

Full Length Research Paper

Phenotypic characterization of indigenous Maefur goat population in Tigray, Northern Ethiopia

Weldeyesus Gebreyowhens^{1*} and Rohatash Kumar²

¹Mekelle Agricultural Research Center, P. O. Box 258, Mekelle, Tigray, Ethiopia.

²Department of Animal, Rangeland, and Wildlife Science College of Dry Land Agriculture and Natural Resources, the School of Graduate Studies, Mekelle University, Mekelle, Tigray, Ethiopia.

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The study was conducted in Erob district eastern Tigray, Ethiopia to phenotypic characterize Maefur goat based on physical body feature and linear body measurements. Six hundred (297 male and 303 female) goats were randomly selected and grouped into four age groups of 0, 1, 2 and ≥ 3 PPI. General Linear Model (GLM) procedure of SPSS version 16.0 and descriptive statistical analysis were used to summarize the collected data. Short ear size (12.3 cm for male and 11.8 cm for female), long and thick horn, medium body size (42.8 kg for male and 32.7 kg for female), and large heart girth (82.1 cm for male and 73.4 cm for female) are the major body characteristics of Maefur goat breed. There was a significant ($P < 0.05$) effect of sex and age on live body weight and linear measurements. Mean \pm SE of live body weight, heart girth, body length and height at wither in male were 34.7 ± 0.57 kg, 75.3 ± 0.53 cm, 64.3 ± 0.61 cm and 64.7 ± 0.46 cm, respectively while in female 28.9 ± 0.35 kg, 70.0 ± 0.33 cm, 60.0 ± 0.40 cm, and 59.3 ± 0.31 cm, respectively. For heart girth in these age groups were 61.1 ± 0.53 , 69.4 ± 0.33 , 70.6 ± 0.4 and 77.7 ± 0.39 cm, respectively while body length were 50.3 ± 0.43 , 56.8 ± 0.42 , 59.3 ± 0.58 and 68.2 ± 0.42 cm, respectively. For height at wither in these age groups were 54.0 ± 0.45 , 59.1 ± 0.35 , 58.4 ± 0.32 and 66.5 ± 0.40 cm, respectively. Heart girth and height at wither were significantly ($P < 0.05$) different among the age groups except between 13-18 and 19-24 months. The study revealed that large heart girth is a unique characteristic of the Maefur indigenous goat. The study concluded that Maefur goat breed is identified as one of the potential goat breed in Tigray, Ethiopia.

Key words: Indigenous goat, Maefur goat, phenotypic characterization, body measurement.

INTRODUCTION

The day to day livelihood activity of smallholder farmers depends on the agricultural practices in almost all part of Ethiopia. The contribution of agriculture in Ethiopian accounts for more than 40% of the national GDP, 90% of

exports, and serve as source of income and basic needs to more than 90% of the poor farmers (Diao, 2010). Ethiopia is endowed with huge livestock biodiversity adapted to varied agro ecological conditions. Among the

*Corresponding author. E-mail: welde26@yahoo.com.

farm animal genetic resources, indigenous goats have unique adaptive mechanisms which enable them to fit in varied agro ecologies and contribute to the livelihood of small holder farmers through producing valuable milk and meat products. Within the agro ecology there are also sub agro ecologies and developed in to niches as home of specific adapted ecotypes. Kolo et al. (2015) described the domestic goat (*Capra Aegagrus*) as a subspecies of goat domesticated from the wild goat of southwest Asia and Eastern Europe. FARM-Africa (1996) described the origin and historical distribution of the highland indigenous goat population of Ethiopia that emphasized on documentation of the goat breeds. The institute of biodiversity conservation (IBC) documented fifteen (15) indigenous goat breeds inhabited in the low land, midland, and highland agro ecologies of Ethiopia (IBC, 2004). The total population of goat in Ethiopia are reported as 24.06 million of which 99.99% are indigenous goat breeds (CSA, 2013). To ensure sustainable utilization of the indigenous goat, there should be a conservation strategy for the present and future use. Phenotypic characterization is the first step for identification of qualitative and quantitative traits of the indigenous goat. An accurate description of Maefur goat kept under extensive management conditions would enable an accurate comparison of this breed with other goat breeds and improvement programs can then be developed using such information. Body weight and linear body measurements determine body size which is important to classify goat breed into groups. Based on height at wither and body weight, indigenous goat in Ethiopia are classified in to three classes (large, >65 cm and weighing 37-50 kg; small, 51-65 cm and weighing 26-36 kg; dwarf, <50 cm and weighing 18-25 kg) (Kassahun and Solomon, 2008). The improvement on local goat depends on the phenotypic information for mass selection, whereby individuals with better trait values is chosen to be parents of the next generation (Carneiro et al., 2010). Maefur goats population is one of the potential indigenous goat breeds found in the regional government of Tigray but not yet well described with limited attempts to characterization for sustainable utilization and designing management intervention under smallholder farmer. Hence identifying and characterizing Maefur indigenous goat population is very important to integrate animals into various production systems and to make effective use of their potential. The objectives of this study were to phenotypic characterization of the indigenous Maefur goat population using linear body measurement (LBM) and physical body characteristics and to evaluate the effect of sex and age on body weight and LBM under extensive management conditions.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Erob district found 47 km northeast of

Adigrat in the eastern zone Tigray. It is located at 14010' to 14025'N and 390 40' to 390 50'E (Tesfay et al., 2011). The max and min annual temperature ranges from 25 to 30°C and 12 to 16°C, respectively. Mean annual rainfall ranges from 250 to 300 mm during the rainy months of June and August (EAZT, 2005). The study area covers an altitude ranging between 1200 and 3000 m above sea level (Tesfay et al., 2011). It has also notable topographic features including the "Ayga" (Appendix Figure 2) and "Assimba" mountains (Appendix Figure 3).

Sampling procedure

Purposive sampling of the district and potential PA was used because of the existence of the potential indigenous goat population named as Maefur DAGRIS (2004) and the information about their distribution in the regional government of Tigray is already reported by Tigray Agricultural Research Institute but no one tried to reach them for phenotypic characterization. About 600 randomly selected indigenous goats of 49.5% male and 50.5% female goats were used during phenotypic characterization. The variables measured included live weight recorded using Salter scale with capacity of 50 kg (accuracy nearest 200 g) and linear body measurements using meter tape (1.5 meter and accuracy 0.5 cm). Age of the sampled animals was determined using dentition as recommended by Solomon (2009) and Wilson and Durkin (1984). The selected animals were grouped into one of the following age categories: 0 PPI (04 to 12 month with 46 male and 36 female, 1 PPI (13 to 18 months) with 47 male and 40 female, 2 PPI (19 to 24 months) 57 male and 77 female, and ≥ 3 PPI (25 to 36 months and above) with 147 male and 150 female. Linear body measurements recorded for each study animal were heart girth, height at withers, height at rump, shoulder width, chest depth, body length, ear length, ear width, horn length, head width and head length.

Procedures of recording body measurements

The coat color (using color chart) and pattern, shape and orientation of the horns and ears, size of tail, and profile of head, back and rump can be recorded using coded descriptors (FAO, 2012). Descriptive information should be recorded on the common flock sizes and structures as well as uses.

Recording LBM

Linear body measurements (LBM) were recorded in the morning before the animals are fed, with the animals standing on a flat surface with head held up (Appendix Table 1). Hanging spring scale was used to measure body weight (BW) to the nearest 0.1 kg. Heart girth (HG) was measured by taking the circumference of the chest using a tailor's tape calibrated in cm, taken as the circumference of the body immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body. Height at wither (HW) was measured as the distance from the ground to the withers. Height at rump (HR) is measured as the distance from the ground to the rump. Shoulder width (SW) was measured as a distance between the shoulders. Chest depth (CD) was measured as the distance between the top behind the scapular and the flow of the sternum (taken to be the depth of brisket) immediately behind forelegs. Body length was the distance from the head of humerus to the distal end of the pubic bone.

Statistical data analysis

Different analysis methods were applied using SPSS version 16.0

software program. Live body weight and linear body measurements were subjected to List-square analysis of variance using the General Linear Model (GLM) procedure of SPSS version 16.0 with sex and age as fixed effects. The Tukey's simultaneous test was used to separate significance of least-square means. Physical body traits were analyzed using descriptive analysis for mean and standard deviation (quantitative data) and frequency (qualitative) of the variables.

$Y_{ij} = \mu + S_i + A_j + L_{ij} + E_{ij}$ Model 1 (General Linear Model, GLM)

Where: Y_{ij} = the observation of the i^{th} animal within the j^{th} age of i^{th} sex; μ = overall mean; S_i = effect of the i^{th} sex (male and female); A_j = effect of j^{th} age (04-12, 13-18, 19-24, and 25-35 months and above); L_{ij} = interaction effect of the i^{th} sex and j^{th} age groups, and E_{ij} = Random error factor.

The effect of sex, age and their interaction on live body weight and linear body measurements were determined at 5% level of significance. Least-squares means for sex and age groups were separated using Student's t-test and Duncan's Multiple Range Test (DMRT), respectively. The difference between and among the least squares means was determined at 5% level of significance. Indices were calculated in the excel Microsoft to provide ranking of the observed body and head color.

Index = Sum of [4 for tick + 3 for rank 1 + 2 for rank 2 + 1 for rank 3] for each color divided by sum of [4 for tick + 3 for rank 1 + 2 for rank 2 + 1 for rank 3] for each color

RESULTS AND DISCUSSION

Physical body characteristic of the indigenous Maefur goat population

The study observed variety of coat pattern in Maefur goat population. The overall coat color pattern of the sampled goat was described as spotty (32.3%), pied 27%, uniform (25%) and shaded (light brown, black, and gray) (15.3%) (Table 1). Medium (1-2 mm) (64%) and short (29.3%) hair length were the overall description of the indigenous Maefur goat population. Short, narrow, thin, and laterally oriented ear (92% of incidence) was the overall characteristic of Maefur indigenous goat breed. This observation of the current study revealed that Maefur goat has dominant lateral ear orientation distinguished from Begait goat with dropped ear orientation. Solomon (2009) stated that ear orientation and size are important for discrimination of more related indigenous goat breeds. The overall descriptions for horn orientation of the observed indigenous Maefur goat breed were backward (45%) and upright (41%), respectively with frequently observed straight (81%) and spiral (18%) horn shapes. The overall body shape characteristics of the sampled Maefur goat breed was in-between with 76% and lanky with 20% (Figure 1). The dominant body shapes (in-between leggy and compacted) had some implication to distinguish Maefur indigenous goat from 12 indigenous goat breed of Ethiopia documented by DAGRIS (2004) and Kassahun and Solomon (2008). Concave (83%) and flat (straight 16%) facial profiles were the most descriptor for the overall facial profile of Maefur goat breed.

Body color of the indigenous Maefur goat was

assessed using randomly selected 750 goats 5 goats from each 150 household (Appendix Figure 1). The most frequently observed body coat color was beige, black and brown with an index value of 0.30, 0.20 and 0.18 (Table 2). Figure 2 illustrates the variety of morphological characteristics of Maefur goat flock. The smooth hair type with spotty coat color, long horn (straight and spiral) and sometimes polled in male), short ear size, straight facial profile and potential for meat improvement are the most important physical characteristics of the indigenous goat population. It has its own distinguishing feature and local name apart from the afar goat. Afar goats are characterized as small breed in Ethiopia (Solomon, 2009). The afar goats are recognized with local name of Adal in Afar region and widar (dwarf) in the border area of Tigray brought to be sold in Mekelle city for meat purpose. Maefur and Afar goat populations are distinct in phenotypic performance (Maefur has larger body size than afar goat) but they have some similarities in the coat color patterns (Figure 2 and Appendix Figure 10).

Body weight and linear body measurement in Maefur goat

Table 3 summarized the least squares means for live body weight and body measurement in different age groups and sex for the Maefur goat breed. The main source of variation on live body weight and linear body measurement were sex, age and the interaction of both sex and age.

Effect of age, sex and their interaction on body weight and linear body measurements

There was a significant ($P < 0.001$) variation for live body weight, heart girth, height wither, height at rump, shoulder width, body length, chest depth, horn length, tail length, head width and head length among the four age groups (04-12, 13-18, 19-24 and 25-35 months) but no significant ($P > 0.05$) variation for ear length and ear width among these age groups. The variation for live body weight, heart girth, height withers, height at rump, shoulder width, body length, and chest depth was also significant ($P < 0.001$) between male and female but no significant ($P > 0.05$) variation for horn length, tail length, ear length, ear width, head width and head length for interaction of sex and age group. The report of this finding is in line to the findings reported by Khan et al. (2006) and Fajemilehin and Salako (2008) and Alemayehu et al. (2012).

Live body weight and linear body measurements

Live body weight

The average live body weight of Maefur male goat in four age groups (04-12, 13-18, 19-24 and 25-35 months) was

Table 1. Morphological features of Maefur goat population.

Morphology traits	Variable	Male		Female		Overall	
		N	%	N	%	N	%
Coat pattern	Pied	50	33.3	32	21	82	27.3
	Spotty	30	20.0	67	45	97	32.3
	Shaded	16	10.7	30	20	46	15.3
	Uniform	54	36.0	21	14	75	25.0
	Subtotal	150	100.0	150	100.0	300	100.0
Hair length	Medium(1-2mm)	93	62	99	66	192	64.0
	Long(>2mm)	11	7	9	6	20	6.7
	Short(<1mm)	46	31	42	28	88	29.3
	Subtotal	150	100.0	150	100.0	300	100.0
Hair type	Curly	5	3	4	3	9	3.0
	Glossy	51	34	52	35	103	34.3
	Smooth	74	49	78	52	152	50.7
	Dull	7	5	9	6	16	5.3
	Straight	13	9	7	5	20	6.7
	Subtotal	150	100.0	150	100.0	300	100.0
Ear orientation	Lateral	141	94	135	90	276	92.0
	Dropping	1	1	3	2	4	1.3
	Forward	2	1	3	2	5	1.7
	Upright	6	4	9	6	15	5.0
	Subtotal	150	100.0	150	100.0	300	100.0
Horn presence	Present	136	91	138	97	274	93.5
	Absent	14	9	5	3	19	6.5
	Subtotal	150	100.0	143	100.0	293	100.0
Horn shape	Curved	3	2	5	3	8	2.7
	Spiral	27	18	12	8	39	13.0
	Polled	8	5	0	0	8	2.7
	Straight	111	74	133	89	244	81.3
	Subtotal	150	100	150	100.0	300	100.0
Horn orientation	Upright	86	57	37	25	123	41.0
	Forward	3	2	4	3	7	2.3
	Lateral	40	27	94	63	134	44.7
	Dropping	12	8	15	10	27	9.0
	Polled	9	6	0	0	9	3.0
	Subtotal	150	100.0	150	100.0	300	100.0
Body shape	Compact	5	3	5	5	10	4.1
	Lanky/leggy	30	20	23	25	53	22.0
	In between	115	77	63	69	178	73.9
	Subtotal	150	100	91	100	241	100
Face profile	Flat	30	20	19	13	49	16.3
	Concave	118	79	130	87	248	82.7
	Convex	2	1	1	1	3	1.0
	Subtotal	150	100.0	150	100.0	300	100.0
Beard	Absent	25	17	150	50.0	175	58.3
	Present	125	83	0	.0	125	41.7
	Subtotal	150	100.0	150	100.0	300	100.0



Figure 1. Adult male (left) and female (right).

Table 2. Ranked body color of Maefur goat breed in the study site.

Body color	Ranks			Index
	1	2	3	
Aqua	1	-	-	0.00
Beige	224	112	29	0.30
Black	144	90	14	0.20
Blue	2	1	-	0.00
Blue gray	67	21	7	0.08
Brown	155	37	9	0.18
Darker red	3	7	2	0.01
Gray	48	30	11	0.07
Orange	7	2	-	0.01
Red	1	-	-	0.00
Red brown	39	12	3	0.05
Violet	5	20	0	0.02
White	54	65	6	0.10
Total	750	397	81	1.00

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular body color of goats divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all body color of randomly selected goats.

20.5±3.3, 28.6±3.1, 31.2±4.1 and 42.8± 6.6 kg, respectively while that of female in the same age groups were noted as 18.5±4.4, 26.4±2.9, 27.9±4.59, and 32.7±4.1 kg, respectively (Table 4). Significant ($P<0.05$) difference was found in live body weight between male

and female goat in all age groups. This finding of the current study is agreed with the report of Khan et al. (2006) and Alemayehu et al. (2012). The average live body weight of Maefur goat was 42.8 and 32.7 kg for adult male and female goat, respectively. For pooled sex



Figure 2. Maefur goat flock.

of the adult Maefur goat, the average live body weight was 37.7 kg. For the indigenous goat breed of Ethiopia, the average live body weight for Gumuz, Agew goats, Begia-Medir goats, Bati goat, Abergelle goats, and Central Abergelle goats was 34.6, 31.5, 32.5, 29.9 and 28.1, 27.9 kg, respectively (Hassen et al., 2012). According the east Africa goat size classification method, body size of the goat breed is categorized in to three groups: Small (20-30 kg), medium (30-45 kg) and large (45-60 kg) (Kiwuwa, 1992).

Accordingly, Maefur goat is classified as medium sized indigenous goat. Saanen goat is a large goat breed with average live body weight of 65 kg for male and 50 kg for female (Pesmen and Yardimci, 2008). Therefore, live body weight is among the production trait used to classify goat population in to breed standard and are important in giving information about the morphological structure and development ability of the animal (Kiwuwa, 1992, Hassen et al., 2012; Riva et al., 2002). Ethiopian goats are classified according to the body weight and height at wither. Based on the average adult age (25-35 months), both male and female Maefur goats have medium body size.

Heart girth

The average heart girth of Maefur male goat in four age groups (04-12,13-18,19-24 and 25-35 months) were found to be 61.9±3.8, 69.9±3.2, 72.8±4.7 and 82.1±6.3

cm while that of female in these age groups were investigated to be 59.9±5.8, 68.7±2.7, 69.0±4.1 and 73.4± 3.2 cm, respectively. Significant ($P<0.05$) difference was reported in heart girth between male and female goat within age group 3 and 4. There was no significant ($P>0.05$) difference in heart girth between male and female in the age group of 1 and 2. The average heart girth 82.1 cm for male and 73.4 cm for female adult Maefur goat breed was higher than that of Abergelle reported as 68.67 and 64.44 cm for adult male and female, respectively (Alemayehu et al., 2012). Body size of the adult goat is the indication of heart girth, body length, height at wither and height at rump. Among these major linear body measurement heart girth is widely used to classify physical characteristic of Ethiopian goat families and breeds (Solomon, 2009). Adult female Maefur goat with an average value of heart girth 73.4 cm had comparable size with Western Highland goats with 75.8 cm classified as large whereas Afar goat with average heart girth 67.4 cm are classified as small indigenous goat in Ethiopia (Solomon, 2009).

Height at wither

The average height at wither of Maefur male goat in four age groups (04-12, 13-18, 19-24 and 25-35 months) were determined as 55.5±3.9, 59.4±2.8, 60.9±3.1, and 70.8±6.1 cm while that of female in these age groups were recorded to be 52.2 ± 3.7, 58.7± 3.8, 56.6±3.1 and

Table 3. MANOVA for live body weight and linear body traits of the indigenous Maefur goat.

Source variation	of	Df	Body measurement (cm)											
			LBW	HG	HW	HR	ShW	BL	ChD	EL	EW	HL	TL	HeW
Age	3	8080.1 ^a	6703 ^a	4572 ^a	1611 ^a	84 ^a	8691.1 ^a	230.4 ^a	13.0 ^b	0.8 ^b	967.9 ^a	33.0 ^a	452.5 ^a	500.0 ^a
Sex	1	5755.4 ^a	4785.0 ^a	4925.2 ^a	2443.0 ^a	202.4 ^a	3736.2 ^a	320.0 ^a	14.5 ^b	2.5 ^b	1159.4 ^a	0.1 ^b	522.5 ^a	291.7 ^a
Age X Sex	3	578.5 ^a	509.5 ^a	442.9 ^a	269.6 ^a	42.9 ^a	641.1 ^a	97.7 ^a	4.1 ^b	1.4 ^b	42.8 ^b	7.4 ^b	38.5 ^b	24.8 ^b
Residual	592	22.5	21.2	20.3	19.3	3.3	31.6	7.1	5.8	1.1	22.6	4.1	18.1	9.6

^a Significant at ($P < 0.001$) and ^b not significant at ($P > 0.05$); HG=Heart girth; WH=Height Wither; RH=Rump height; ShW=Shoulder Width; BL=Body length; ChD=Chest depth; EL=Ear Length; EW=Ear width; HL=Horn, Length; TL=Tail Length; HeW=Head Width; HeL=Head length.

Table 4. Mean value \pm (SD) of the linear body measurement and body weight.

Variable	0PPI		1PPI		2 PPI		≥ 3 PPI	
	Male N=46	Female N=36	Male N=47	Female N=40	Male N=57	Female N=77	Male N=147	Female N=150
BW	20.5 \pm 3.3 ^a	18.5 \pm 4.4 ^b	28.6 \pm 3.1 ^a	26.4 \pm 2.9 ^b	31.2 \pm 4.1 ^a	27.9 \pm 4.6 ^b	42.8 \pm 6.6 ^a	32.7 \pm 4.1 ^b
HG	61.9 \pm 3.8 ^a	59.9 \pm 5.8 ^a	69.9 \pm 3.2 ^a	68.7 \pm 2.7 ^a	72.8 \pm 4.7 ^a	69.0 \pm 4.1 ^b	82.1 \pm 6.3 ^a	73.4 \pm 3.2 ^b
HW	55.5 \pm 3.9 ^a	52.2 \pm 3.7 ^a	59.4 \pm 2.8 ^a	58.7 \pm 3.8 ^a	60.9 \pm 3.1 ^a	56.6 \pm 3.1 ^b	70.8 \pm 6.1 ^a	62.3 \pm 4.6 ^b
HR	56.8 \pm 4.7 ^a	56.2 \pm 4.9 ^a	61.8 \pm 4.1 ^a	61.2 \pm 4.3 ^a	62.2 \pm 4.2 ^a	58.5 \pm 5.1 ^b	67.6 \pm 4.5 ^a	61.5 \pm 3.9 ^b
SW	10.1 \pm 1.7 ^a	8.5 \pm 2.3 ^b	9.7 \pm 3.1 ^a	10.8 \pm 2.0 ^a	11.6 \pm 1.5 ^a	10.3 \pm 2.0 ^b	12.1 \pm 1.4 ^a	10.4 \pm 1.5 ^b
BL	51.0 \pm 4.1 ^a	49.4 \pm 3.6 ^a	56.2 \pm 4.0 ^a	57.5 \pm 3.7 ^a	61.8 \pm 6.8 ^a	57.6 \pm 6.4 ^b	72.3 \pm 7.1 ^a	64.3 \pm 5 ^b
CD	7.0 \pm 2.3 ^a	5.4 \pm 2.5 ^b	7.1 \pm 2.4 ^a	7.4 \pm 2.7 ^a	7.0 \pm 2.6 ^a	7.3 \pm 1.7 ^a	10.4 \pm 2 ^a	7.6 \pm 2.7 ^b
E L	11.7 \pm 1.8 ^a	11.5 \pm 2.5 ^a	11.6 \pm 2.5 ^a	11.1 \pm 2.3 ^a	11.9 \pm 2.3 ^a	12.0 \pm 2.4 ^a	12.3 \pm 2.5 ^a	11.8 \pm 2.3 ^a
EW	4.9 \pm 0.8 ^a	4.9 \pm 0.8 ^a	5.2 \pm 1.1 ^a	4.9 \pm 0.7 ^a	5.0 \pm 1.1 ^a	5.1 \pm 1.3 ^a	5.2 \pm 1.0 ^a	5.0 \pm 0.1 ^b
HL	11.4 \pm 3.5 ^a	9.9 \pm 5.0 ^a	16.7 \pm 4.1 ^a	13.4 \pm 3.5 ^b	16.6 \pm 3.6 ^a	15.0 \pm 4.4 ^b	19.3 \pm 5.9 ^a	15.7 \pm 4.2 ^b
TL	12.4 \pm 1.2 ^a	12.4 \pm 1.9 ^a	13.7 \pm 2.2 ^a	12.8 \pm 2.4 ^a	13.3 \pm 4.3 ^a	13.5 \pm 1.7 ^a	13.6 \pm 2.1 ^a	13.8 \pm 2.2 ^a
Hew	9.2 \pm 4.0 ^a	9.4 \pm 3.5 ^a	12.3 \pm 3.5 ^a	9.4 \pm 3.9 ^b	12.9 \pm 2.4 ^a	10.7 \pm 3.3 ^b	14.4 \pm 5.0 ^a	12.5 \pm 4.5 ^b
HeL	17.2 \pm 3.2 ^a	14.0 \pm 4.2 ^b	19.0 \pm 3.3 ^a	18.2 \pm 2.5 ^a	19.3 \pm 2.5 ^a	18.1 \pm 3.8 ^b	21.1 \pm 3.1 ^a	19.9 \pm 2.5 ^b

^a, ^bMean within age group connected with different superscripts differ significantly ($P < 0.05$); HG=Heart girth; WH= Height Wither; RH=Rump height; ShW=Shoulder Width; BL=Body length; ChD=Chest depth; EL=Ear Length; EW=Ear width; HL=Horn Length; TL=Tail Length; HeW=Head Width; HeL=Head Width.

62.3 \pm 4.6 cm, respectively (Table 4). Significant ($P < 0.05$) difference was reported in height at wither between male and female goat within age group 3 and 4. There was no significant ($P > 0.05$)

difference in height at wither between male and female between age group of 1 and 2. The stage of growth and development might mask the difference between male and female at early age.

The adult female (25-35 months) Maefur goat breed with 62.3 cm height at wither is in between the Afar and Western Highland goat breed as 60.9 and 70.8 cm, respectively (Solomon, 2009). Both

male and female adult Maefur goat with average height at wither 70.8 and 62.3 cm, respectively are larger than the Abergelle goat reported as 61.05 and 59.44 cm, respectively for adult male and female (Alemayehu et al., 2012). According to the classification criteria using height at wither and body weight for body size of Ethiopia indigenous goat suggested by Kassahun and Solomon (2008), there are three classes: large, >65 cm and weighing 37-50 kg; small, 51-65 cm and weighing 26-36 kg; dwarf, <50 cm and weighing 18-25 kg). Therefore, both male and female Maefur indigenous goats are classified as large body size.

Heights at rump

The average heights at rump of the Maefur male goat in four age groups (04-12, 13-18, 19-24, and 25-35 months) were determined as 56.8±4.7, 61.8±4.1, 62.2±4.2 and 67.6±4.5 cm, respectively whereas in female were noted to be 56.2±4.9, 61.2±4.3, 58.5±5.1 and 61.5±3.9 cm, respectively. Significant ($P<0.05$) difference was reported in height at rump between male and female goat within age group 3 and 4. There was no significant ($P>0.05$) difference between male and female in age group of 1 and 2.

Shoulder width

The average shoulder width of the Maefur male goat in four age groups (04-12, 13-18, 19-24 and 25-35 months) were recorded to be 10.1±1.7, 9.7±3.1, 11.6±1.5, 12.1±1.4 cm while in female in these age groups were 8.5±2.3, 10.8±2.0, 10.3±2.0 and 10.4±1.5 cm, respectively. Significant ($P<0.05$) difference was reported in shoulder width between male and female goat within age groups 1, 3, and 4. There was no significant ($P>0.05$) difference between male and female in age group 2.

Body length

The average body length of Maefur male goat in four age groups (04-12, 13-18, 19-24, and 25-35 months) were recorded to be 51.0±4.1, 56.2±4.0, 61.8±6.8, and 72.3±7.1 cm while in female in these age groups were 49.4±3.6, 57.5±3.7, 57.6±6.4, and 64.3±5.0 cm, respectively. Significant ($P<0.05$) difference was reported in body length between male and female goat within age group 3 and 4. There was no significant ($P>0.05$) difference between male and female in the age group of 1 and 2. Both male and female adult Maefur goat with average body length 72.3 and 64.3 cm, respectively are larger than the Abergelle goat reported as 53.00 and 52.03 cm, respectively for adult male and female (Alemayehu et al., 2012). The faster growth of male goats

than females at early stage is suggested because of the hormonal effect that is non-release of androgen (which is known to have growth and weight - stimulating effects) in male animals until the testis are well developed (Frandsen and Elmer, 1981). Therefore, male goats are heavier and larger than female goat.

Chest depth

The average chest depth of Maefur male goat in four age groups (04-12, 13-18, 19-24, and 25-35 months) were recorded to be 7.0±2.3, 7.1±2.4, 11.9±2.6, and 10.4±2 cm, respectively whereas in female in these age group were 5.4±2.5, 7.4±2.7, 7.3±1.7, and 7.6±2.7 cm, respectively. Significant ($P<0.05$) difference was reported in chest depth between male and female goat within age group 1 and 4. There was no significant ($P>0.05$) difference chest depth between male and female in the age group of 2 and 3.

Ear length and ear width

The average ear length of Maefur male goat in four age groups (04-12, 13-18, 19-24 and 25-35 months) were determined to be 11.7±1.8, 11.6±2.5, 5.0±1.1 and 12.3±2.5 cm, respectively while in female in these age groups were 11.5±2.5, 11.1±2.3, 12.0±2.4 and 11.8±2.3 cm, respectively. The average ear width of Maefur male goat in four age groups (04-12, 13-18, 19-24 and 25-35 months) were determined to be 4.9±0.8, 5.2±1.1, 16.6±3.6 and 5.2±1.0 cm while in female in these age groups were 4.9±0.8, 4.9±0.7, 5.1±1.3 and 5.0±0.1 cm, respectively (Table 5). There was no significant ($P>0.05$) difference in ear length between male and female in all age groups whereas ear width significantly ($P<0.05$) differed between male and female in age group 4 whereas it was not significantly ($P>0.05$) differed in age group 1, 2, and 3. The indigenous Maefur goat is described as short and narrow ear.

Horn length

The average horn length of Maefur male goat in four age groups (04-12, 13-18, 19-24 and 25-35 months) were determined to be 11.4±3.5, 16.7±4.1, 13.3±2.1 and 19.3±6.3 cm while in female in these age groups were 9.9±5.0, 13.4±3.5, 15.0±4.3 and 15.6±4.2 cm, respectively. Significant ($P<0.05$) difference was reported in horn length between male and female goat within age group 2, 3 and 4 whereas there was not significantly ($P>0.05$) differed in age group 1. Maefur indigenous goat has medium sized and thick horn with some times spiral shape pointed upward for male whereas for female, short, thick, straight, and backward oriented horn.

Table 5. LSM± (SE) of the live body weight and linear body measurements for pooled age.

Body traits	Sex of goat	
	Male	Female
Body weight	34.7±0.6 ^a	28.9±0.4 ^b
Heart girth	75.3±0.5 ^a	70.0±0.3 ^b
Height at Wither	64.7±0.5 ^a	59.3±0.3 ^b
Height at Rump	64.8±0.3 ^a	59.2±0.3 ^b
Shoulder Width	11.3±0.1 ^a	10.2±0.1 ^b
Body length	64.3±0.6 ^a	60.0±0.4 ^b
Chest depth	8.7±0.2 ^a	7.2±0.1 ^b
Ear Length	12.0±0.1 ^a	11.7±0.1 ^a
Ear width	5.1±0.1 ^a	5.0±0.1 ^a
Tail Length	13.4±0.1 ^a	13.4±0.1 ^a
Horn Length	17.1±0.3 ^a	14.5±0.3 ^b
Head Width	13.0±0.3 ^a	11.3±0.2 ^b
Head length	19.8±0.2 ^a	18.5±0.2 ^b

^{a, b} means across the row connected with different subscription are differed significantly ($P < 0.05$).

Tail length

The average tail length of Maefur male goat in four age groups (04-12, 13-18, 19-24 and 25-35 months) were determined to be 12.4±1.2, 13.7±2.2, 12.9±4.3 and 13.6±2.1 cm while in female in these age groups were 9.2±4.0, 12.3±3.5, 19.2±2.4 and 14.4±5.0 cm, respectively. There was no significant ($P > 0.05$) difference in tail length between male and female in all age group.

Head width and length

The average head width of Maefur male goat in four age groups (04-12, 13-18, 19-24 and 25-35 months) were determined to be 9.2±4.0, 12.3±3.5, 9.4±3.9, 10.7±3.3 and 14.4±5.0 cm while in female in these age groups were 9.4±3.5, 9.4±3.9, 10.7±3.3 and 12.6±4.5 cm, respectively. The average head length of male in these age groups were 17.2±3.2, 19.0±3.3, 19.3±2.5 and 21.1±3.1 cm while for female in these age group were 14.0±4.2, 18.9±1.7, 18.2±2.5 and 19.9±2.5 cm, respectively. Significant ($P < 0.05$) difference was reported in head length between male and female goat within age group 2, 3 and 4 whereas it was not significantly ($P > 0.05$) differed in age group 1. Significant ($P < 0.05$) difference was reported in head width between male and female goat within age group 1, 3 and 4. It was not significantly ($P > 0.05$) differed in age group 2.

Effect of sex on body weight and linear body measurements

The LSM of body weight, heart girth, height wither, height

at rump, shoulder width, body length, chest depth in male were 34.7±0.57 kg, 75.3±0.53 cm, 64.7±0.46 cm, 64.8±0.34 cm, 11.3±0.12 cm, 64.3±0.61 cm, and 8.7±0.18 cm, respectively (Table 5). The LSM for these measurements (same order) in females were 28.9±0.35 kg, 70.0±0.33 cm, 59.3±0.31 cm and 59.2±0.27 cm, 10.2±0.11 cm, 60.0±0.40 cm, and 7.2±0.15 cm, respectively. There was significant ($P < 0.05$) difference between male and female LSM value of these measurements. Considering the LSM value of the live body weight and the major linear body measurement like heart girth, height at wither, body length and height at rump, the study revealed that male goat are heavier and larger than female goat at 95% level of confidence. This result of the current study is in line to the findings of Hassan and Ciroma (1990) in the Red Sokota goat breeds.

Effect of age on body weight and linear measurements

There was a significant ($P < 0.05$) difference both in live body weight and linear body measurements among the four age groups (04-12, 13-18, 19-24 and 25-35 months) of Maefur goat breed (Table 6). Superscripts (a), (b), (c) and (d) are used to indicate the order of the difference from larger (a) to small (d) mean value respectively at 5% level of significance with larger mean (a) and smaller mean (b) otherwise similar superscripts (either of these letters) connected for non-significant pair of difference. The LSM value of live body weight in four age groups (04-12, 13-18, 19-24 and 25-35 months) were 19.6±0.4, 27.6±0.3, and 29.3±0.4 and 37.5±0.4 kg, respectively.

Table 6. LSM (\pm SE) for body weight and body measurements for goats of pooled sex.

Body traits	Age group			
	04-12 months =1	13-18 months =2	19-24 months=3	25-35 months =4
Body weight	19.6 \pm 0.4 ^d	27.6 \pm 0.3 ^c	29.3 \pm 0.4 ^b	37.5 \pm 0.4 ^a
Heart girth	61.1 \pm 0.5 ^d	69.4 \pm 0.3 ^c	70.6 \pm 0.4 ^b	77.7 \pm 0.4 ^a
Height at Wither	54.0 \pm 0.4 ^c	59.1 \pm 0.3 ^b	58.4 \pm 0.3 ^b	66.5 \pm 0.4 ^a
Height at Rump	56.5 \pm 0.5 ^d	61.5 \pm 0.4 ^c	60.2 \pm 0.4 ^b	64.5 \pm 0.3 ^a
Shoulder Width	9.4 \pm 0.2 ^c	10.2 \pm 0.3 ^b	10.9 \pm 0.1 ^a	11.2 \pm 0.1 ^a
Body length	50.3 \pm 0.4 ^d	56.8 \pm 0.4 ^c	59.3 \pm 0.6 ^b	68.2 \pm 0.4 ^a
Chest depth	6.3 \pm 0.3 ^c	7.2 \pm 0.3 ^b	7.2 \pm 0.2 ^b	9.0 \pm 0.2 ^a
Ear Length	11.4 \pm 0.3 ^a	11.6 \pm 0.3 ^a	11.9 \pm 0.2 ^a	12.0 \pm 0.1 ^a
Ear width	4.9 \pm 0.1 ^a	5.1 \pm 0.1 ^a	5.1 \pm 0.1 ^a	5.1 \pm 0.1 ^a
Horn Length	10.8 \pm 0.5 ^c	15.20.4 ^b	15.7 \pm 0.4 ^b	17.4 \pm 0.3 ^a
Tail Length	12.4 \pm 0.2 ^b	13.3 \pm 0.2 ^a	13.4 \pm 0.2 ^a	13.7 \pm 0.1 ^a
Head Width	9.3 \pm 0.4 ^c	10.9 \pm 0.4 ^b	11.6 \pm 0.3 ^b	13.5 \pm 0.3 ^a
Head length	15.8 \pm 0.5 ^c	18.6 \pm 0.3 ^b	18.8 \pm 0.3 ^b	20.5 \pm 0.2 ^a

a, b, c, d Means carrying the same superscript within a row are not significantly different ($P > 0.05$).

Live body weight was significantly ($P < 0.05$) differed among the four age groups, the oldest (25-35 month) age group is heavier than the younger age group 04-12 month. As there were consistent increases in live body weight as the animals aged. The LSM of heart girth in these age groups were 61.1 \pm 0.5, 69.4 \pm 0.3, 70.6 \pm 0.4, and 77.7 \pm 0.4 cm, respectively. The LSM of height at wither in these age groups were 54.0 \pm 0.4, 59.1 \pm 0.3, 58.4 \pm 0.3, and 66.5 \pm 0.4 cm, respectively. There was significant ($P < 0.05$) difference between the age group pairs in heart girth and height at wither but there was no significant ($P > 0.05$) difference between the least squares mean of age group 13-18 and 19-24 month in both measurements. The LSM of high at rump in these age groups were 56.5 \pm 0.5, 61.5 \pm 0.4, 60.2 \pm 0.4, and 64.5 \pm 0.3 cm, respectively whereas for body length in these age groups were 50.3 \pm 0.4, 56.8 \pm 0.4, 59.3 \pm 0.6 and 68.2 \pm 0.4 cm, respectively. There was a significant ($P < 0.05$) difference between the age group pair in both body length and height at rump. The LSM of shoulder width in these age groups were 9.4 \pm 0.23, 10.2 \pm 0.28, 10.9 \pm 0.17 and 11.2 \pm 0.10 cm, respectively. There was a significant ($P < 0.05$) difference between the age group pair in shoulder width but there was no significant ($P > 0.05$) difference between age group 19-24 and 25-35 months. This result is however not surprising since the size and shape of the animal is expected to increase as the animal is growing with age. There was wide variation as the age of the animals increased in the live body weight.

This result is in line to the finding of Khan et al. (2006) and Alemayohu et al. (2012). However, the variability among the age group at maturity sharply reduced between age groups (Fajemilehin and Salako, 2008). In some linear measurement, the difference between age group 2 and 3 was not significant as the body condition of

the animal affects the consistent growth of the animal and then the measurements (Devendra and Burns, 1983). Most of the linear body measurement of the sampled indigenous goat significantly ($P < 0.05$) increased with age, the older animals (25 months and above) being heavier and larger than the kids (04-12 months), with the growers being intermediate. The current study observed that growth rate from 0 to 1 PPI was higher than as compared to that from 1 to 2 PPI and 2 \geq 3PPI in live body weight of the highland sheep population (Figure 3).

The indigenous Maefur goat has the following key identifying features

83 and 16% have concave and flat (straight) facial profile respectively, with narrow face. Ear is laterally oriented for about 92% of the sampled population. Maefur indigenous goat has been classified as short earned goat. Maefur indigenous goat has the body conformation in- between lanky and compacted (76%) and lanky (20%). It has rectangular body shape. Straight (81%) and spiral (13%) horn shape with Upright (41%) and backward (45%) horn orientation. Polledness occurred at 3% of the flock and 6% in male with thick and long horn Mean horn length 15.8 cm (Male 17 cm). Spotty (33%) with gray (white) and black, pied (27%) white on black, uniform (25%) black or white (rare) and shaded 15% with beige like pall brown. Variable hair coat length: Medium (64%), short (29%) and long (7%) hair coat length. Hair type smooth (50.7%) and glossy (34.3%), straight (6.7%), curly (3%) and dull (5.7%). Variable body colors: White (9.5%), beige (light brown 29.6%), black (20%), and brown (17.5%), blue gray (8%). Long hair is present in neck 44%, tail 56% head 38%, chest 33%, thigh 32%, back 30% and leg 28

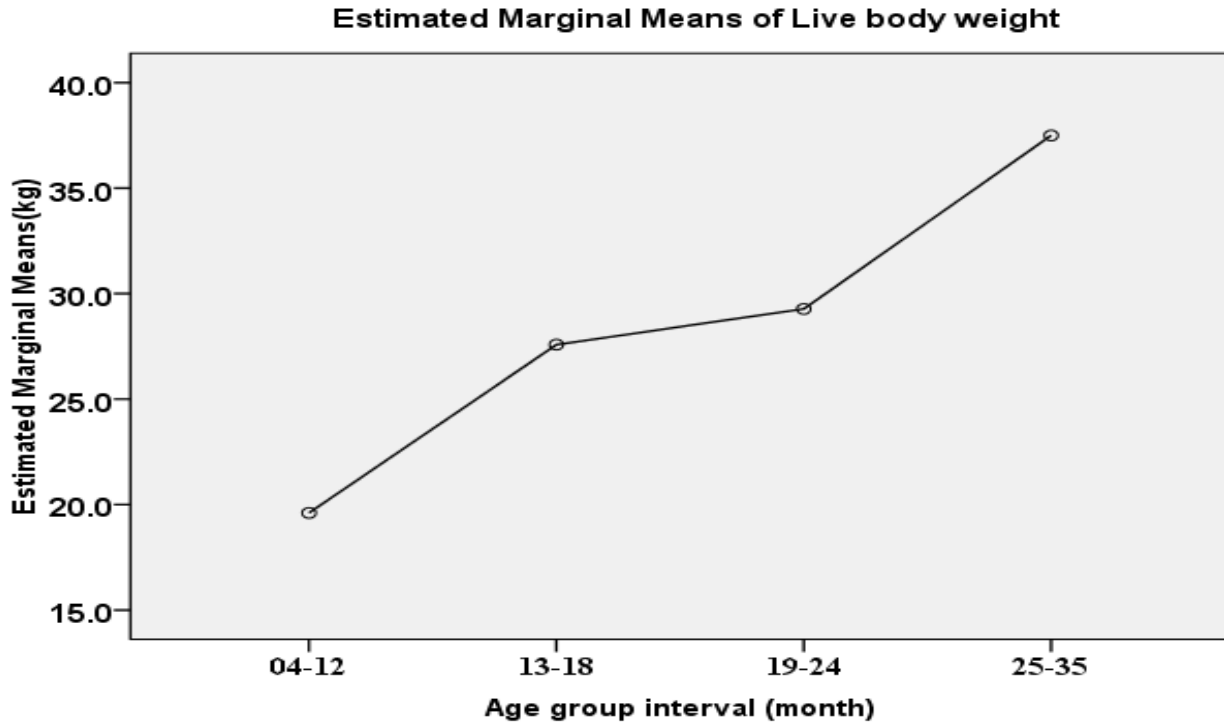


Figure 3. Effect of age on live body weight in relation to growth rate in Maefur goat.

of the goats. Beard is present in male (83%) and uncommon for female. Wattles are rare (29%). Toggle is present in 45% of the flock. It is used for Function: Milk and Meat production. It adapted drought and mountainous topography features.

Conclusion

Maefur indigenous goat populations adapted to the mountainous topographical features and survived through utilizing browsed indigenous plant species around the hillside of Erob district eastern Tigray. The analyses of data on body measurements provide quantitative measure of body size and shape. Body measurements provide quantitative measure of body size and shape. It has an identified body characteristic from other indigenous goat found in the regional government of Tigray by its conformation (rectangular shape), large heart girth (82.1 cm for adult male and 73.4 cm for adult female), thick and long horn in male, variable coat color and concave facial profile. Accordingly, the indigenous Maefur goats breed is characterized as medium-size breeds (42.8 kg for adult male and 32.7 kg for adult female). Based on this evidence, male goat is larger than female goat. It has distinguished feature from Afar (dwarf goat) by its large size (has large heart girth) in between the compacted and leggy body confirmation. Afar goat is in habited in the regional government of Afar around the

lowland but Maefur is inhabited in the mountainous highland area of Tigray. In addition, to increase the validity of this on farm preliminary study, it is important to undertake well planned on station study for phenotypic and genetic characterization of the goat under study within breeds and then to improve their genetic potential. Community based breed improvement through selection should be designed for proper mating superior male and female goat. It is better to make a group of households of the same village in a local, small-scale community-based indigenous goat breeding organization.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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APPENDIX

Table 1. Data collection format for linear body measurement (LBM).

S/N	Name of the owner	Sex (1=M; 2=F)	*Age group	value of LBM in cm											
				BW	HG	HW	RH	SW	BL	CD	EL	Ew	HL	TL	
1															
2															
3															
4															
5															
6															

*age group for 04-12months=A, for 13-18 months=B, for 19-24months=C and for 25-35 months= D For age grouping use milk and permanent teeth pair (milk teeth= Group A, for 1pair of permanent teeth=Group B, for 2 pair of permanent teeth=Group C and for >=3pair of permanent teeth =D). BW=Body weight, HG=Heart girth, HW=Height at wither, RH=Height at Rump, SW=Shoulder width, BL=Body Length, CD=Chest Depth, E L=Ear length, Ew=Ear Width, HL=Horn length and TL=Tail length.

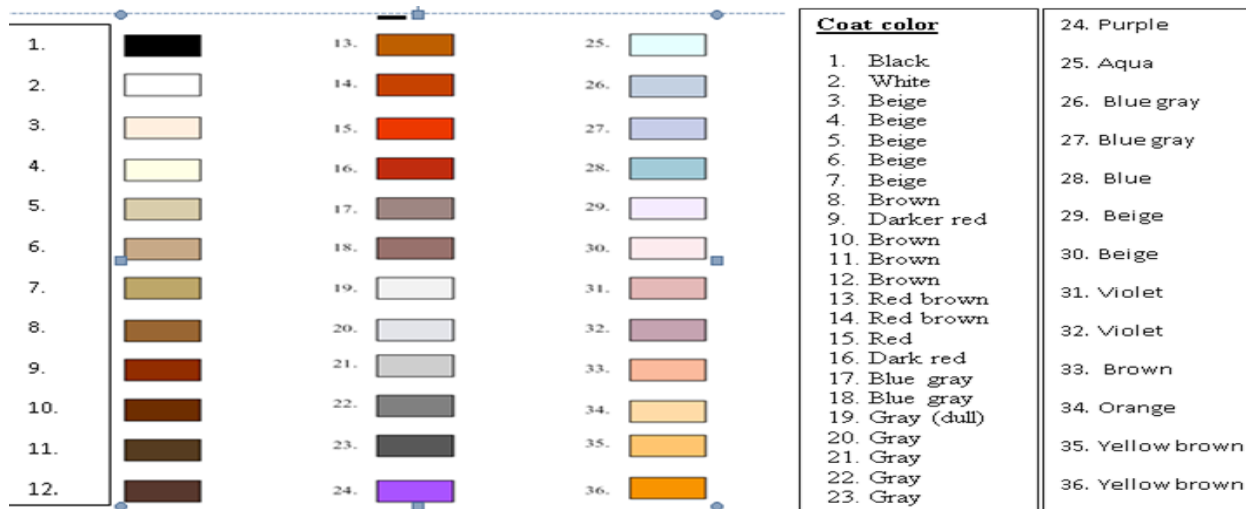


Figure 1. Chart of body coat color and pattern.

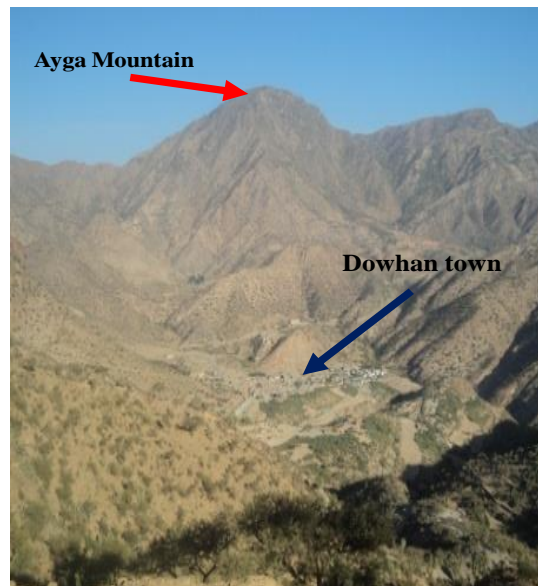


Figure 2. Typical mountain landscape "Ayga Mountain".

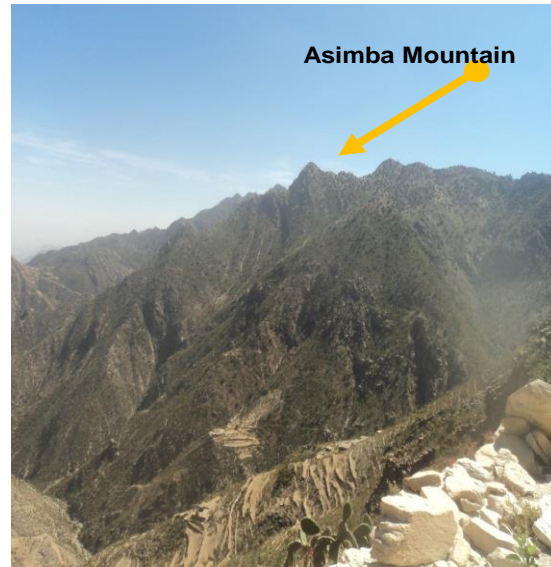


Figure 3. Typical mountain landscape (Asimba Mountain).



Figure 4. Working downhill towards the targeted HH.



Figure 5. Moving uphill from one respondent to the next for personal interview.



Figure 6. Personal interview with Ato Kabsay residence of Haraze-Sabata..



Figure 7. Personal interview with Ato Sibhat residence of Haraze-Sabata



Figure 8. Focus group discussion with goat owner.



Figure 9. Indigenous browse plant species.



Figure 10. Maefur goat flock in the study area.