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On-farm phenotypic characterization of native sheep types in North Wollo zone, Northern Ethiopia

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Research Paper

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The study was conducted to generate organized information on physical characteristics of native sheep types in North Wollo Zone. The study was performed based on field measurements and body measurements were taken from 450 sheep of both sexes. Majority of the sheep have plain brown coat color (40.9%) and they are docile in temperament. Average observed heart girth, wither height, body length and scrotal circumferences for male sheep were 73.4, 63.5, 59.7 and 22.7 cm, respectively, while that for female sheep, was 67.5 for heart girth, 57.4 for wither height and 55.9 for body length. Male sheep in the Habru district weighed about 28.1kg where as female sheep weighed about 24.0 kg. About 87.5% of rams have curved horns with backwards as the dominant horn orientation while ewes are usually hornless. Average observed heart girth, wither height, body length and scrotal circumferences for male sheep were 70.0, 64.7, 57.4 and 24.5 cm, respectively, while that for female sheep it was 66.6 for heart girth, 61.8 for wither height, and 53.2 cm for body length and male sheep weighed about 25.9 kg where as female sheep weighed about 22.6 kg. The present phenotypic information could be complemented with genetic analyses; and serve as a basis for designing appropriate conservation, breeding and selection strategies for sheep.

Key words: Body measurement, characterization, native sheep, qualitative trait.

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).

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 indigenous sheep breeding should be made available. Hence, this study was attempted to physically characterize indigenous sheep types in North Wollo zone, Northern Ethiopia.

MATERIALS AND METHODS

Study Areas

The study was conducted in two districts (Habru and Gubalafto) of Northern Wollo zone of the Amhara National Regional state. Habru is situated an altitude ranging from 1200-2350 m.a.s.l at 39° 38'E longitude and 11°35'N latitude in the semi-arid tropical belt of north-eastern Ethiopia (Figure 1). Its mean annual maximum and minimum temperatures were 28.5 °C and 15 °C, respectively where as the mean annual rainfall of the district varied from 750 to 1000 mm. Gubalafto is located an altitude range of 1600 to 3300 m.a.s.l at 36.31° and 39.81°E longitude and 9.11° and 14.59°N latitude in north west highlands of Ethiopia. The mean annual maximum and minimum temperatures recorded in Gubalafto were 22.28 °C and 7.5 °C, respectively while the mean annual rainfall of the study areas varied from 777 to 1050 mm.

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 AhunTegegn, KosoAmba, Merto and GosshWoha. 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 100 from Merto, 98 from Gosh Woha, 112 from KosoAmba and 140 from AhunTegegn 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 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 SAS (2005). 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 SAS (2005) 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 sex, dentition and dentition by sex interaction.

RESULTS AND DISCUSSION

Qualitative traits of Gubalafto and Habru sheep

The proportion of each level of the 15 qualitative traits recorded for each district is given in (Table 1). The Gubalafto sheep have mainly plain coat color pattern (67.5%) followed by patchy (21.8%) and spotted (10.7%). Among the sampled sheep population in Habru, however about 58.1% had plain coat color pattern followed by patchy pattern (25.8%) and spotted (16.2%). The dominant coat color types were black (34.5%) followed by black dominant (18.3), white (12.7%), light red (8.7%), white dominant (6.0%) and light red (4.8) in Gubalafto where as in Habru, 40.9% of the total sheep had brown coat color followed by brown dominant (15.2%), white (11.1%), white dominant (8.2%), light red (6.1), light red dominant (5.6%), black (4.6%), dark red (5.1%) and black dominant (3.5%). The current finding on coat color type of Gubalafto sheep is in agreement with previous findings

Table 1. Descriptions of qualitative traits in Habru and Gubalafto sheep in Northern Wollo zone.

Traits	Attribute	Habru sheep						Gubalafto sheep					
		Female		Male		Total		Female		Male		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
Coat color pattern	Plain	80*	58.0	35*	58.3	115*	58.1	119*	69.2	51*	63.8	170*	67.5
	Patchy	35	25.4	16	26.7	51	25.8	32	18.6	23	28.8	55	21.8
	Spotted	23	16.7	9	15.0	32	16.2	21	12.2	6	7.5	27	10.7
	X^2-value	*39.26*		*18.10*		*57.30*		*100.55*		*38.73*		*136.74*	
Coat color type	Black	5	3.6	4	6.7	9	4.6	60*	34.9	27*	33.8	87*	34.5
	White	14	10.1	8	13.3	22	11.1	22	12.8	10	12.5	32	12.7
	Light red	7	5.1	5	8.3	12	6.1	15	8.7	7	8.8	22	8.7
	Dark red	5	3.6	5	8.3	10	5.1	8	4.7	6	7.5	14	5.6
	Brown	61*	44.2	20*	33.3	81*	40.9	6	3.5	-	-	6	2.4
	Gray	-	-	-	-	-	-	8	4.7	5	6.3	13	5.2
	Black dominant	7	5.1	-	-	7	3.5	33	19.2	13	16.3	46	18.3
	White dominant	11	8.0	5	8.3	16	8.1	8	4.7	7	8.8	15	6.0
	Red dominant	5	3.6	6	10.0	11	5.6	7	4.1	5	6.3	12	4.8
	Brown dominant	23	16.7	7	11.7	30	15.2	5	2.9	-	33.8	5	2.0
	X^2-value	*105.65*		*15.47*		*122.45*		*159.40*		*38.20*		*223.71*	
Coat hair type	Hair	116*	84.1	47*	78.3	163*	82.3	12	7.0	7	8.8	19	7.5
	Coarse wool	17	12.3	13	21.7	30	15.2	155*	90.1	68*	85.0	223*	88.5
	Wool	5	3.6	-		5	2.5	5	2.9	5	6.3	10	4.0
	X^2-value	*161.35*		*19.27*		*218.58*		*249.99*		*96.18*		*345.50*	
Hair length	Short	90*	65.2	35*	58.3	125*	63.1	9	5.2	7	8.8	16	6.4
	Medium	29	21.0	17	28.3	46	23.2	148*	86.1	61*	76.3	209*	82.9
	Long	19	13.8	8	13.3	27	13.6	15	8.7	12	15.0	27	10.7
	X^2-value	*64.22*		*18.90*		*81.85*		*215.38*		*66.78*		*279.74*	

Table 1.contd.

	Attribute	Habru sheep						Gubalafto sheep					
		Female		Male		Total		Female		Male		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
Horn	Present	-	-	6	10.0	6	10.0	-	-	70*	87.5	70*	87.5
	Absent	-	-	54*	90.0	54*	90.0	-	-	10	12.5	10	12.5
	X^2-value	-	-	*38.40*		*38.40*				*45.00*		*45.00*	
Horn orientation	Lateral	-	-	6	100.0	6	100.0	-	-	17	24.3	17	24.3
	Backwards	-	-	-		-		-	-	53*	75.7	53*	75.7
	Obliquely upwards	-	-	-	-	-	-	-	-	-		-	
	X^2-value	-	-	-	-	-	-	-	-	*18.51*		*18.51*	
Horn shape	Scurs	-	-	6	10.0	6	10.0	-	-	5	7.1	5	7.1
	Straight	-	-	-	-	-	-	-	-	14	20.0	14	20.0
	Curved	-	-	-	-	-	-	-	-	32*	45.7	32*	45.7
	Spiral	-	-	-	-	-	-	-	-	19	27.1	19	27.1
	X^2-value	-	-	-	-	-	-	-	-	*21.77*		*21.77*	
Ear Orientation	Erect	7	5.1	-	Traits	7	3.5	12	7.0	5	6.3	17	6.8
	Semi-pendulous	85*	61.6	35*	58.3	120*	60.6	86*	50.0	49*	61.3	135*	53.6
	Rudimentary	29	21.0	17	28.3	46	23.2	47	27.3	17	21.3	64	25.4
	Carried horizontally	17	12.3	8	13.3	25	12.6	27	15.7	9	11.3	36	14.3

Table 1.contd.

	X^2-value	*105.59*		*18.90*		*149.27*		*71.67*		*59.80*		*127.46*	
Wattle	Present	6	4.4	-	-	6	3.0	-	-	-	-	-	-
	Absent	132*	95.7	60	100.0	192*	97.0	172	100.0	80	100	252	100
	X^2-value	*115.04*		-		*174.73*		-		-		-	
Body skin color	Pigmented	*138*	*100*	*60*	*100*	*198*	*100*	*172*	*100*	*80*	*100*	*252*	*100*
	Non pigmented	-		-		-		-		-		-	-
	X^2-value	-		-		-		-		-		-	

Table 1.contd.

Traits	Attribute	Habru sheep						Gubalafto sheep					
		Female		Male		Total		Female		Male		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
Ruff	Present	-	-	9	15.0	9	4.6	-	-	13	16.3	13	5.2
	Absent	138	10	51*	85.0	189*	95.5	172	100	67*	83.8	239*	94.8
	X^2-value	-		*29.40*		*163.64*		-		*36.45*		*202.68*	
Head profile	Straight	30	21.7	37*	61.7	67	33.8	45	26.2	49*	61.3	94	37.3
	Concave	96*	69.6	18	30.0	114*	57.8	110*	64.0	21	26.3	131*	52.0
	Convex	12	8.7	5	8.3	17	8.6	17	9.9	10	12.5	27	10.7
	X^2-value	*85.04*		*25.90*		*71.30*		*79.41*		*30.33*		*66.17*	
Tail type	Thin	-	-	-	-	-	-	-	-	-	-	-	-
	Fat rumped	-	-	-	-	-	-	-	-	-	-	-	-
	Thick at base	-	-	-	-	-	-	-	-	-	-	-	-
	Fat	138	100.0	60	100.0	198	100.0	172	100.0	80	100.0	252	100.0
	X^2-value	-		-		-		-		-		-	
Tail shape	Cylindrical straight	17	12.3	7	11.7	24	12.1	25	14.5	13	16.3	38	15.1
	Cylindrical turned up at the end	121*	87.7	53*	88.3	174*	87.9	147*	85.7	67*	83.8	214	84.9
	X^2-value	*78.38*		*35.27*		*113.88*		*86.53*		*36.45*		*122.92*	
Rump profile	Flat	19	13.8	7	11.7	26	13.1	19	11.1	13	16.3	32	12.7
	Sloping	33	23.9	21	35.0	54	27.3	41	23.8	22	56.3	63	25.0
	Roof	86*	62.3	32*	53.3	118*	59.6	112*	65.1	45*	27.5	157*	62.3
	X^2-value	*54.30*		*15.70*		*67.39*		*82.41*		*20.43*		*100.9*	

*P<0.05; N = Number of sheep exhibiting a particular qualitative character; X^2 = Pearson chi-square.

for central highland sheep (Sisay, 2002) and Tikur sheep (Kassahun and Solomon , 2008). Like Habru sheep, brown hair color was frequently observed in Afar sheep (Kassahun and Solomon, 2008) and in 25.3% Mareka sheep (Amelmal, 2011).

In both districts, all the sheep studied are exclusively short fat tailed (100%) where the dominant tail shape is cylindrical with curved tip at the end (84.9% for Gubalafto and 87.9% for Habru). The rest sheep showed tail shape of cylindrical straight with corresponding percentages of 15.1% for Gubalafto and 12.1% for Habru. The sheep in both districts showed considerable variation in development and form of tail. The fat tail in Habru sheep, for example, has wide base and can reach near the point of hock.

The proportions of sheep with straight, concave and convex head profile in Gublafto were 37.3%, 51.9% and 10.7%, respectively and the corresponding proportions for Habru were 33.8%, 57.6%, and 8.6%. According to the result, the majority of the female sample sheep population (69.6% for Habru and 64.0% for Gubalafto) exhibited concave head profile where as the male sheep indicated straight head profile (63.3% for Habru and 61.3 % for Gubalafto). To this end,

Table 2. Least squares Means± Standard errors for fixed effects o f sex, age group and sex by age on body weight (kg) and LBMs (cm) for Habru sheep.

Effects and levels	N	Heart girth	Wither height	Body length	Body weight	Hair length	Ear length	Tail length	Ramp height	Scrotal circumference.
Over all	198	69.93±5.69	59.36± 6.23	57.46±5.17	25.51± 2.15	8.69±2.34	6.45±2.59	19.52±3.60	63.20±6.49	24.26±2.29
CV	198	8.14	10.49	8.99	8.45	26.98	40.16	18.45	10.27	9.44
R^2	198	0.36	0.24	0.22	0.48	0.26	0.02	0.2	0.22	0.15
Sex		*	*	*	*	ns	ns	*	*	
Female	138	67.51±0.55^{b}	57.37 ±0.60^{b}	55.94±0.50^{b}	24.00±0.21^{b}	8.56±0.23^{a}	6.16±0.25^{a}	18.54±0.35^{b}	61.11± 0.62^{b}	-
Male	60	73.38±0.77^{a}	63.48±0.84^{a}	59.68± 0.70^{a}	28.13±0.29^{a}	8.41±0.32^{a}	7.04±0.35^{a}	20.98±0.49^{a}	67.11±0.88^{a}	24.50±0.27
Age group		*	*	*	*	*	ns	*	*	
0 PPI	58	65.27±0.75^{c}	56.93±0.082^{c}	54.26±0.68^{c}	24.17±0.28^{c}	6.80±0.31^{c}	6.40±0.34^{a}	17.56±0.47^{c}	60.71±0.85^{b}	
1 PPI	46	70.34±0.85^{b}	59.52±0.93^{b}	58.37±0.77^{b}	26.01±0.32^{b}	8.43±0.35^{b}	6.38±0.39^{a}	19.58±0.54^{b}	63.05±0.97^{b}	
≥2 PPI	94	75.73±0.85^{a}	64.82±0.93^{a}	60.81±0.77^{a}	28.07±0.32^{a}	10.23±0.35^{a}	7.03±0.39^{a}	22.14±0.54^{a}	68.56±0.61^{a}	
Sex by age group		*	*	*	*	*	ns	*	*	
Female, 0 PPI	31	62.55±1.02^{d}	54.23±1.12^{c}	52.54±0.93^{e}	22.23±0.34^{e}	7.19±0.42^{cd}	6.16±0.47^{a}	16.68±0.65^{d}	58.35±1.17^{c}	
Female, 1 PPI	26	68.23±1.12^{c}	58.38±1.12^{b}	56.73±1.01^{cd}	24.27±0.42^{d}	8.65±0.46^{b}	5.96±0.51^{a}	18.65±0.71^{c}	61.31±1.27^{bc}	
Female, 2 PPI	81	71.77±0.63^{b}	59.48±0.69^{b}	58.54±0.57^{bc}	25.60±0.24^{c}	9.84±0.26^{a}	6.37±0.29^{a}	20.28±0.40^{b}	63.65±0.72^{b}	
Male, 0 PPI	27	68.00±1.10^{c}	59.62± 1.20^{b}	55.96±0.99^{d}	26.11±0.41^{c}	6.41±0.45^{d}	6.63±0.50^{a}	18.44±0.60^{cd}	63.07±1.25^{b}	
Male, 1 PPI	20	72.45±1.27^{b}	60.65±1.39^{b}	60.00±1.16^{ab}	27.75±0.48^{b}	8.20±0.52^{bc}	6.80±0.60^{a}	20.50±0.80^{bc}	64.80±1.45^{b}	
Male, 2PPI	13	79.69±1.58^{a}	70.15±1.73^{a}	63.08±1.43^{a}	30.54±0.60^{a}	10.62±0.65^{a}	7.69±0.72^{a}	24.00±1.00^{a}	73.46±1.80^{a}	

Means with different superscripts within the same column and class are statistically different. Ns = Non significant; *significant at 0.05; 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors.

similar conclusion was made by Sisay (2002) for central highland sheep; but most of female Mareka sheep had slightly convex (93.4%) while few had straight (6.6%) head profile (Amelmal, 2011). The predominant ear forms observed in the sample sheep population were semi-pendulous (60.6% for Habru and 53.6% for Gubalafto) followed by rudimentary (23.2% for Habru and 25.4% for Gubalafto) and carried horizontal ear form (12.6% for Habru and 14.3% for Gubalafto). To this end, similar result was reported by Sisay (2002) for central highland sheep. Tesfaye (2008) also reported semi-pendulous ear form for Menz sheep. Sheep with carried horizontal ear were higher in Gubalafto but rudimentary ear form was more frequently observed in Habru. Like Habru sheep, majority of Afar sheep possessed rudimentary ear forms (Tesfaye, 2008).In Gubalafto, majority (88.5%) of sheep had medium coarse wool coat hair type where as sheep with wool and hair (fur) coat hair type accounted for 7.5 and 4.0%, respectively and long hair length (10.7%) was the 2nd common hair length observed next to medium (82.9%) among the sheep populations in the same district. Such hair type is frequently seen across the cold to very cold mountains and plateau of the central highland (Sisay, 2002). But short wool hair (6.4%) was rarely observed among the sample sheep populations in Gubalafto. Unlike to Gubalafto, hairy or fur hair coat types (82.3%) were most frequently observed among the sample sheep populations in Habru. The proportions of sheep with coarse wool and wool hair coat types were 15.2% and 2.5%, respectively. About 65.2% of Habru sheep had short hair length where sheep with medium and long hair lengths took 21.0% and 13.8%, respectively. Unlike the present finding on sheep hair length where majority of the sample sheep population had short in Habru and medium in Gubalafto districts, Sisay (2002), Kassahun and Solomon (2008) and Tesfaye (2008) reported long coarse wool hair coat type for fat tailed sheep in central high land areas.In the present study, horn was present in 87.5 % male but absent in female Gubalaafto sample sheep population. Most common horn orientation observed in the sample male population in the district were backwards orientation (75.7%) where as the dominant horn shape (45.7 %) were curved one. The remaining 7.1%20.0% and 27.1% had horn shape of scurs, straight and spiral for the same district. The current finding on horn of sheep in Gubalafto is consistent with report by (Sisay 2002; Kassahun and Solomon 2008; and Tesfaye 2008). But about 100% of female and 90% of male sheep in Habru had no horn. Only 10% of the male sample population had horn. Out of the horned rams, all of them had scur horn shape and exclusively, all horned sheep had lateral horn orientation.

Effect of sex by age group interaction

Sex by age group

The least squares means and standard errors for the effect of sex, age group and their interaction on body weight and other LBMs are presented in (Table 2) for Habru sheep and (Table 3) for

Table 3. Least squares Means ± Standard errors for fixed effects of sex, age group and sex by age on body weight (kg) and LBMs (cm) for Gubalafto sheep.

Effects and levels	N	Heart girth	Wither height	Body length	Body weight	Hair length	Ear length	Tail length	Ramp height	N	Scrotal circumference
Over all	252	68.13± 4.71	62.98±4.74	54.86±5.45	23.79± 1.72	10.00±1.95	6.96±2.58	19.14±4.14	66.85±4.31	80	24.26±2.29
CV	252	6.91	7.53	9.93	7.22	19.48	39.41	21.62	6.45	80	9.44
R^2	252	0.37	0.23	0.25	0.55	0.24	0.02	0.03	0.21	80	0.15
Sex		*	*	*	*	*	*	Ns	*		
Female	172	66.57±0.40^{b}	61.80±0.40^{b}	53.22±0.46^{b}	22.55±0.15^{b}	10.38±0.16^{a}	7.13±0.23^{a}	19.03±0.35^{a}	65.84± 0.36^{b}		-
Male	80	69.95±0.56^{a}	64.73±0.56^{a}	57.42± 0.65^{a}	25.86±0.20^{a}	9.02±0.23^{b}	6.44±0.33b	19.34±0.49^{a}	68.58±0.51^{a}	80	24.50±0.27
Age group		*	*	*	*	*	ns	ns	*		
0 PPI	92	64.84± 0.50^{c}	60.54±0.50^{c}	52.71±0.58^{b}	22.91±0.18^{c}	8.78±0.21^{c}	6.78±0.29^{a}	18.51±0.44^{a}	64.91±0.46^{c}	38	23.29±0.37^{b}
1 PPI	45	67.12 ±0.73^{b}	63.20±0.74^{b}	54.23±0.85^{b}	23.75±0.28^{b}	9.78±0.30^{b}	6.71±0.43^{a}	19.81±0.64^{a}	67.30±0.67b	16	24.94±0.57^{a}
≥2 PPI	115	72.83 ±0.52^{a}	66.05±0.53^{a}	59.02±0.61^{a}	25.96±0.19^{a}	10.53±0.22^{a}	6.87±0.31^{a}	19.22±0.46^{a}	69.41±0.48^{a}	26	25.27±0.45^{a}
Sex by age group		*	*	*	*	*	ns	*	*		
Female, 0PPI	54	63.52±0.64^{d}	59.26±0.65^{d}	50.02±0.74^{d}	21.37± 0.23^{e}	9.61±0.27^{b}	6.93±0.37^{a}	18.06±0.56^{b}	63.54±0.59^{c}		-
Female, 1PPI	29	65.79±0.87^{c}	61.66±0.88^{c}	59.90±1.01^{cd}	22.24±0.32^{d}	10.38±0.36^{ab}	7.10±0.51^{a}	19.31±0.77^{a}	66.17±0.80^{b}		-
Female, 2PPI	89	70.39±0.50^{b}	64.48±0.50^{b}	55.73±0.58^{b}	24.03±0.18^{c}	11.15±0.21^{a}	7.35±0.29^{a}	19.72±0.44^{a}	67.82±0.46^{b}		-
Male, 0PPI	38	66.16±0.76^{c}	61.82± 0.77^{c}	54.39±0.88^{bc}	24.45±0.28^{c}	7.95±0.32^{c}	6.53±0.44^{a}	18.97±0.67^{ab}	66.29±0.70^{b}		23.29±0.37^{b}
Male, 1PPI	16	68.44±1.18^{bc}	64.75±1.19^{a}	55.56±1.36^{bc}	25.25±0.43^{b}	9.19±0.49^{b}	6.31±0.69^{a}	20.31±1.03^{ab}	68.44±1.08^{b}		24.94±0.57^{a}
Male, 2PPI	26	75.27 ±0.93^{a}	67.62±0.93^{a}	62.31±1.07^{a}	27.88±0.34^{a}	9.92±0.38^{b}	6..38±0.54^{a}	18.73±0.81^{ab}	71.00±0.85^{a}		25.27±0.45^{a}

Means with different superscripts within the same column and class are statistically different. Ns = Non significant; *significant at 0.05; 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors.

Gubalafto sheep. The interaction of sex and age group was significant ($p<0.05$) for all quantitative traits analyzed except ear length for both Habru and Gubalfto sheep implying that all parameters of body measurements except ear length were affected by the sex-age interaction effect. Heart girth (HG), wither height (WH), body length (BL) and live body weight (LBW) of Habru ram in youngest age group were 68.0 cm, 59.62 cm, 55.96 cm and 26.11 kg, respectively and the values for females in the same age group were 62.55, 54.23, 52.54 cm and 22.23 kg, respectively. The measurements for the oldest age group were 79.69 ,70.15, 63.08 cm and 30.54 kg for males and 71.77, 59.489 and 58.54 cm and 25.60 kg for females, respectively. In all age groups of Habru sheep, males were higher ($p<0.05$) than females but EL was similar for the two sexes at all age groups. In all age groups of Gubalafto sheep, similar to Habru sheep,males were heavier ($p<0.05$) than females except EL which it was similar for both male and female at all age groups. HG, WH, BL and LBW of Gubalafto ram in youngest age group were 66.16, 61.82, 54.39 cm and 24.45 kg, respectively and the values for females in the same age group were 63.52, 59.26, 50.02 cm and 21.37 kg, respectively. The measurements for the oldest age group were 75.27, 67.62, 62.31 cm and 27.88 kg for males and 70.39 cm, 64.48 cm, 55.73 cm and 24.03 kg for females, respectively. Similarly, body weight of females in all age group in the current study was higher that the values reported for Menz ewes (19.1±0.27kg) in the same age group (Tesfaye, 2008).

Body weight and other linear body measurements

The Pearson's correlation coefficient among quantitative variables for all age groups of male and female sample sheep population is presented in (Table 4). Correlations between the quantitative traits in the male sample sheep population showed low to strong positive values. Strong and significant ($P<0.05$) positive associations were observed between body weight and heart girth ($r = 0.98$). Body weight was significantly ($P<0.05$) correlated with all continuous traits considered in this study. But the strong correlation was recorded with heart girth ($r = 0.94$) and body length ($r = 0.59$). The highest correlation of chest girth with body weight than other body measurements was in harmony with other results of (Amelmal, 2011; Tesfaye, 2008; Zewdu, 2008) and it can indicate that chest girth is the best variable for predicting live weight than other measurements. In female sample population, strong and significant ($P<0.05$) positive correlation were also observed between wither height and rump height ($r=0.88$).

Table 4. Pearson's correlation coefficients of quantitative traits of males (above the shadow) and females (bellow the shadow) in Habru and Gubalafto districts.

	LBW	N	HG	N	WH	N	BL	N	TL	N	RH	N	SC
LBW		140	0.98*	140	0.57*	140	0.61*	140	0.32*	140	0.54*	140	0.28*
HG	0.94*	310		140	0.63*	140	0.63*	140	0.32*	140	0.60*	140	0.27*
WH	0.37*	310	0.51*	310		140	0.53*	140	0.34*	140	0.93*	140	0.33*
BL	0.59*	310	0.54*	310	0.30*	310		140	0.10^{ns}	140	0.45*	140	0.22*
TL	0.39*	310	0.39*	310	0.24*	310	0.17*	310		140	0.36*	140	0.12^{ns}
RH	0.32*	310	0.45*	310	0.88*	310	0.24*	310	0.22*	310		140	0.31*
SC	-		-		-		-		-				

N= Number of sheep; *P<0.05; ns=non significant; LBW= live body weight, HG= heart girth, WH= Height at Withers, BL= body length, TL, tail length, RH = Rump height, SC= scrotal circumference.

Table 5. Multiple linear regression analysis of live body weight on different LBMs for female sheep by age group.

Age group	Model	Parameters									
		Intercept	β_1	β_2	β_3	β_4	R^2	C(*p*)	AIC	Root MSE	SBC
0 PPI	HG	1.16±0.97	0.36±0.02	-	-	-	0.87	35.75	-52.29	0.73	-47.40
	HG+WH	0.26±0.89	0.42±0.02	-0.09±0.02		-	0.90	9.06	-74.26	0.63	-66.93
	HG+WH+BL	-0.76±0.95	0.40±0.02	-0.08±0.02	-0.03±0.01	-	0.91	4.59	-78.75	0.61	-68.98
	HG+WH+BL+RH	-0.31±0.99	0.40±0.02	-0.05±0.03	0.03±0.01	-0.03±0.03	0.91	4.28	-79.19	0.61	-66.98
1 PPI	HG	-2.53±1.76	0.38±0.03	-	-	-	0.80	25.41	-19.73	0.82	-15.71
	HG+WH	-0.82±1.63	0.42±0.03	-0.07±0.02	-	-	0.85	10.69	-31.31	0.73	-25.29
	HG+WH+BL	-1.22±1.54	0.38±0.03	-0.07±0.02	0.06±0.02	-	0.87	4.97	-36.93	0.69	-28.90
	HG+WH+BL+TL	-0.98±1.52	0.39±0.03	-0.06±0.02	0.06±0.02	-0.05±0.03	0.87	4.09	-38.06	0.68	-28.02
≥2 PPI	HG	0.11±0.88	0.35±0.01	-	-	-	0.83	44.86	-45.86	0.87	-39.59
	HG+WH	2.22±0.94	0.37±0.01	-0.05±0.01	-	-	0.85	22.59	-64.65	0.82	-55.24
	HG+WH+BL	0.92±0.96	0.35±0.01	-0.06±0.01	0.05±0..01	-	0.86	7.94	-78.53	0.78	-65.99
	HG+WH+BL+TL	0.37±0.97	0.34±0.01	-0.05±0.01	0.05±0.01	0.05±0.02	0.86	4.13	-82.45	0.77	-66.77
Overall	HG	-1.36±0.52	0.37±0.01	-	-	-	0.88	88.07	-115.14	0.83	-107.66
	HG+WH	0.24±0.54	0.40±0.01	-0.06±0.01	-	-	0.90	37.85	-157.22	0.77	-146.01
	HG+WH+BL	-0.73±0.54	0.37±0.01	-0.06±0.01	0.05±0.01	-	0.91	4.24	-189.31	0.73	-174.37

Table 6. Multiple linear regression analysis of live body weight on different LBMs for male sheep by age group

Age group	Model	Parameters								
		Intercept	β_1	β_2	β_3	β_4	R^2	C(*p*)	AIC	Root MSE	SBC
0 PPI	HG	-0.71+0.91	0.37+0.01	-	-	-	0.93	5.37	-70.81	0.57	-66.46
	HG+RH	0.46+0.97	0.40+0.01	-0.03+0.01	-	-	0.94	0.43	-75.99	0.54	-69.47
1 PPI	HG	0.40+1.5	0.36+0.02		-	-	0.95	20.22	-38.49	0.28	-36.95
	HG+WH	1.25+1.32	0.41+0.03	-0.07+0.03	-	-	0.98	5.80	-47.89	0.21	-45.58
	HG+WH+TL	1.40+0.92	0.42+0.02	-0.05+0.02	-0.07+0.02	-	0.99	1.62	-53.82	0.17	-50.73
≥2 PPI	HG	-3.40+1.20	0.42+0.02		-	-	0.95	0.56	-47.21	0.53	-43.88
	HG+WH	-4.71+1.41	0.41+0.02	0.07+0.04	-	-	0.96	0.01	-48.11	0.52	-43.12
Overall	HG	-1.28+0.50	0.39+0.01		-	-	0.96	18.32	-158.23	0.56	-152.35
	HG+TL	-1.30+0.50	0.39+0.01	0.01+0.01	-	-	0.96	6.17	-169.69	0.54	-160.87
	HG+TL+RH	0.46+0.52	0.41+0.01	0.02+0.01	-0.03+0.01	-	0.96	4.67	-171.23	0.53	-159.47
	HG+TL+RH+SC	-1.25+0.67	0.41+0.01	0.02+0.01	-0.04+0.01	-0.05+0.03	0.96	4.13	-171.86	0.53	-157.15

HG = Heart girth; WH = Wither height; TL = Tail length, RH = Rump height; SC = Scrotal circumference; 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor and ≥ 2 PPI = 2 or more pairs of permanent incisors; R2 = R- square; MSE= Mean square of error; AIC= Alkaike's Information Criteria; SBC= Schwarz Bayesian Criteria; C(p)= the Mallows C parameters.

Multiple linear regression analysis

Multiple linear regression equations were developed for predicting body weight (LBW) from other LBMs: Body length (BL), wither height (WH), heart girth (HG), tail length (TL), rump height (RH) and scrotum circumference (SC) for Habru and Gubalafto sheep population. To this end, stepwise multiple linear regression analysis was carried out for each sheep population within each sex and age group and for pooled age group within each sex by entering the LBMs one at a time for male and by excluding SC for females (Tables 5 and 6). Three variables with significant contribution to the prediction model which included heart girth, height at wither and body length were fitted first, second and third, where they accounted for 91% of the total variability of the female sheep for age group 0 PPI. In male sample population, however, heart girth, height at wither and tail

Table 7. Percent classified into each district (hite rate) for female sample populations using discriminant analysis.

District	Gubalafto	Habru	Over all
Gubalafto	162 (94.2)	10 (5.8)	172 (100)
Habru	19 (13.8)	119 (86.2)	138 (100)
Total	181(58.4)	129 (41.6)	310 (100)
Rate	0.0581	0.1377	0.0935
Prior	0.5548	0.4452	

Table 8. Percent classified into each district (hite rate) for sample male populations using discriminant analysis.

District	Gubalafto	Habru	Over all
Gubalafto	76(95.0)	4 (5.0)	80 (100)
Habru	3(5.0)	57 (95.0)	60 (100)
Total	79 (56.4)	61 (43.6)	140 (100)
Rate	0.0500	0.0500	0.0500
Prior	0.5714	0.4286	

length which included in the model first, second and third in that order accounted for 99% of the total variability in live body weight for age group 1 PPI. Across all the age groups of the sample sheep population, heart girth alone accounted for about 88% of the variation in body weight in female sheep and 96% in male sheep. This agrees with findings on indigenous Dawro zone and Konta special woreda sheep population (Amelmal, 2011). The regression analysis to predict body weight from linear measurements indicated that body weight, in most of the cases, could be predicted with a higher level of accuracy from more than one independent trait. Comparable R^2 values were obtained for all relationships existing between LBW and other LBMs for both female and male sample sheep population. Thus under field conditions, live weight estimation using heart 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 as well. Besides, coefficient of determination obtained for all pooled age groups using HG as explanatory variable was high and comparable across the three (0 PPI, 1 PPI and ≥ 2 PPI) age groups.

Discriminant analysis

In case of female sample sheep population, the overall average error count estimate was 9.4 for all observations (Table 7) from both districts, which means that 90.6% of the samples were correctly classified. The error count estimate for male populations (5.0) was even very low as compared to female sample populations (Table 8). This implied that 95.0% of the samples were correctly classified.

Canonical discriminant analysis

All squared Mahalanobis' distances obtained among districts populations for females and males were significant ($P<0.05$), indicating the existence of measurable differences between females and males district populations or districts (Table 9). Canonical analyses showed that Mahalanobis distance of the morphological traits between Habru and Gubalafto sheep was larger. Particularly in male sample sheep population, longest Mahalanobis' distances (12.84) were seen between these two districts. Similarly, larger differentiation (8.05) was observed between the two districts in female sample sheep. All multivariate tests that is, Wilk's Lambda, Pillia's Trace, Hotelling-Lawley Trace and Ray's Greatest Root obtained from canonical discriminant analysis showed significant differences ($P<0.05$) among districts.

In this test, values of most quantitative variables considered were significantly different ($P<0.05$) between districts. For example, the value of Wilks' Lambda was 0.39 and 0.28 for the female and male sample sheep populations, respectively. This shows that most (61% for female and 72% for male) of the variability in the discriminator variables was due to differences between populations rather than variation within populations.

Table 9. Squared Mahalanobis' distance among district populations for male and female sample sheep populations.

	Male		Female	
From district	1	2	1	2
Gubalafto	0	12.84	0	8.05
Habru	10.02	0	7.20	0

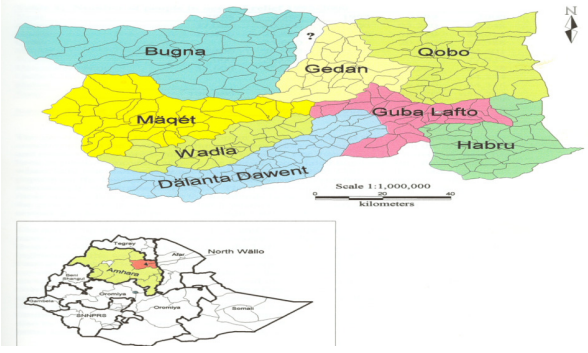

Figure1. Maps of the study areas.

CONCLUSION

Majority of the sheep in the study area have plain brown coat color pattern. 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. All squared Mahalanobis' distances obtained among districts populations for females and males were significant ($P<0.05$), indicating the existence of measurable differences between females and males district populations or districts. The present morphometric information could aid future decision on the management, conservation and improvement of the indigenous 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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