

On Farm Phenotypic Characterization of Indigenous Sheep Types in Wolaita Zone, Southern Ethiopia

Mesfin Asaminew[1*] Kefelegn Kebede[2] Yosef Mekasha[2]
1. Department of Animal Science, Wolaita Soddo Agricultural TVET College, P.O.box 120, Wolaita Soddo, Ethiopia
2. Department of Animal and Range Science, Haramaya University, Haramaya, Ethiopia P.O.box 138, DireDawa, Ethiopia

Abstract
The study was conducted in Soddo Zuria, Damote Gale and Damote Sore districts of Wolaita zone of Southern Nations Nationalities Peoples Regional State. The objectives of the study were to undertake phenotypic characterization of indigenous sheep type under farmers' management condition and to develop equation for prediction of body weight by using linear body measurements. Data on the assessment of qualitative characters and linear body measurements were collected from a total of 630 sheep that were drawn from 180 households. The sampled sheep were identified by sex, age and district. The most dominant coat colour patterns were plain and patchy. Red, red with white spotted and white were the most frequently observed coat colour with short and smooth hair type. Most sheep possessed long fat tail with straight tip. Sex, dentition and district had significant effect on body weight and most of body measurements. Positive and highly significant correlations were observed between body weight and most of the body measurements in both sexes. The result of the multiple regression analysis showed that chest girth explained more variation than any other measurements in both ewes (94%) and rams (93%). The prediction of body weight could be based on regression equation y=-43.62 + 0.98x for female and y=-71.30 + 1.39xfor male sample sheep population where y and x are body weight and chest girth, respectively. Further study of sheep at molecular level should be done to determine the genetic differences of sheep types in the study area.
Keywords: Body weight, characterization, linear body measurement

1. Introduction

Ethiopia is one of the major gateways for domestic sheep migration from Asia to Africa (Devendra and McLeroy, 1982). With 25.5 million sheep (CSA, 2011) and 14 traditional populations (Gizawet al., 2007; Gizaw, 2008), Ethiopia has highly diversified indigenous sheep types which are parallel to the diversity in ecology (Galal, 1983), ethnic communities and production systems in the country (Solomon, 2008). The sheep can survive under harsh environments such as feed scarcity, disease challenges and are highly adapted to low-input systems (Markos et al., 2006). They are also considered as living banks for their owners and serve as source of immediate cash and insurance against crop failure especially where land productivity is low and unreliable due to erratic rainfall, severe erosion, frost, and water logging problems (Markos, 2006).

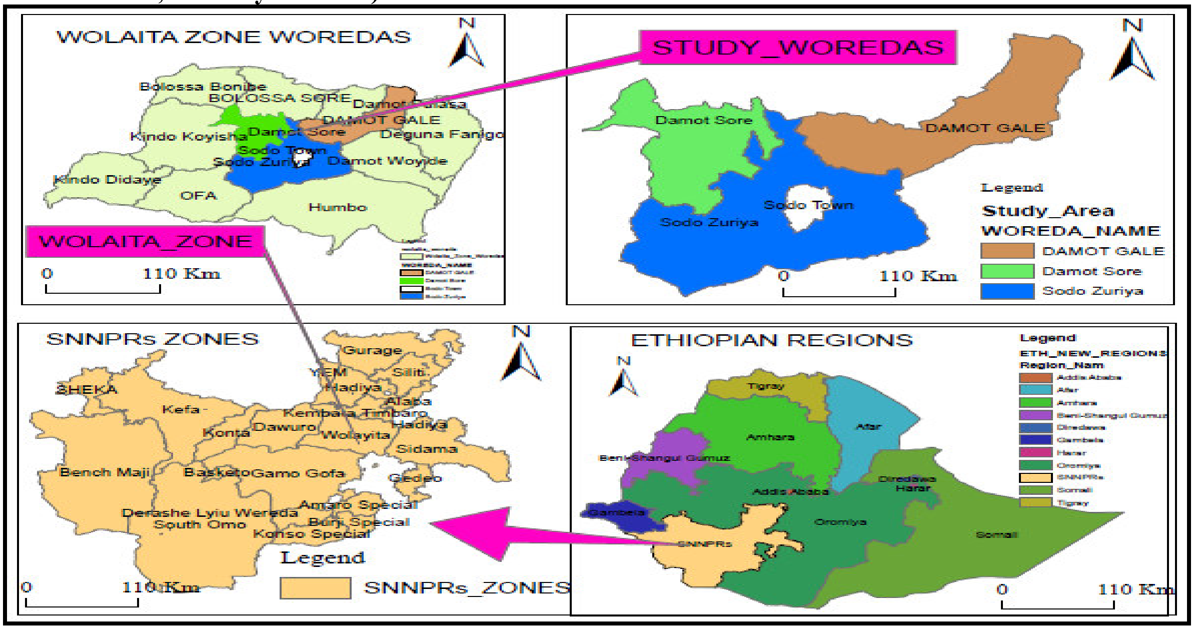
Information on phenotypic and genetic characteristics for majority of indigenous sheep types is not only scarce but also limited to already known specific sheep types involving on-station managed flocks with major emphasis on body weight and related measurements. Often populations bear the names of communities that own them and locations in which they are found. However, there is no clear phenotypic or genetic evidence to show that these names and differential adaptive characters relate to distinct breed types (Zewdu, 2008). A more comprehensive morphological and molecular characterization study was conducted by Gizaw et al.(2007) and Gizaw (2008) using 14 sheep populations that were traditionally recognized, phenotypically distinct, and geographically isolated populations. Detailed and up-to-date information on indigenous knowledge of managing the breed, identification of important traits and typical features with full participation of farmers are important for effective and sustainable utilization of typical sheep breeds (Kosgey et al., 2006). Such information is not adequately available for Wolaita sheep types at smallholder farmer's level. This study, therefore, was carried to undertake phenotypic characterization of indigenous sheep type in their environment and to develop equation for prediction of body weight of sheep by using linear body measurements

2. Materials and methods

2.1. Description of the Study Area

The study was conducted in three districts (Soddo Zuria, Damote Gale and Damote Sore) of Wolaita Zone of the Southern Nations, Nationalities and Peoples Regional state of Ethiopia.

Figure 7. Map of the study area (a: Ethiopia; b: South Nations Nationalities Peoples Regional State; c: Wolaita Zone; d: Study Districts)



Wolaita zone is divided in to 12 woredas and 302 rural and 22 urban kebeles. Wolaita zone possesses agro-ecological zones of 11% of wet highlands (Dega), 57% of intermediate wet highlands (Woyinadega) and 32% of semi-dry lowlands (Kolla). Altitude in the zone ranges between 1500 and 2500 m.a.s.l. except for some parts where it falls below 1500 m. Rainfall occurs in two distinct rainy seasons. 'Kiremt' rains occurring in summer (June, July and August) and 'Belg' rains occurring in spring (the mid February to mid-May period). Mean annual rainfall in the area varies between 800 mm and 1400 mm. Average temperature varies between 17 to 31oc in the zone (CSA, 2004). Environmental variables and sheep populations of the study areas are presented in table below (NMA, 2012).

Table 2. Environmental variables and sheep populations of the study locations

District	Altitude (masl)	Latitude (°N)	Longitude (°E)	Annual avg. max.temp.(°C)	Annl avg. min.temp.(°C)	Annual rainfall(mm)	Total sheep popn the area
Damote Sore	1752	7.98–7.18	37.62–37.83	22.5	17.6	1449	26, 928
Damot Gale	2043	6.89–7.11	37.75–37.99	25.1	13.6	1175	25, 739
Sodo Zuria	1854	6.72–6.99	37.59–37.86	25.6	14.6	1321	23, 457

2.2. Sampling Techniques

A multi-stage purposive sampling technique was employed for selection of districts and peasant associations for the study. In the first stage, districts known for their sheep populations were identified and this was followed by identification of potential peasant association and villages. Potentials for sheep production and road accessibility were used as criteria in selecting the sites. Thus, three districts were purposively selected based on sheep population potential and road accessibility. From each districts three peasant associations (PA) was selected purposively based on the same criteria. A total of 630 sheep were used for physical measurements (210 from each district).

2.3. Data Collection

2.3.1. Qualitative traits

Visual observation was made and morphological features were recorded based on breed morphological characteristics descriptor list of FAO (2012) for phenotypic characterization of sheep. Each animal was identified by its sex, dentition and sampling site. Dentition record was included, as this was the only reliable means to estimate the approximate age of an animal.

2.3.2. Quantitative trait

Linear body measurements were taken using measuring tape while body weight of animals was measured using suspended spring balance. Sheep were classified into five age groups: no pair of permanent incisor (0 PPI), 1PPI, 2 PPI, 3 PPI and 4 PPI to represent age of less than 1 year, 1-1 1/2 years, 1½-2years, 2½-3 years and more than three years, respectively (Wilson, 1991).

2.4. Data Management and Analysis

2.4.1. Qualitative and body measurement data

Qualitative and quantitative body measurement data were first entered into Excel 2007 computer software and analyzed using Statistical Analysis System (SAS version 9.2, 2008). Qualitative data were analyzed using the frequency procedure of SAS (2008) while quantitative data were analyzed using the Generalized Linear Model (GLM) procedure of SAS. Sex, district and age group were fitted as fixed effects while linear body measurements were fitted as dependent variables. When analysis of variance declares significance, least square means were separated. Pearson's correlation coefficients were estimated among body weight and linear body measurements and between linear body measurements for females and males (SAS, 2008). Pearson's correlation coefficients) between body weight and the linear measurements were computed for the population within each sex. A multiple correspondence analysis was carried out on qualitative traits to determine their associations on a bi-dimensional graph. The REG procedures of SAS (2008) were used to determine the best fitted regression equation for the prediction of body weight from linear body measurements. For male sheep body weight and other body measurements including height at whither (HW), body length (BL), chest depth(CD),chest girth (CG),rump length (RL), rump height(RH),pelvic width(PW), shoulder width(SW), head width (HW), head length (HL),cannon bone length (CBL), cannon bone circumference (CBC), ear length (EL), horn length (HL), tail length (TL),tail circumference (TC) and scrotum circumference (SC)were considered. For female sheeps, the same body measurements except scrotum circumference were considered.

The following models were used for the estimation of bodyweight from LBM (s).

For Male:

$Y=\beta o+\beta 1X1+\beta 2X2+\ldots+ \beta 17X17+ ej$

Where:

Y=the response variable (bodyweight)

βo=the intercept

X1,…,X17 are the explanatory variables(height at whither, body length, chest depth, chest girth, rump length, rump height, pelvic width, shoulder width, head width, head length, cannon bone length, cannon bone circumference, ear length, horn length, tail length, tail circumference and scrotum circumference)

β1,…, β17are regression coefficients of the variables X1,…,X17

ej=random error

For female:

$Y=\beta o+\beta 1X1+\beta 2X2+ \ldots + \beta 16X16+ej$

Where:

Y=the dependent variable body weight

βo=the intercept

X1,...,X16 are independent variables (height at whither, body length, chest depth, chest girth, rump length, rump height, pelvic width, shoulder width, head width, head length, cannon bone length , cannon bone circumference , ear length , horn length, tail length and tail circumference)

β1,…,β16 are regression coefficients of the variable X1,…,X16

ej=random error

3. Results and discussion

3.1. Phenotypic Characterization

3.1.1. Qualitative traits

The observed overall coat color pattern for both sexes were plain (58.1%), patchy (28.7%) and spotted (13.2%) (Table 2). This is consistent with the reports of Edea et al. (2010) and Markos and Ginbar (2004) for Bonga and Horro sheep types, respectively. The result indicate that plain red(30.2 %) was the most frequently observed hair coat color followed by red with white spotted (19.7%) and white coat color (17.3 %).These findings are in good agreement with Galal (1983)who reported for Menz sheep and Markoset al.,(2004) and Edea et al. (2010) who reported for Horro and Bonga sheep. Most of the sheep(78.1%) in the study area were characterized by possessing short and smooth hair coat type, whereas the rest (21.9%) of the sampled sheep population was long and course. The predominant tail type observed in sample sheep populations were long fat tail (78.7%) in both sexes followed distantly by the long thin tail (17.3%). The proportion of long fat tail was higher in females (83.7%) as compared to males (72.1%) while differences were observed in the long thin tail of rams (23.4%) was replaced higher frequency than ewes (12.7%). The tail form as observed indicate that both the rams and ewes had tail dominantly ending with a straight tip (95.4%) with small proportion of curved at the tip (4.6%).These findings are inagreement with Gizaw, (2008) for Adilo and Arsi-Bale, Getachew et al., (2010) for Horro and Menz and Edea et al. (2010) for Bonga sheep. In other studies conducted by Markos et al.,(2004) and Getachew et al., (2010), the Menz sheep had a characteristic short fat tail, which was curved upward at the tip.

The majority (93.8%) of sheep population in the study area had straight head profile with few frequency of concave (4%) and convex (2.2 %) head profiles, respectively (Table 2). In contrast to this, those rams & ewes with concave head profile were observed in large numbers in sheeps in Gamogofa and Gurage Silite (87%)(Aberaetal., 2013). The majority (68.4%) of sampled sheep populations were polled, whereas, 31.6%were horned. Higher proportion of horned was observed in males (63.9%) as compared to females (7.5%) whereas the polled ewes (92.5%) outnumbered the polled rams (36.9%). Rudimentary horn shape (77.9%) predominates in the study areas, whereas about 11.6% and 10.6% of them were having a horn with curved and straight shape, respectively. None had a horn with spiral shape. Ear forms oriented horizontally were the most frequently observed in the districts which accounts for 67.9% of the sampled population, whereas 30.5% of them had semi-pendulous ear orientation. Proportionately semi pendulous ear forms were higher in females (34.3%) as compared to males (25.3%).The presence of wattle in the study area was less pronounced for both male and female populations. A total of only 11.1% of both male and female sheep population possessed wattle whereas the majorities (88.9%) were devoid of wattles. Ruff was grossly absent in most of sheep in the study area.

Figure 8. Matured Wolaita ram sheep (left) and Wolaita sheep ram and ewe of different coat color pattern (right)

Table 3 Qualitative traits of Sheep population in the study area

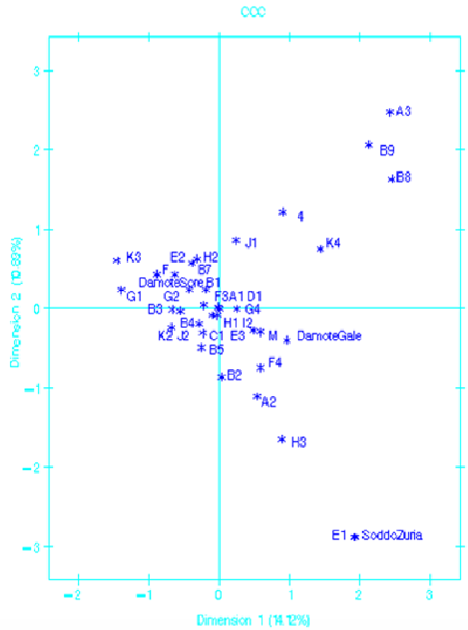
	Districts						
Qualitative Character	Soddo Zuria		Damote Gale		Damote Sore		Overall mean for both sexes
	Female N (%)	Male N (%)	Female N (%)	Male N (%)	Female N (%)	Female N (%)	N (%)
Coat color Pattern							
Plain	78(57.8)	44(58.7)	45(57.7)	76(57.5)	88(59.5	35(56.5)	366(58.1)
Patchy	37(27.4)	20(26.7)	23(29.5)	38(28.8)	45(30.4	18(29)	181(28.7)
Spotted	20(14.8)	11(14.7)	10(12.8)	18(13.6)	15(10.1)	9(14.5)	83(13.2)
			X^2 value=1.217ns				
Coat color type							
Red	40(29.6)	23(30.7)	23(29.5)	41(31.1)	44(29.7)	19(30.6)	190(30.2)
White	25(18.5)	12(16)	1519.2)	21(15.9)	27(18.2)	9(14.5)	109(17.3)
Black	6(4.4)	4(5.3)	3(3.8)	5(3.8)	6(4.1)	3(4.8)	27(4.3)
Brown	7(5.2)	4(5.3)	4(5.1)	7(5.3)	8(5.4)	3(4.8)	33(5.20)
Grey	16(11.9)	8(10.7)	9(11.5)	14(10.6)	17(11.5)	7(11.3)	71(11.3)
Red + White	27(20)	14(18.7)	16(20.5)	25(18.9)	30(20.3)	12(19.4)	124(19.7)
White + Grey	4(3)	3(4)	2(2.6)	5(3.8)	4(2.7)	3(4.8)	21(3.3)
Brown +	5(3.7)	3(4)	3(3.8)	5(3.8)	5(3.4)	2(3.2)	23(3.7)
Black + White	5(3.7)	4(5.33)	3(3.8)	9(6.8)	7(4.7)	4(6.53)	32(5.1)
			X^2 value =0.819ns				
Hair coat type							
Short &Smooth	109(80.7)	59(78.7)	68(87.2)	88(66.7)	120(81.1)	48(77.4)	492(78.1)
Long &Course	26(19.3)	16(21.3)	10(12.8)	44(33.3)	28(18.9)	14(22.6)	138(21.9)
			X^2 value =2.672ns				
Horn							
Present	0(0)	75(100)	5(6.4)	64(48.5)	22(14.9)	33(53.2)	199(31.6)
Absent	135(100)	0(0)	73(93.6)	68(51.5)	126(85.1)	29(46.8)	431(68.4)
			X^2 value =4.642ns				
Horn shape							
Rudimentary	0(0)	75(100)	5(100)	52(81.2)	4(18.2)	19(57.6)	155(77.9)
Straight	0(0)	0(0)	0(0)	0(0)	14(63.6)	7(21.2)	21(10.6)
Curved	0(0)	0(0)	0(0)	12(18.8)	4(18.2)	7(21.2)	23(11.6)
			X^2 value =83.166*				
Horn orientation							
Polled	135(100)	0(0)	73(100)	68(85)	126(87.5)	29(67.4)	431(90.5)
Upward	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Backward	0(0)	0(0)	0(0)	8(10)	18(12.5)	8(18.6)	34(7.1)
Lateral	0(0)	1(100)	0(0)	4(5)	0(0)	6(14)	11(2.3)
			X2 value =27.04*				

Ear orientation							
Erect	2(1.5)	0(0)	3(3.8)	0(0)	5(3.4)	0(0)	10(1.6)
Semi-pendulous	52(38.5)	19(25.3)	25(32.1)	35(26.5)	47(31.8)	14(22.6)	192(30.5)
Pendulous	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Horizontal	81(60)	56(74.7)	50(64.1)	97(73.5)	96(64.9)	48(77.4)	428(67.9)
	X^2 value =2.925ns						
Head profile							
Straight	128(94.8)	69(92)	73(93.6)	123(93.2)	141(95.3)	57(91.9)	591(93.8)
Concave	4(3)	4(5.3)	3(3.8)	7(5.3)	4(2.7)	3(4.8)	25(4)
Convex	3(2.2)	2(2.7)	2(2.6)	2(1.5)	3(2)	2(3.2)	14(2.2)
Markedly convex	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
	X^2 value =0.71ns						
Rump profile							
Flat	0(0.00)	0(0.00)	0(0.00))	0(0.00)	0(0.00)	0(0.00)	0(0.00)
Sloppy	135(100)	75(100)	78(100)	132(100)	148(100)	62(100)	630(100)
Roofy	0(0.00))	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
	X^2 value =1.217ns						
Tail Type							
Short Fat tailed	2(1.5)	2(2.7)	1(1.3)	4(3)	2(1.35)	0(0)	11(1.7)
Long Fat tailed	112(83)	54(72)	65(83.3)	94(71.2)	125(84.5)	46(74.2)	496(78.7)
Short Thin tailed	3(2.2)	2(2.7)	2(2.6)	3(2.3)	3(2.03)	1(1.6)	14(2.2)
Long Thin tailed	18(13.3)	17(22.7)	10(12.8)	31(23.5)	18(12.2)	15(24.2)	109(17.3)
	X^2 value =2.81ns						
Tail Form							
Curved tip	6(4.4)	4(5.33)	4(5.1)	6(4.5)	7(4.7)	2(3.2)	29(4.6)
Straight tip	129(95.6)	71(94.7)	74(94.9)	126(95.5)	141(95.3)	60(96.8)	601(95.4)
Blunt	0(0.00))	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
	X^2 value =0.072ns						
Wattle							
Present	18(13.3)	7(9.3)	9(11.5)	11(8.3)	19(12.8)	6(9.7)	70(11.1)
Absent	117(86.7)	68(90.67)	69(88.5)	121(91.7)	129(87.2)	56(90.3)	560(88.9)
	X^2 value =0.803ns						

ns=non-significant;*P<0.05

A multiple correspondence analysis was carried out on the eleven qualitative traits recorded and a bi-dimensional graph representing the associations among the different categories of qualitative traits is presented in Figure 4. The interpretation is based on points found in approximately the same direction from the origin and in approximately the same region of the space. From the figure it can be seen that 25.01% of the total variation is explained by the first two dimensions (14.12%) by the first and (10.89%) by the second dimensions. On the identified dimensions, the sheep population in Damote Sore district were clustered with red, black, brown and white dominant on gray coat color type, plain coat color pattern, erect and semi-pendulous ear orientation, concave facial profile, backward horn orientation, straight horn shape, long fat and short thin tailed tail type, and no wattle. In Damote Gale district the sheep populations were closely associated with white and gray coat color type, patchy coat color pattern, horizontally carried ear orientation, straight head profile, curved horn shape, lateral horn orientation, sloppy rump profile and long thin tailed tail type. Whereas, in Soddo Zuria district the sheep population was closely associated with scurs/rudimentary horn shape and convex facial profile.

Figure 9. Bi-dimensional plot showing the associations among the categories of the different morphological variables



Legend for figure 3

Variable Name	Levels and Description
Coat color Pattern	A1=Plain A2=Patchy A3=Spotted
Coat color type	B1= Red B2= White B3= Black B4= Brown B5= Gray B6=Red dominant on white B7=White dominant on grey B8= Brown dominant B9= Black dominant on white
Hair coat type	C1 = Short & Smooth hair C2 = Long & Smooth hair C3 = Short & Course hair C4 = Long & Course hair
Horn	D1=Present D2=Absent
Horn shape	E1 = Scurs/Rudimentary E2 = Straight E3 = Curved E4 = Spiral
Horn orientation Ear orientation	F1=Polled or just stumps F2 = Obliquely Upward F3 = Backward F4 = Lateral
Head Profile	G1=Erect G2=Semi-pendulous G3=Pendulous G4=Carried
Rump Profile	horizontally
Wattle	H1=Straight H2= Concave H3= Convex I1=Flat I2= Sloping I3= Roofy J1=Present J2=Absent
Tail Type	K1 =Short Fat tailed K2 = Long Fat tailed K3 = Short Thin tailed K4 = Long Thin tailed K5 = Fat ramped

3.1.2. Body weight and linear body measurements

Sex effect: -The least square means and standard errors for the effect of sex and their interaction on body weight and other body measurement are presented in Table 3. In all districts sex has significant effect on body weight and most of linear body measurements. Male sheep were having consistently higher values of body weight, chest girth, height at wither, body length, pelvic width, shoulder width, chest depth, head length, cannon bone length, cannon bone circumference, tail circumference and rump height than females except ear length which is higher in females. Head width, tail length and rump length were not affected by sex.

Age effect:-The size and shape of the animal increases until the animal reach its maturity and the effect of age on body weight and other body measurements were also observed in different sheep breeds of Ethiopia (Tesfaye, 2008). Body weight and all body measurements were significantly affected by age group except horn length. All the body measurements were increased as the age increased from the intermediate age group (0PPI) to the oldest4PPIage group.

Sex by age interaction:-The interaction of sex and age group were significantly ($p < 0.05$) different for body weight (BW),height at whither (HW), body length (BL), chest girth (CG), rump height (RH), head width (HW), cannon bone length (CBL), pelvic width (PW), head length(HDL), ear length (EL), tail length (TL) and tail circumference (TC) (Table 25). However, shoulder width (SW), chest depth (CD), cannon bone circumference (CBC), horn length (HL), and rump length (RL) were not significantly affected by the sex-age interaction effect. The value of body weight for sheep of both sexes increased as dentition class increased from 0PPI to 4PPI.

District Effect: - District had a significant effect on body weight and all other linear body measurements except chest depth.

Table 4. Least square mean (± SE) body weight (kg) and other linear body measurements by sex, age and district

Effect and	BW	CG	HW	BL	PW	SW	CD	HDW	HDL
Level	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	26.7±0.20	71.21±0.17	65.17±0.17	65.13±0.18	16.79±0.08	16.95±0.07	30.64±0.15	9.26±0.05	18.15±0.07
CV%	7.02	2.25	3.0.	2.78	6.03	5.27	10.3	8.02	4.9
R^2	0.86	0.85	0.78	0.83	0.69	0.73	0.34	0.66	0.67
Sex	*	*	*	*	*	*	*	NS	*
Female	25.22 ±0.26^{b}	70.54 ±0.26^{b}	63.29±0.20^{b}	63.55±0.22^{b}	16.99±0.12^{a}	16.50 ±0.09^{b}	29.74 ±0.23^{b}	9.20 ±0.07^{a}	18.0 ±0.09^{b}
Male	28.51 ±0.29^{a}	72.03 ±0.20^{a}	67.48 ±0.22^{a}	67.06 ±0.24^{a}	16.55 ±0.10^{b}	17.52±0.12^{a}	31.73 ±0.16^{a}	9.34 ±0.08^{a}	18.34±0.10^{a}
Age	*	*	*	*	*	*	*	*	*
0PPI	21.80±0.31^{e}	66.96±0.30^{e}	61.82±0.32^{e}	61.30±0.34^{e}	14.92±0.07^{e}	15.30±0.12^{e}	28.2±0.20^{d}	7.9±0.07^{e}	16.29±0.07^{d}
1PPI	25.27±0.25^{d}	69.64±0.20^{d}	64.39±0.28^{d}	63.79±0.23^{d}	16.30±0.08^{d}	16.65±0.11^{d}	30.69±0.20^{c}	8.93±0.08^{d}	18.25±0.11^{c}
2PPI	28.48±0.27^{c}	73.03±0.18^{c}	66.61±0.20^{c}	67.04±0.20^{c}	17.61±0.11^{c}	17.66±0.10^{c}	30.73±0.43^{c}	9.91±0.06^{c}	18.90±0.09^{b}
3PPI	31.81±0.42^{b}	75.72±0.24^{b}	68.63±0.40^{a}	69.33±0.41^{a}	18.03±0.18^{b}	18.24±0.16^{b}	32.94±0.17^{b}	10.4±0.08^{b}	19.09±0.11^{b}
4PPI	32.49±0.20^{a}	76.41±0.16^{a}	67.51±0.21^{b}	68.08±0.13^{b}	20.13±0.26^{a}	18.87±0.10^{a}	34.03±0.22^{a}	10.8±0.10^{a}	19.92±0.15^{a}
District	*	*	*	*	*	*	Ns	*	*
Soddo Zuria	27.11±0.27^{a}	72.15±0.23^{a}	64.92±0.26^{b}	65.50±0.21^{b}	17.58±0.16^{a}	16.35±0.11^{b}	30.49±0.36^{a}	9.04±0.10^{b}	18.80±0.12^{a}
Damote Gale	27.97±0.40^{a}	71.68±0.29^{a}	66.62±0.33^{a}	66.70±0.34^{a}	16.70±0.11^{b}	17.85±0.12^{a}	30.96±0.19^{a}	9.22±0.09^{b}	17.83±0.10^{b}
Damote Sor	25.0±0.35^{b}	69.79±0.34^{b}	63.97±0.25^{c}	63.20±0.31^{c}	16.10±0.10^{c}	16.66±0.12^{b}	30.46±0.19^{a}	9.52±0.08^{a}	17.81±0.10^{b}
Sexbyage	*	*	*	*	*	NS	NS	*	*
Female, 0PPI	18.36±0.22	63.33±0.32	58.07±0.22	57.22±0.31	14.66±0.08	14.54±0.12	26.21±0.14	7.51±0.09	15.70±0.09
Female,1PPI	22.37±0.18	68.04±0.23	61.11±0.25	61.26±0.20	16.18±0.11	15.64±0.11	29.04±0.20	8.34±0.11	17.58±0.14
Female,2PPI	26.28±0.21	72.30±0.26	64.76±0.11	65.55±0.15	17.52±0.18	16.83±0.08	29.09±0.66	9.75±0.07	18.47±0.10
Female,3PPI	29.31±0.22	74.42±0.16	66.24±0.19	66.83±0.16	17.63±0.23	17.50±0.15	32.29±0.18	10.10±0.08	18.92±0.14
Female,4PPI	32.49±0.20	76.41±0.16	67.51±0.21	68.08/±0.13	20.13±0.26	18.87±0.10	34.03±0.22	10.80±0.10	19.92±0.15
Male, 0PPI	24.26±0.31	69.54±0.18	64.49±0.30	64.20±0.27	15.11±0.10	15.85±0.14	29.63±0.23	8.18±0.09	16.70±0.08
Male,1PPI	27.62±0.23	70.93±0.21	67.05±0.23	65.83±0.23	16.39±0.11	17.46±0.11	32.02±0.24	9.40±0.09	18.80±0.14
Male,2PPI	31.63±0.25	74.08±0.17	69.25±0.18	69.17±0.25	17.75±0.10	18.86±0.12	33.09±0.20	10.10±0.09	19.51±0.13
Male,3PPI	37.83±0.25	78.83±0.23	74.37±0.18	75.33±0.24	19.0±0.15	20.0±0.15	34.50±0.18	11.0±0.15	19.50±0.18

Effect and	CNL	CNC	TL	TC	RH	RL	EL	HL	SC
Level	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	16.17±0.06	10.12±0.07	29.7±0.15	18.77 ±0.15	66.74±0.17	19.99±0.24	10.33±0.03	8.16±0.93	22.77±0.22
CV%	4.86	8.16	7.17	7.69	2.75	20.04	7.46	31.59	3.22
R^2	0.69	0.79	0.69	0.84	0.78	0.36	0.19	0.48	0.13
Sex	*	*	NS	*	*	NS	*	*	-
Female	16.01 ±0.07^{b}	9.74±0.09^{b}	29.70 ±0.22^{a}	17.19 ±0.16^{b}	65.36 ±0.21^{b}	19.71 ±0.43^{a}	10.45±0.05^{a}	5.23 ±0.12	NA
Male	16.38 ±0.10^{a}	10.58 ±0.11^{a}	29.71 ±0.21^{a}	20.69 ±0.22^{a}	68.44 ±0.23^{a}	20.34 ±0.14^{a}	10.17 ±0.05^{b}	9.75±1.33	22.77±0.22
Age	*	*	*	*	*	*	*	NS	*
0PPI	14.66±0.08e	8.32±0.12^{d}	26.68±0.14^{d}	15.06±0.20^{e}	62.81±0.31^{d}	17.95±0.17^{d}	9.93±0.06^{d}	11.5±2.46	21.33±0.31^{c}
1PPI	16.12±0.07^{d}	9.82±0.12^{c}	29.17±0.29^{c}	18.95±0.23^{d}	66.16±0.22^{c}	19.38±0.20^{c}	10.26±0.06^{c}	6.69±0.98	23.51±0.33^{b}
2PPI	16.66±0.09^{c}	10.87±0.11^{b}	31.23±0.29^{b}	20.14±0.26^{c}	68.32±0.22^{b}	19.97±0.22^{c}	10.40±0.07^{b}	12±3.024	25.0±0.11^{a}
3PPI	17.30±0.14^{b}	11.65±0.10^{a}	30.79±0.28^{b}	21.03±0.35^{b}	70.10±0.34^{a}	21.76±0.24^{b}	10.56±0.10^{b}	5.0±0	NA
4PPI	17.69±0.13^{a}	11.74±0.07^{a}	35.49±0.31^{a}	21.79±0.20^{a}	70.36±0.18^{a}	26.54±3.41^{a}	11.31±0.12^{a}	NA	NA
Location	*	*	*	*	*	*	*	*	*
Soddo Zuria	15.64±0.09^{c}	9.06±0.12^{c}	32.57±0.32^{a}	18.15±0.20^{b}	67.19±0.20^{b}	17.73±0.22^{c}	10.44±0.05^{a}	NA	23.22±0.25^{a}
Damote Gale	16.67±0.12^{a}	10.80±0.12^{a}	27.69±0.13^{c}	19.76±0.32^{a}	67.99±0.31^{a}	18.85±0.14^{b}	10.00±0.06^{b}	17±0	23.15±0.62^{a}
Damote Sore	16.22±0.09^{b}	10.48±0.10^{b}	28.86±0.17^{b}	18.39±0.24^{b}	65.05±0.30^{c}	23.40±0.62^{a}	10.53±0.07^{a}	7.38±0.9	22.26±0.39^{b}
Sexbyage	*	NS	*	*	*	NS	*	NA	NA
Female, 0PPI	14.57±0.10	7.57±0.09	25.10±0.12	13.09±0.22	59.63±0.32	16.99±0.22	9.75±0.09	6±0	NA
Female,1PPI	15.89±0.10	8.84±0.17	27.71±0.28	16.13±0.18	63.80±0.19	17.61±0.23	10.32±0.07	NA	NA
Female,2PPI	15.97±0.07	10.10±0.11	31.28±0.34	17.72±0.18	66.56±0.18	18.68±0.22	10.51±0.08	NA	NA
Female,3PPI	16.60±0.12	11.22±0.08	30.92±0.40	18.96±0.19	68.08±0.18	22.08±0.33	10.72±0.10	5±0	NA
Female,4PPI	17.69±0.13	11.74±0.07	35.49±0.31	21.79±0.21	70.36±0.18	26.54±3.41	11.31±0.12	NA	NA
Male, 0PPI	14.73±0.11	8.85±0.15	27.81±0.15	16.46±0.19	65.09±0.30	18.64±0.23	10.06±0.07	17±0	21.33±0.31
Male,1PPI	16.31±0.09	10.62±0.12	30.35±0.44	21.22±0.16	68.07±0.21	20.82±0.21	10.22±0.09	6.69±0.98	23.51±0.33
Male,2PPI	17.66±0.10	12.05±0.11	31.15±0.51	23.60±0.14	70.83±0.22	21.82±0.29	10.25±0.11	12.0±3.02	25.0±0.11
Male,3PPI	19.0±0.15	12.67±0.14	30.50±0.09	26.0±0.15	74.93±0.21	21.0±0.15	10.17±0.20	NA	NA

column with different superscripts within the specified dentition group are significantly different ($P<0.05$); Ns = Non-significant ($P>0.05$); *significant at 0.05; N.A= not available, EL= Ear length; RH= rump height; CBL= cannon bone length; RL= Rump length; RW= Rump width; SC= Scrotal circumference; BL= body length; CG= chest girth; HW=height at wither; BW=bodyweight; 0PPI=No Pair of Permanent Incisors; 1PPI=1 Pair of

Permanent Incisors; 2PPI=2 Pairs of Permanent Incisors; 3PPI=3 Pairs of Permanent Incisors; 4PPI=4 pair of permanent incisors.

3.2. Correlation between Body Weight and Linear Body Measurements

In males positive and strong association were found between body weight and chest girth (r=0.96), wither height (r=0.95), body length (r=0.95), rump height (r=0.96), pelvic width (r=0.89), tail circumference (r=0.82), cannon bone length (r=0.81) and Chest depth (r=0.81). These linear body measurements were highly affected by the change in body weight; hence, they are more important in prediction of body weight of the animal. Cannon bone circumference (r=0.62), head width(r=0.73), head length(r=0.73) and Shoulder width(r=0.78) had moderate and positive correlation with body weight. Tail length (r=0.41), rump length(r=0.23) and ear length(r=0.31) showed mild and positive correlation, whereas Horn length did not showed significant correlation. In females also chest girth (r=0.97), body length (r=0.96), height at wither (r=0.93), rump height (r=0.96), tail circumference (r=0.90), Shoulder width (r=0.88), head length (r=0.88) and head width (r=0.86) showed strong positive correlation with body weight. Ear length (r=0.65) and cannon bone length (r=0.62) had moderate and positive correlation with body weight. Rump length(r=0.34) showed mild and positive correlation, whereas horn length showed negative correlation with body weight. Among the body measurements, chest girth was the most strongly correlated trait with body weight (r= 0.96 for males; r= 0.97 for females). This highest association of chest girth with body weight than other body measurements was in agreement with other results (Thiruvenkadan, 2005; Afolayan et al., 2006).

Table 5. Coefficient of correlations between body weight and linear body measurements (Above diagonal for female and below diagonal for male)

	BW	HG	HW	BL	PW	SW	CD	HDW	HDL	CNL	CNC	TL	TC	RH	RL	EL
BW	1	.97*	.93*	.96*	.81*	.88*	.60*	.86*	.88*	.77*	.84*	.84*	.90*	.96*	.34*	.65*
HG	.96*	1	.90*	.97*	.79*	.83*	.55*	.82*	.88*	.72*	.78*	.83*	.86*	.97*	.30*	.61*
HW	.96*	.92*	1	.91*	.73*	.90*	.57*	.91*	.84*	.79*	.90*	.77*	.88*	.90*	.37*	.66*
BL	.96*	.94*	.94*	1	.75*	.83*	.55*	.82*	.86*	.70*	.78*	.81*	.83*	.96*	.29*	.60*
PW	.90*	.88*	.85*	.86*	1	.78*	.45*	.73*	.89*	.65*	.65*	.94*	.84*	.80*	.11^{ns}	.49*
SW	.78*	.75*	.73*	.76*	.91*	1	.61*	.92*	.82*	.89*	.9*	.76*	.86*	.84*	.36*	.69*
CD	.81*	.79*	.79*	.74*	.83*	.69*	1	.60*	.56*	.63*	.61*	.48*	.6*	.58*	.33*	.53*
HDW	.73*	.74*	.64*	.65*	.88*	.80*	.76*	1	.79*	.86*	.93*	.73*	.85*	.82*	.35*	.72*
HDL	.73*	.70*	.68*	.62*	.82*	.69*	.86*	.84*	1	.76*	.72*	.91*	.89*	.88*	.21*	.63*
CBL	.81*	.80*	.72*	.76*	.93*	.92*	.72*	.91*	.76*	1	.84*	.63*	.81*	.74*	.37*	.73*
CBC	.62*	.60*	.53*	.58*	.79*	.90*	.52*	.79*	.62*	.91*	1	.63*	.78*	.78*	.39*	.62*
TL	.40*	.42*	.36*	.31*	.45*	.19*	.71*	.58*	.77*	.33*	.15*	1	.88*	.83*	.20*	.54*
TC	.82*	.76*	.75*	.75*	.90*	.92*	.70*	.86*	.78*	.94*	.89*	.33*	1	.87*	.40*	.69*
RH	.97*	.91*	.94*	.94*	.89*	.80*	.78*	.69*	.71*	.79*	.62*	.34*	.82*	1	.31*	.64*
RL	.23*	.22*	.12^{ns}	.14^{ns}	.47*	.51*	.27*	.71*	.57*	.62*	.67*	.35*	.64*	.23*	1	.35*
EL	.31*	.34*	.31*	.27	.47*	.37*	.54*	.56*	.59*	.35*	.28*	.50*	.31*	.33*	.40*	1
SC	.73*	.59*	.67*	.66*	.67*	.57*	.63*	.49*	.65*	.49*	.30*	.49*	.62*	.71*	.26*	.39*

BW=Body weight; CG=Chest girth; HW=Height at whither; BL=Body length; PW=Pelvic width; SW=Shoulder width; CD=Chest depth; HDW=Head width; HDL=Head length; CBL=Cannon bone length; CBC=Cannon bone circumference; TL=Tail length; TC=Tail circumference; RH=Rump height; RL=Rump length; EL=Ear length; HL=Horn length; SC= Scrotum circumference; *P<0.05.

3.3. Prediction of Body Weight from LBMs

Weight has been the pivot on which animal production thrives. The knowledge of livestock weight assessment remains the backbone on which all animal production management practices are hinged (Otoikhian, etal., 2008). Multiple linear regression analysis was carried out to predict live body weight of an animal. Regression of body weight over independent variables, which have higher correlation with body weight, was done to set adequate model for the prediction of body weight separately for each sex. In this study in order to develop the prediction equation, only five quantitative traits were selected in the prediction equation for ewes (HG, SW, CC, TL and RH) and only five linear body measurements were taken to be incorporated in to the model for rams (HG, HW, CL, RH and EL) (Table 4 and 5). The fitted prediction model was selected with smaller value of C (p), AIC, SBC, RMSE and higher R2 values. Chest girth selected first, which explain more variation than any other linear body measurements in both ewes (94%) and rams (93%). Although there is slight increment on adjusted R2 value when new variable added in the model, in the case of field measurement or if there is no availability of enough equipments and materials for measurement using only chest girth measurement for the prediction of body weight might be sufficient. The overall equation for all age group using CG as explanatory variable might be used for the prediction of body weight for male and female sample sheep population in all districts. Thus, prediction of body weight could be based on regression equation y = -43.62 + 0.98x for female sample population and y = -71.30 + 1.39x for male sample sheep population where, y and x are body weight and chest girth, respectively.

Table 6. Multiple regression analysis of live weight on different body measurements of ewes in all age groups

Model	Parameters												
	Interc.	*β1*	*β2*	*β3*	*β4*	*β5*	R^2	Adj.R2	C(p)	AIC	RMSE	SBC	SSE
HG	-43.6	.98					0.94	0.94	364.32	108.1	1.16	115.81	468.4
HG + SW	-41.1	.76	.76				0.96	0.96	115.73	-41.6	0.94	-30.12	302.4
HG + SW + CBC	-39.0	.75	.50	.30			0.96	0.96	91.72	-60.0	0.91	-44.62	285.2
HG + SW + CBC + TL	-36.4	.69	.36	.39	.10		0.97	0.97	70.06	-77.6	0.89	-58.37	269.5
HG + SW + CBC + TL + RH	-39.6	.53	.28	.40	.09	.24	0.97	0.97	43.74	-100.6	0.86	-77.54	250.8

HG = Heart girth; SW = Shoulder width; CC = Cannon Bone Circumference; TL = Tail length; RL = Rump Height

Table 7. Multiple regression analysis of live weight on different body measurements of rams in all age groups

Model	Parameters												
	Interc.	*β1*	*β2*	*β3*	*β4*	*β5*	R^2	Adj.R^2	C(p)	AIC	RMSE	SBC	SSE
HG	-71.3	1.4					0.92	0.92	1140.5	160.6	1.3	167.9	492.1
HG + HW	-68.1	.75	.62				0.96	0.96	442.92	-29.5	0.9	-18.6	249.6
HG + HW + CBL	-63.2	.59	.63	.39			0.97	0.97	317.60	-82.6	0.9	-68.0	205.5
HG + HW + CBL + RH	-64.5	.53	31	.20	.44		0.98	0.98	123.76	-194.2	0.7	-175.9	137.6
HG + HW + CBL + RH + EL	-63.4	.54	.30	22	.45	-.22	0.98	0.98	101.43	-210.1	0.7	-188.2	129.1

HG = Heart (Chest) girth; HW =Height at Wither; CL = Cannon Bone Length; RH = Rump Height; EL = Ear Length

4. Summary, conclusions and recommendations

The most dominant coat colour patterns in the sample populations were plain and patchy with red, red with white spotted and white the most frequently observed coat color types. Most of the sheep were characterized by possessing short and smooth hair coat type. The predominant tail type observed in both sexes of sampled sheep populations were long fat tail with straight at the tip. The majority of the sample populations had straight head profile with few frequency of concave profile. Horn was absent (polled) in most of the sampled sheep populations and rudimentary horn shape predominates for those horned sheep. The most frequently observed ear orientations were horizontal and semi-pendulous. The majorities of male and female sheep population were devoid of wattles. Ruff was grossly absent in most of sheep in the study area. Sex of animals had significant effect ($P<0.05$) on body weight and most of body measurements except head width, tail length and rump length. District also had significant effect $P<0.05$) on body weight and most of body measurements except chest depth. Dentition classes of animals contributed significant differences to body weight and most of the linear body measurements except horn length. Generally, positive and highly significant ($P<0.01$) correlations were observed between body weight and most of the body measurements in both males and females. Chest girth was selected first, which explain more variation than any other linear body measurement in both ewes (94%) and rams (93%). The prediction of body weight could be based on regression equation $y = -43.62 + 0.98x$ for female and $y = -71.30 + 1.39x$ for male sample sheep population where y and x are body weight and chest girth, respectively. Generally most of the body measurements of sheep were affected by sex and dentition class differently, whereas district effect was not apparent across all of the body measurements. Further characterization of sheep in the study area at molecular level should be done.

References

Aberra Melesse, Sandip Banerjee, Admasu Lakew, Fekadu Mersha, Fsahatsion Hailemariam,Shimelis Tsegaye and Tafesse Makebo. 2013. Morphological characterization of indigenous sheep in Southern Regional State, Ethiopia. *International journal of Animal Genetic Resources*52: 39–50. doi:10.1017/S2078633612000513.

Afolayan, R.A., I.A.Adeyinka and C, A, M.Lakpinin, 2006. The estimation of live weight from body measurements in Yankasa sheep.*Czech J.Anim.Sci*. 51:343-348.

CSA (Central Statistics Authority). 2004. The 2001/02 Ethiopian Agricultural Sample Enumeration (EASE), Executive Summary, May, 2004, Addis Ababa, Ethiopia.

CSA (Central Statistics Authority) 2011. Ethiopian Agricultural SampleEnumeration for the year 2010/2011. Statistical Report on FarmManagement Practices, Livestock and Farm Implements. CentralStatistical Authority, Addis Ababa, Ethiopia.

Devendra, C and McLeroy,G.B. 1982. Goat and sheep production in the tropics. In:Intermediate Tropical Agricultural Series. Longman, London/New York, 271p

Edea, Z., Haile, A., Tibbo, M., Sharma, A.K., Assefa, D., Sölkner, J. & Wurzinger, M. 2010. Morphological characterization of Bonga and Horro indigenous sheep breeds under smallholder conditions in Ethiopia. *Ethiopian Journal of Animal Production* 9(1): 117–133.

FAO. 2012. Draft Guidelines on Phenotypic Characterization of Animal Genetic Resources. Commission on Genetic Resources for Food and Agriculture. Thirteenth, Regular session, Rome, 18-22 July 2012.

Galal, E.S.E. 1983. Sheep germplasm in Ethiopia. Animal Genetic Resources Information 1: 4–12. (available at: ftp://ftp.fao.org/docrep/ fao/012/q7426t/q7426t00.pdf).

Getachew Tadesse, Alemargot Haile, Markos Tibbo, A.K. Sharma, J. Solkner and M. Wurzinger, 2010. Herd management and breeding practices of sheep owners in a mixed crop livestock and a pastoral system of Ethiopia. Debre Brehan Research Center, Ethiopia

Gizaw, S. 2008. Sheep resources of Ethiopia: genetic diversity and breeding strategy. Wageningen University, Wageningen, The Netherlands, 145 pp. (Ph.D. thesis

Gizaw, S., Van Arendonk, J.A.M., Komen, H., Windig, J.J. & Hanotte, O. 2007. Population structure, genetic variation and morphological diversity in indigenous sheep of Ethiopia. *Animal Genetics* 38: 621–628.

Kosgey, I., R. Baker, H. Udo and Van Arendonk,J.A.M. 2006. Successes and failures of small ruminant breeding programmes in the tropics: *A Review of Small Ruminant. Res*. 61:13-28.

Markos Tibbo and Ginbar, T. 2004. Phenotypic characterization of the Bonga sheep in Kaffa zone: Field mission Report. 10p

Markos Tibbo, Workeneh Ayalew, Kassahun Awgichew, Ewnetu Ermias and J. E. O. Rege, 2004. On-station characterization of indigenous Menz and Horro sheep breeds in the central highlands of Ethiopia. AGRI, 35: 61-74.

Markos Tibbo. 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. Doctoral Thesis, Swedish University of Agricultural Sciences. Uppsala, Sweden.74p.

Markos Tibbo, Philipsson, J.& Workneh Ayalew. 2006. Sustainable sheep breeding programmes in the tropics: a frame work for Ethiopia. Poster presented at Conference on International Agricultural Research for Development, University of Bonn, 11–13 October, 2006, Bonn, Germany

NMA (National Metrological Agency). 2012. Awassa Branch Directorate. Southern Nations, Nationalities and Peoples of Regional State, Ethiopia

SAS (Statistical Analysis System), 2008. SAS for windows, Release 9.1.3 SAS Institute, Inc., Cary, NC, USA.

Solomon Gizaw. 2008. Sheep resources of Ethiopia: genetic diversity and breeding strategy. PhD thesis, Wageningen University, The Netherlands

Tesfaye Getachew. 2008. Characterization of Menz and Afar Indigenous Sheep Breeds of Smallholders and Pastoralist for Designing Community Based Breeding Strategies in Ethiopia. An M Sc. Thesis presented to the School of Graduate Studies of Haramaya University, Dire Dawa, Ethiopia

Thiruvenkadan, A. K. 2005. Determination of best-fitted regression model for estimation of body weight in Kanni Adu Kids under farmer's management system. *Livestock research forRural Development*.17: 1-11

Wilson, R.T. 1991. Small ruminant production and the small ruminant genetic resource in Tropical Africa. *Animal prod Health*. FAO, Rome. 88:20-28.

Zewdu Edea. 2008. Characterization of Horro and Bonga indigenous sheep breeds of smallholders for designing community based-breeding strategies. An MSC Thesis Presented to Shool of Graduate Studies of Haramaya University, Ethiopia. 81p. 125p.