,* 2000). Measurement of SC is thus an essential part of the breeding soundness evaluation (Yoseph, 2007) and selection could be based on testicular circumference (Toe et al., 2000).

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Table 1 - Descriptions of qualitative traits of Holla Sheep

Parameters		Kalu				Worebabu				Over all	
		Male	Female	X^2-value	P-value	Male	Female	X^2-value	P-value	Male	Female
		N (%)	N (%)			N (%)	N (%)			N (%)	N (%)
Coat Color Pattern	Plain	23(52.30)	105(58.0)	62.58	0.000	30(47.6)	98(60.5)	63.44	0.000	53(49.5)	203(59.2)
	Patchy	13(29.50)	23(28.2)			23(36.5)	42(25.9)			36(33.6)	93(27.1)
	Spotted	8(18.20)	25(13.8)			10(15.9)	22(13.6)			18(16.8)	47(13.7)
Coat Color Type	White	8 (18.20)	40(22.1)	76.25	0.000	13(20.6)	36(22.2)	75.45	0.000	21(19.7)	76(22.2)
	Brown	11(25.00)	53(29.3)			15(23.8)	48(29.6)			26(24.2)	101(29.4)
	Brown and white	14 (31.80)	50(27.6)			20(31.7)	44(27.2)			34(31.8)	94(27.4)
	Brown and red with red dominant	3 (6.8)	13(7.2)			5(7.9)	12(7.4)			8(7.5)	25(7.3)
	Black and white	6(13.6)	11(6.1)			3(4.8)	13(8.0)			9(8.4)	24(7.0)
	Reddish brown and black	2(4.5)	7(11.10)			7(11.10)	9(5.6)			9(8.4)	23(6.7)
Head Profile	Straight	23(52.3)	106(58.6)	85.62	0.000	31(49.2)	97(59.9)	84.34	0.000	54(50.5)	203(59.2)
	Concave	17(38.6)	63(34.8)			28(44.4	53(32.7)			45(42.1)	116(33.8)
	Convex	4(9.1)	12(6.6)			4(6.3)	12(7.4			8(7.5)	24(7.0)
Dewlap	Present	4(9.1)	13(7.2)	2.09	0.000	2(3.2)	8(4.9)	2.17	0.000	6(5.6)	21(6.1)
	Absent	40(90.9)	168(92.8)			61(96.8)	154(95.1)			101(94.4)	322(93.9)
Wattle	Present	-	12(6.6)	1.29	0.000	-	8(4.9)	1.94	0.000	0(0.0)	20(5.8)
	Absent	44(100.0)	169(93.4)			63(100)	154(95.1)			107(100)	323(94.2)
Ear formation	Rudimentary	13(29.5)	46(25.4	50.88	0.000	18(28.6)	41(25.3)	50.88	0.000	31(29)	87(25.4)
	Short	31(70.5)	135(74.6)			45(71.4)	121(74.7)			76(71.0)	256(74.6)
Tail type	Short fat tailed	28(63.6)	103(56.9)	6.08	0.014	35(55.6)	96(59.3)	6.08	0.014	63(58.9)	199(58.0)
	Long fat tailed	16(36.4)	78 (43.1)			28(44.4)	66(40.7)			44(41.1)	144(42.0)
Tail form	Curved tip	23(52.3)	84(46.4)	49.52	0.000	30(47.6)	77(47.5)	49.52	0.000	53(49.5)	161(46.9)
	Blunt	17(38.6)	75(41.4)			27(42.9)	65(40.1)			44(41.1)	140(40.8)
	Straight & tip down word	4(9.1)	22(12.2)			6(9.5)	20(12.3)			10(9.3)	42(12.2)
Hair type	Short and coarse	27(61.4)	130(72.2)	36.16	0.000	42(66.7)	115(71.4)	36.16	0.000	69(64.5)	245(71.4)
	Short and smooth	17(38.6)	50(27.8)			21(33.3)	46(28.6)			38(35.5)	98(28.6)

N=number of households; X^2 = *Pearson chi-square;* Ns = Non-significant (P > 0.05);*P < 0.05; **P < 0.01

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Table 2 - Least squares means ± standard errors of body weight(kg) and other body measurements (cm) for the effects of district, age, and sex and sex by age for *Holla* sheep

Effect & level	Body weight (kg)		Body length(cm)		Height at withers (cm)		Heart girth (cm)		Rump height (cm)	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Over all mean	414	22.09±0.19	420	52.40±0.34	445	58.43±0.33	426	69.95±0.38	429	61.31±0.34
C v	414	7.23	420	7.23	445	6.70	426	6.27	429	6.19
R^2	414	0.53	420	0.53	445	0.43	426	0.46	429	0.44
District	–	**		NS		NS		NS		NS
Kalu	207	22.45±0.22	210	52.15±0.40	231	58.56±0.39	210	70.06±0.45	210	61.55±0.40
Werebabu	207	21.72±0.22	210	52.64±0.38	214	58.31±0.38	216	69.85±0.43	219	61.06±0.38
Age group	–	***		***		***		***		***
0PPI	88	18.21±0.23^{a}	95	46.68±0.39	97	52.98±0.39	98	64.24±0.44^{a}	100	55.86±0.37
1PPI	78	20.34±0.26^{b}	81	50.11±0.45^{a}	81	55.27±0.47^{a}	78	66.02±0.54^{a}	80	59.45±0.46^{a}
2PPI	105	22.14±0.25^{c}	98	51.08±0.44^{a}	102	57.40±0.44^{a}	103	69.28±0.51	106	60.72±042^{a}
3PPI	76	23.41±0.56^{c}	74	56.13±1.11^{b}	75	61.28±0.98^{b}	76	73.14±1.11^{b}	74	64.18±1.10^{b}
4PPI	67	26.33±0.65^{d}	72	57.98±1.18^{b}	72	65.23±1.13^{b}	71	77.09±1.28^{b}	69	66.32±1.10^{b}
Sex		NS		NS		**		NS		*
Male	97	22.20±0.20	96	52.17±0.68	97	59.34±0.63	96	69.60±0.72	98	62.03±0.65
Female	317	21.97±0.12	324	52.62±0.21	330	57.53±0.21	330	70.31±0.24	331	60.58±0.20
Age by sex	–	*		***		***		***		NS
Male 0PPI	40	18.40±0.35a	42	47.24±0.58a	42	53.39±0.59a	42	63.82±0.67a	43	56.62±0.57a
Female 0PPI	48	18.03±0.44ab	53	46.12±0.51a	55	52.56±0.51a	56	64.66±0.58ab	57	55.11±0.49a
Male 1PPI	25	19.77±0.44b	24	48.83±0.76ab	23	54.29±0.8ab	23	62.85±0.90a	23	59.24±0.78b
Female 1PPI	53	20.91±0.30c	57	51.40±0.49b	58	56.25±0.50b	55	69.18±0.58c	57	59.65±0.49b
Male 2PPI	25	21.64±0.45d	24	49.00±0.77b	25	57.63±0.78b	24	67.39±0.91b	26	60.85±0.74b
Female 2PPI	80	22.63±0.24a	73	53.16±0.43b	77	57.17±0.43b	79	71.16±0.49cd	80	60.59±0.41b
Male 3PPI	4	23.75±0.26b	3	55.54±2.17cd	4	61.75±1.91c	4	74.25±2.17de	3	64.50±2.16c
Female 3PPI	72	23.07±0.26bc	71	56.72±0.44c	71	60.82±0.45c	72	72.04±0.4d	71	63.86±0.44c
Male 4PPI	3	27.45±1.28c	3	60.24±2.17d	3	69.63±0.22d	3	79.69±2.51	3	68.95±2.16c
Female 4PPI	64	25.21±0.28d	69	55.72±0.46c	69	60.83±0.47c	68	74.50±0.55	66	63.69±0.47c

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Table 2 - Least squares means ± standard errors of body weight(kg) and other body measurements (cm) for the effects of district, age, and sex and sex by age for *Holla* sheep

Effect & level	Tail length(cm)		Tail width(cm)		Pelvic width (cm)		Scrotal circumference		Ear length (cm)		Chest depth (cm)	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Over all mean	429	23.37±0.27	435	15.54±0.15	436	13.78±0.15	107	23.52±0.50	450	4.12±0.06	444	32.80
Cv	429	14.98	435	12.25±	436	13.75	107	13.63	450	19.02	444	5.49
R	429	0.28	435	0.24	436	0.25	107	25.75	450	0.14	444	0.28
district		***		NS		***		NS		***		**
Kalu	215	22.53±0.33	218	15.68±0.48	214	14.32±0.18	44	23.10±0.80	225	4.26±0.07	221	32.56±0.17
Werebabu	214	24.22±0.31	217	15.34±0.7	222	13.24±0.17	63	23.94±0.60	225	3.98±0.07	223	33.05±0.17
Age group		***		**		***		***		**		***
0PPI	96	20.92±0.34	101	15.00±0.18	98	12.32±0.19	45	20.66±0.45^{a}	104	3.81±0.07a	104	30.99±0.17
1PPI	82	22.78±0.39^{a}	80	15.83±0.21^{a}	8	13.39±0.22^{a}	26	22.74±0.59^{ab}	85	4.01±0.09^{a}	85	32.35±0.20^{a}
2PPI	106	23.75±0.36^{a}	108	15.11±0.20^{a}	106	14.11±0.20^{a}	28	23.45±0.61^{b}	109	4.24±0.08^{b}	108	32.75±0.20^{ab}
3PPI	71	24.10±0.76^{a}	74	15.05±0.46^{a}	78	14.28±0.48^{a}	5	24.50±1.38^{b}	78	4.30±0.17^{b}	78	33.62±0.41^{bc}
4PPI	74	25.33±0.96^{a}	72	16.56±0.53^{a}	73	14.80±0.54^{a}	3	26.25±1.86^{b}	74	4.22±0.22^{ab}	69	34.30±0.52^{c}
Sex		***		***		NS		NS		NS		NS
Male	103	25.52±0.52	103	16.72±0.29	103	13.96±0.29	107	23.52±0.50	107	4.15±0.12	106	32.75±0.28
Female	326	21.23±0.18	332	14.30±0.10	333	13.61±0.10			343	4.08±0.04	338	32.86±0.09
Age by sex		*		***		***		***		NS		NS
Male 0PPI	42	22.51±0.51^{c}	43	15.75±0.27^{b}	43	11.69±0.28	45	20.66±3.67^{a}	45	3.76±0.11^{a}	45	30.87±0.26^{a}
Female 0PPI	54	19.32±0.45^{a}	58	14.24±0.23^{a}	55	12.95±0.25^{a}			59	3.87±0.0.10^{a}	29	31.10±0.23^{a}
Male 1PPI	25	25.10±0.66^{c}	25	17.72±0.36^{c}	24	13.80±0.38^{a}	26	22.74±3.52^{ab}	26	4.06±0.0.15^{a}	26	31.88±0.34^{a}
Female 1PPI	57	20.47±0.43^{ab}	55	13.93±0.24^{a}	57	12.98±0.24^{a}			59	3.96±0.10^{a}	59	32.83±0.23^{b}
Male 2PPI	28	24.60±0.63^{c}	28	15.87±0.34^{b}	28	14.76±0.35^{b}	28	23.45±1.62^{b}	27	4.29±0.0.14^{b}	27	32.19±0.35^{ab}
Female 2PPI	78	22.89±0.37^{c}	80	14.36±0.20^{a}	78	13.70±0.21^{a}			81	4.19±0.08^{a}	81	33.31±.0.19^{bc}
Male 3PPI	5	26.24±1.48^{cd}	4	16.00±0.9^{bc}	5	14.70±0.0.83 ab	5	24.50±1.51^{b}	5	4.57±0.34^{b}	5	33.86±0.79^{c}
Female 3PPI	66	21.96±0.40^{b}	70	14.10±0.21^{a}	73	13.87±0.21^{b}			73	4.02±0.09^{a}	73	33.38±0.20^{c}
Male 4PPI	3	29.16±1.91^{d}	3	14.83±1.07^{c}	3	13.83±1.07^{b}	3	26.25±1.73^{b}	3	4.05±0.44^{a}	3	34.93±1.03^{c}
Female 4PPI	71	21.49±0.41^{b}	69	14.76±0.22a^{b}	70	14.76±0.23^{b}			71	4.38±0.09^{b}	66	33.67±0.22^{c}

^{a,b,c,,d} means on the same column with different superscripts within the specified dentition group are significantly different (p <0.05); Ns = Non-significant (P>0.05); ** P< 0.01

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Trait		Dentition class (Age group)									
		0PPI		1PPI		2PPI		3PPI		4PPI	
		M	F	M	F	M	F	M	F	M	F
BL	r	0.29*	0.54***	0.68***	0.62***	0.43*	0.64***	-	0.32***	-	0.22*
HW	r	0.35*	0.64***	0.36^{NS}	0.68***	0.09^{NS}	0.52***	-	0.37**	-	0.50***
HG	r	0.06^{NS}	0.65***	0.19^{NS}	0.74***	0.71***	0.69***	-	0.69***	-	0.54***
RH	r	0.41**	0.65*	0.53*	0.71***	0.21^{NS}	0.57**	-	0.31**	-	0.38***
TL	r	0.07^{NS}	0.08^{NS}	0.1^{NS}	0.07^{NS}	-	0.31**	-	0.63***	1.00***	0.15^{NS}
TW	r	-	0.36*	-	0.04^{NS}	0.46*	-0.01^{NS}	0.89^{NS}	0.27*		0.15^{NS}
PW	r	-	0.39**	-	0.56***	0.19^{NS}	-0.12^{NS}	0.81^{NS}	-0.08^{NS}		0.25*
EL	r	0.16^{NS}	0.39**	-	0.42**	0.03^{NS}	0.12^{NS}	1.0***	0.57***		0.05^{NS}
EW	r	0.09^{NS}	0.45**	0.26^{NS}	0.27*	-	0.23^{NS}	0.81^{NS}	0.56***		0.14^{NS}
CD	r	0.17^{NS}	0.33*	0.03^{NS}	0.16^{NS}	0.12^{NS}	0.29**	0.96*	0.46***		0.34**
SC	r	0.34*	-	0.27^{NS}	-	0.26^{NS}	-	0.96*	-		

Table 3 - Coefficient of correlation between Body Weight and other body measurements with in age group and sex

N= number of observations. r = coefficient of correlation, 1PPI = 1 pair of permanent incisor and NS = non-significant;* < 0.05, ** < 0.01 PPI= pair of permanent incisor M=male, F=female, BL=body length, HG= hart girth, WH =wither at Height, RH= rump height, TL= Tail length, TW= Tail width, PW =pelvic width, CD=chest dept., SC=scrotal Circumference

Table 4 - Regression Models for Predicting Body Weight of Female *Holla* Sheep at Different age Groups

Age group	Model	B_0	B_1	B_2	B_3	B_4	B_5	B_6	R^2	MSE
0	HG	3.08	0.22						0.48	2.89
	HG+WH	-2.81	0.15	0.20					0.55	3.20
	HG+WH+EL	-1.75	0.10	0.19	0.66				0.62	3.02
1	WH	-10.87	0.56						0.65	3.65
	WH+HG	-18.05	0.41	0.22					0.72	3.97
	WH+HG+TW	-21.69	0.43	0.21	0.23				0.74	4.36
	WH+HG+TW+EW	-23.01	0.47	0.21	0.29	-0.84			0.76	4.32
	WH+HG+TW+EW+BL	-21.14	0.58	0.25	0.26	-1.07	-0.19		0.78	4.34
	WH+HG+TW+EW+BL+TL	-20.47	0.61	0.25	0.41	-1.26	0.21	-0.14	0.79	4.27
2	HG	-1.05	0.33						0.41	3.51
	HG+RH	-10.20	0.23	0.25					0.51	4.13
	HG+RH+CD	-19.14	0.21	0.29	0.25				0.55	5.53
	HG+RH+CD+EW	-24.38	0.14	0.36	0.33	1.56			0.60	5.5
	HG+RH+CD+EW+EL	-19.78	0.14	0.33	0.29	-1.53			0.66	5.34
	HG+RH+CD+EW+EL+TW	-13.36	0.12	0.34	0.27	4.85	-2.25	-0.28	0.69	5.94
	HG+RH+CD+EW+EL+TW+BL	-11.82	0.09	0.23	4.96	-2.50	-0.26	0.11	0.70	5.96

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Table 4 (Continued)

Age group	Model	B_0	B_1	B_2	B_3	B_4	B_5	B_6	R^2	MSE
3	HG	-5.29	0.39						0.46	4.01
	HG+TL	-3.10	0.29	0.20					0.51	4.02
	HG+TL+PW	-0.15	0.29	0.22	-0.23				0.53	4.37
	HG+TL+PW+EW	3.23	0.24	0.20	-0.30	0.91			0.55	4.77
	HG+TL+PW+EW+CD	10.75	0.28	0.23	-0.45	1.18	-0.28		0.57	6.47
4	CD	5.79	0.56						0.27	4.27
	CD+BL	1.98	0.47	0.12					0.34	4.36
	CD+BL+EW	0.09	0.39	0.17	0.63				0.42	4.22
	CD+BL+EW+PW	-6.08	0.39	0.21	0.66	0.25			0.48	4.77
	CD+BL+EW+PW+WH	-9.16	0.34	0.18	0.78	0.18	0.12		0.50	5.08
	CD+BL+EW+PW+WH+RH	-8.69	0.40	0.18	0.77	0.19	0.20	-0.12	0.53	5.01
over all 3	HG	10.28	0.45						0.51	1.98
	HG+WH	-15.26	0.28	0.29					0.62	1.84
	HG+WH+EW	-15.04	0.24	0.31	0.92				0.65	1.77
	HG+WH+EW+BL	14.24	0.21	0.19	1.01	0.14			0.67	1.73
	HG+WH+EW+BL+TL	14.36	0.20	0.18	1.07	0.14	0.06		0.67	1.72
	HG+WH+EW+BL+TL+EL	-13.91	0.20	0.17	1.58	0.15	0.06	-0.46	0.68	1.73

Table 5 - Regression models for predicting body weight of male *Holla* sheep at different age groups

Age group	Model	B_0	B_1	B_2	B_3	B_4	B_5	B_6	R^2	MSE
0	RH	6.93	0.20						0.12	5.29
	RH+HG	16.04	0.26	-0.19					0.26	6.33
	RH+HG+SC	20.67	0.23	-0.31	-0.20				0.39	6.14
1	BL	0.18	0.38						0.37	6.17
	BL+RH	9.68	0.64	-0.38					0.51	7.34
2	HG	-12.23	0.49						0.64	6.46
	HG+PW	-19.35	0.72	-0.52					0.76	6.05
	HG+PW+TW	-19.10	0.56	-0.36	0.47				0.80	5.76
	HG+PW+TW+RH	-27.39	0.42	0.03	0.64	0.17			0.84	6.79
	HG+TW+RH	-27.55	0.40		0.66	0.18			0.84	6.41
	HG+TW+RH+SC	-24.08	0.56		0.49	0.27	-0.74		0.92	4.70
4	CD	4.0	0.66						1.00	0
over all	HG	-6.39	0.39						0.50	3.09
	HG+RH	-12.51	0.27	0.27					0.58	3.30

HG= Heart Girth; BL=Body Length; HW= Height at wither; CW=Chest Width; PW = Pelvic Width; TW = Tail Width; BCS= Body Condition Score; SC= Scrotal Circumference; 0PPI = 0 Pair of Permanent Incisors; 1PPI = 1Pairs of Permanent Incisors; 2 PPI = 2 Pairs of Permanent Incisors; 3 PPI = 3 Pair Permanent Incisors; 4 PPI = 4 Pairs of Permanent Incisors

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Multiple linear regression analysis

The regression analysis of live body weight on different body measurements for ewes and rams are presented in Tables 4 and 5, respectively. The result of Stepwise regressions procedure was carried out to predict the dependent variable body weight based on independent variables which had positive correlation with body Weight. Around ten body measurements for Body length, Height at wither; Heart girth, Rump height, Tail length, Tail width Ear length, Ear width and Chest depth were utilized in female for estimation of body weight. The male body weight also estimated using the above measurements and scrotal circumference. Six variables with significant contribution to the prediction model which included heart girth, body length, and height at wither, tail length, tail width and were fitted first to six steps where they accounted for 68 % of the total variability of the female sheep. Across all the 2 age groups of male sheep, heart girth, tail width, rump height and scrotal circumference alone accounted for about 92 % and polled data were heart girth and rump height for 58% of the variation in body weight, while step one procedure of stepwise regression of all sex and age category, for predication of body weight heart girth was consistently selected and entered into the model because of its higher coefficient of determination (R^2) value and its larger contribution to the model than other variables.

Multiple linear Regression equation were developed for predicting body weight (LBW) from other LBMs female and male using the pooled data for all age groups due to the low proportion of animals at each dentition classes. The regression equations were developed for male and female by using chest girth, body length, height at wither, tail length, ear width and ear length of was independent variable and body weight as dependent (predicted) variable female sample population and chest girth and rump height was independent variables and body weight as dependent variable for male sample population. Parameter estimates in multiple linear regression model showed that ewes had higher R^2 (68%) value than rams (58%). This point out that those linear measurements could predict more accurately in females compared to males. Overall equation of the pooled age group using, height at wither, tail length, ear width, body length and ear length as important variable used for the prediction of body weight for female sheep and also heart girth and rump height used for prediction of body weight for male sheep. The prediction of body weight could be based on the following regression equation:

$Y=-13.91+0.20\,HG+0.17HW+1.58EW+0.15BL+0.06TL+(-0.46)\,EL$ for ewes and

$Y=-12.51+0.27\,HG+0.27\,RH$ for rams.

CONCLUSION AND RECOMMENDATION

Majority of the female Holla sheep in the study area have plain patch and spotted coat color pattern. Similarly male Holla sheep were plain, brown and brown and white. Generally, positive and significant ($P<0.05$) correlations were observed between body weight and most of the body measurements. Live body weight estimation using chest girth alone would be preferable to combinations with other measurements because of difficulty of the proper animal restraint during measurement and the low proportion of animals at each dentition classes. The high correlation coefficients between body weight and body measurements for all age groups suggest that either of these variables or their combination could provide a good estimate for predicting live weight of sheep from body measurements. More emphasis needs to be placed on the improvement of Holla sheep breeds due to their significant contribution to the family food and income and their ability to survive and reproduce in the extreme environments in which crop production as well as maintaining large ruminants is difficult. The present Morphometric information could aid future decision on the management, conservation and improvement of the Holla sheep genetic resources. It is suggested that it is important to undertake well planned on station study to predict further genetic potential of sheep type in the study areas.

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Competing Interests

The authors declare that they have no conflict of interest with respect to the research, authorship or publications of this article.

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