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Characterization of Indigenous Goat Populations in Selected Areas of Ethiopia

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Abstract: The objective of this study was to characterize Bati, Borena and Short-eared Somali goat populations kept under traditional management systems. The survey conducted in three locations; namely Bati, Borena and Siti (the previous Shinille) representing Bati, Borena and Short-Eared Somali goat populations, respectively. For production systems description a total of 345 households (98 in Bati, 132 in Borena and 115 in Siti) were interviewed. Phenotypic records were also taken on 601(162 Bati (128 females and 34 males), 246 Borena (201 females and 45 males) and 193 Short-eared Somali (139 females and 54 males)) heads of adult goats with 4 pair of permanent incisors (PPI). However, because of difficulty of finding adequate number of 4PPI sample males, measurements were taken from 2PPI and above males. In this study, goats accounted 72.01%, 50.93% and 47.38% of other livestock species in Siti, Bati and Borena areas, respectively. The average (±SE) goat flock size (44.02±3.33) per household of Siti was significantly ($p<0.05$) higher than those observed in Borena (23.08±1.94) and Bati (8.99±0.59). The major challenges of goat rearing in the studied areas include feed and water shortage, disease incidence and recurrent drought with different order of prioritization. Plain brown (deep and light) (51.85%) coat color was the predominant coat color observed on Bati goats of both sexes. Meanwhile, plain white coat color was most frequently observed on Borena goats (71.54%) and only 36.27% in Short-eared Somali goats. Though most quantitative traits showed slightly higher average values in the Bati goats, differences with Borena goats were not significant ($p>0.05$), whereas Short-eared Somali goats remained significantly ($p<0.05$) lower for most of the measured characteristics. Average live weight of Bati, Borena and Short-eared Somali does were 33.97±0.4, 31.49±0.36 and 24.67±0.28kg, respectively and the corresponding values for bucks were 41.30±0.85, 40.04±1.21 and 30.62±0.67kg. Correlation coefficient (r) was consistently highest between live weight and chest girth in both sexes across the goat populations.

Key words: Bati · Borena · Characterization · Short-eared Somali

INTRODUCTION

Ethiopia has a large number of goats (approximately 24.06 million) mainly of indigenous breeds [1]. [2] Identified 12 goat types in the country. [3] has classified the indigenous goat types in to 8 distinct genetic entities using genetic DNA markers, These are:- Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergalle, Afar, Highland goats (previously separated as Central and North West Highland) and the goats from the previously known Hararghe, South eastern Bale and Southern Sidamo provinces (Hararghe Highland, Short-eared Somali and Long-eared Somali goats). These indigenous goat breeds/types are widely distributed and are found in all administrative regions [4].

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Farmers/pastoralists kept goats for the purpose of food source, income generation, socio-cultural wealth and source of other valuable non-food products such as skin and manure [5, 6, 7]. Despite the large size, wide distribution and diversified functions the Ethiopian goat population productivity is relatively low. This may be due to different factors such as poor nutrition, prevalence of diseases and lack of appropriate breeding strategies and poor understanding of the production system [7].

To increase and sustain the productivity of goats so as to respond to the growing domestic and foreign demands for live goats and products, improvement programs are necessary and should be crafted, especially for countries like Ethiopia where extensive system of husbandry is the commonest type. Characterization studies are essential for planning improvement, sustainable utilization and conservation strategies of a breed at local, national, regional and global levels [8]. It is also important in mapping out an inventory of peculiar characteristics of a group of animals. In the absence of baseline characterization information, some breed populations and unique characteristics they contain may decline significantly, or be lost, before their value is recognized and measures taken to conserve them [9]. In Ethiopia, various goat characterization studies had been executed [2, 6, 10, 3, 7]. Despite the studies done, information on phenotypic characteristics and production systems of some indigenous goat populations is still scanty. Some of the works published has also the disadvantage of having been carried out long years back where the results may not reflect the current situation. Therefore, this study aimed to provide production system and physical characteristics information of Bati, Borena and Short-eared Somali indigenous goat populations in Ethiopia.

MATERIALS AND METHODS

Study Areas: The study was conducted in Bati (Amhara Region), Borena (Oromiya Region) and Siti (the previous Shinille) (Somali Region). The geographical location of Bati district is 10°55' and 11°30'N latitudes and 39°50' and 40°15'E longitude. Bati is predominantly lowland. It has an altitude range of 1001-2500m above sea level. Rainfall is bi-modal and the short rainy season starts in January and extends to April. The long rainy season starts in June and extends to September. The rainfall distribution in the study area is erratic in nature and from 600 to 800 mm annually while the annual temperature ranges from 23 to 32°C [11].

Borena Zone is also characterized by the predominant lowland (69.1%), some midland (28.5%) and less agricultural highland (2.4%). It lies at an altitude of less than 1500m above sea level. The average annual rainfall ranges between 350 and 900mm with considerable variability in quantities and distribution. The average annual temperature ranges between 19 and 26°C. Siti Zone is mostly lowland and is arid or semi-arid. The altitude ranges from 950 to 1350m above sea level. The annual mean temperature ranges between 22.5 and 32.5°C, depending on the location within the Zone. The average annual rainfall ranges between 500 to 700mm [12].

Methods of Data Collection: Multi-stage sampling procedure was followed where the big sampling frames were Administrative Zones. After the rapid informal field survey and discussion with the Zonal Agricultural Bureau officers and elders, representative districts were selected. By conducting further discussion with the districts' Agricultural Development Agents and leaders, a total of 14 peasant associations (5 in Bat area; 5 in Siti; 4 in Borena) were selected. During selection of districts and peasant associations, production potential of the targeted goats and accessibility were considered. A total of 345 households (98 in Bati, 132 in Borena and 115 in Siti) were interviewed. Pre-tested semi-structured questionnaire, prepared by adopting a questionnaire prepared by International Livestock Research Institute and Oromiya Agricultural Development Bureau for survey of livestock breeds in Oromiya [13] was used.

Records were taken on 601(162 Bati (128 females and 34 males), 246 Borena (201 females and 45 males) and 193 Short-eared Somali (139 females and 54 males)) heads of adult goats with 4 pair of permanent incisors (PPI) using [8] descriptor list for morphological characterization of goats. However, because of difficulty of finding adequate number of 4PPI sample males, measurements were taken from =2PPI. Qualitative traits such as: sex, coat color pattern, coat color type, horn shape; horn and ear orientation; facial and back profile; presence or absence of horn, wattles, beard and ruff were recorded. Quantitative records taken for both sexes were Body Length (BL), Chest Width (CW) and Height at Wither (HW), Chest Girth (CG), Rump Length (RL), Pelvic Width (PW), Horn Length (HL) and Ear Length (EL). Scrotum Circumference (SC) was also measured for males. Body weight measurements were taken in the morning to avoid the effect of feeding and watering on the animal's size [8].

Statistical Analyses Techniques: The percentage of each level of qualitative data was obtained using PROC FREQ procedure of [28]. Indices were calculated according to a formula: Index = sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) given for an individual attribute divided by the sum of (3 for rank 1 + 2 for rank 2 + 1for rank 3) for overall attributes. The Generalized Linear Model (GLM) procedures of [14] was used to analyze the quantitative data (separately for males and females) fitting goat population as fixed effect. The magnitudes of quantitative variables were expressed as Least Squares Means (±SE). Tukey-Kramer test was used to separate least squares means with more than two levels. The following statistical model was used to analyze linear body measurements. Pearson's correlation coefficient was estimated between body weight and other linear body measurements for each population by sex.

$$Y_{ij} = \mu + B_i + \varepsilon_{ij}$$

where:

Y_{ij} = Observed quantitative measurement of trait of interest
μ = Population mean
B_i = i^{th} goat population effect (i = 1, 2, 3)
ε_{ij} = random error associated with quantitative body measurements

RESULTS

Livestock Composition and Holding Pattern: In terms of numbers, goats were the predominant species in all surveyed areas accounting for 72.01, 50.93 and 47.38% of the total of livestock species in Siti, Bati and Borena areas, respectively. The survey indicated significant variation ($p<0.05$) in the average goat possession per household across study areas (Table 1). The least square mean (±SE) goat flock size per household (44.02±3.33) in Siti was significantly ($p<0.05$) higher than those observed in Borena (23.08±1.94) and Bati (8.99±0.59) areas.

Flock Structure: Does older than one year and kids less than 6 months represent the major proportion in the flock in all study areas (Fig. 1). The mean (±SE) number of breeding does per household was 3.51±0.91, 9.30±0.78 and 13.30±0.84 in Bati, Borena and Siti areas, respectively. The proportion of adult females (30.23%) and kids less than 6 months old (29.62%) in Siti area were slightly smaller than their counterparts in Bati and Borena areas. On the other hand, comparing with Bati and Borena areas, the share of kids between 6-12 months age (23.86%) and intact males older than 1 year (12.64%) in the flocks of Siti area were higher. The contribution of castrates males in Siti, Bati and Borena were 3.65, 3.52 and 0.95%, respectively.

Breeding Management: Sources of breeding buck and type of natural mating systems are shown in Table 2. Even though half of the respondents around Bati (50%) as well as 64.39 and 83.48% in Borena and Siti areas, respectively, had their own breeding buck, uncontrolled natural mating system was surpassed due to extensive communal production system in all the study areas. The average number of breeding bucks per flock within the interviewed households was 0.7, 1.1 and 1.4 for Bati, Borena and Siti areas, respectively. Owners kept bucks on average until 2.4, 4.9 and 5.8 years of age in Bati, Borena and Siti areas, respectively, with a maximum stay of 4, 8 and 10 years in the same order.

The selection criteria for breeding stock slightly varied across the study areas. Goat producers around Bati and Borena areas gave more weight for physical characteristics (visual appraisal) than production characteristics during selection of breeding females. Siti pastoralists/agro-pastoralists were more concerned about milk production potential of does followed by body size and litter size. Body size was ranked first for selection of breeding buck across the surveyed areas. In Bati area, after body size, coat color, growth rate and fertility were ranked the most important traits, while sexual desire, growth rate and coat color were the major traits in Borena area; in Siti area, growth rate, maternal history and sexual desire received the higher index after body size.

Feeding and Watering Strategies: Natural pasture (shrubs and bushes) was the primary source of goat feed across the study areas during the dry and wet seasons of the year. Very few respondents also indicated the use of established forage, conserved hay and crop residues to feed their goats. Established forage trees such as sesbania (*Sesbaniasesban*), leucaena (*Leucaenaleucocephala*) and the commonly "kurkura" (*Ziziphisspina-christi*) planted on soil conservation structures and stock exclusion areas were reported as source of goat feed, used through cut-and-carry system around Bati. Feed shortage was reported in the three study areas, occurring in several months of the year (Fig. 2) and by distinct causes. The major strategies for control of the feed shortage include collecting and providing of green leaves and pod from perennial plants,

Table 1: Average number of heads (Mean ±SE) per household according to species and area of survey

	Bati (N=98)		Borena (N=132)		Siti (N=115)	
Species	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%
Goat	8.99±0.59^{c}	50.93	23.08±1.94^{b}	47.38	44.02±3.33^{a}	72.01
Cattle	3.94±0.29^{b}	22.33	10.42±1.21^{a}	21.39	1.70±0.26^{c}	2.78
Sheep	1.27±0.22^{c}	7.16	7.82±0.82^{b}	16.05	11.89±1.14^{a}	19.45
Chicken	2.43±0.36^{a}	13.77	3.70±0.49^{a}	7.60	0.16±0.13^{b}	0.26
Camel	0.31±0.07^{b}	1.77	1.64±0.32^{a}	3.37	1.88±0.29^{a}	3.08
Donkey	0.40±0.08^{b}	2.27	0.78±0.17^{b}	1.60	1.47±0.14^{a}	2.40
Beehive	0.31±0.13^{ab}	1.77	1.27±0.49^{a}	2.61	0.01±0.01^{b}	0.07

N= Number of respondents; Means with different superscripts (^{abc}) within the same column are statistically different (at least $p<0.05$)

Table 2: Type of natural mating systems and sources of breeding buck

Particulars	Bati		Borena		Siti	
Natural mating system	N	%	N	%	N	%
Controlled	11	11.22	2	1.52	2	1.74
Uncontrolled	87	88.78	130	98.48	113	98.26
Source of breeding buck						
Own flock	49	50	85	64.39	96	83.48
Others flock	49	50	47	35.61	19	16.52

N= Number of respondents

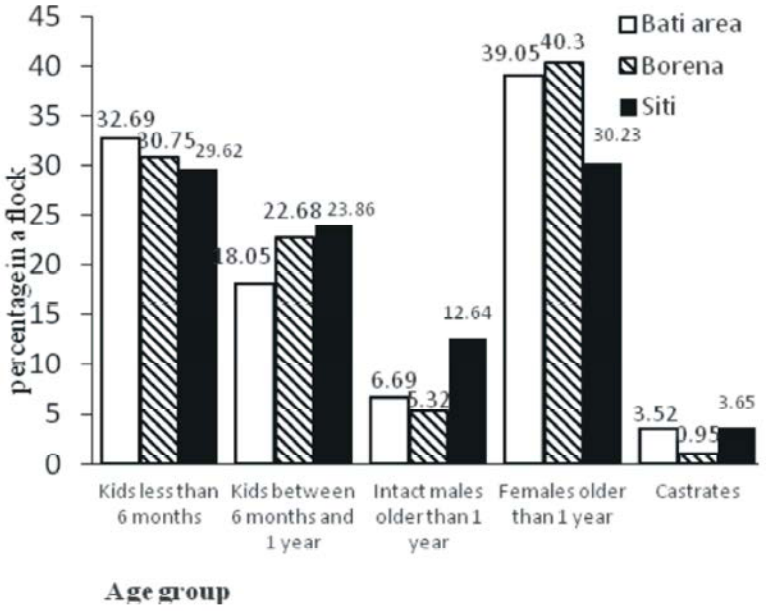

Fig. 1: Flock structures in Bati, Borena and Siti areas

crop residues, collected and standing hay in Bati and migration of adult and healthy animals in Borena and Siti areas. About 55% of Bati area goat owners also reported supplementations based on availability of kitchen and milling residues, homemade grain, residues of local grain grinding houses and oilseed cake. In all the study areas, majority of the goat owners use mineral supplement (table salt) during wet season only when there is sufficient feed.

The major sources of water comprise traditional hand dug wells, rivers/streams, ponds and pump water. The most frequently stated water source in Bati area was permanent rivers/streams (76.53%), followed by pump water, spring, ponds and hand dug wells in order of importance. The traditional hand dug wells (locally known as "*ella*") was the most important source of water supply in Borena (98.48%) and Siti (87.8%), followed by ponds and rivers/streams, respectively for the regions.

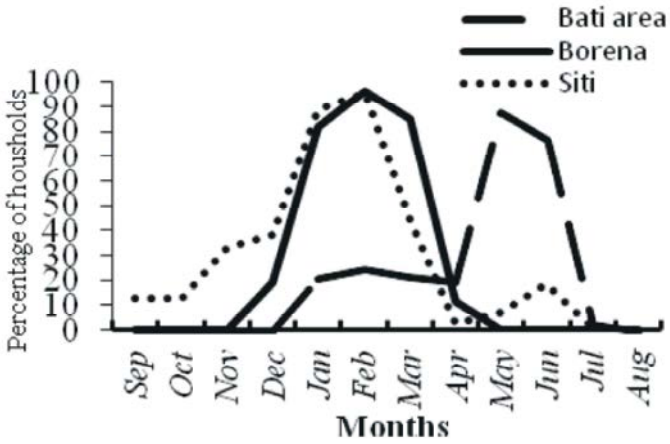

Fig. 2: Period of feed shortage across study areas

Table 3: Watering frequency during dry season in the study areas

Particulars	Bati		Borena		Siti	
Frequency of watering	N	%	N	%	N	%
Once a day	92	93.88	3	2.27	35	30.43
Once in 2 days	6	6.12	62	46.97	67	58.26
Once in 3 days	0	0	67	50.76	13	11.30

N= Number of respondents.

Table 4: Goat production constraints as perceived by the respondents.

	Bati				Borena				Siti			
Constraints	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Drought	13	39	19	0.237	17	40	55	0.234	60	26	17	0.359
Feed shortage	46	21	14	0.338	26	60	38	0.296	20	41	28	0.245
Water shortage	0	3	5	0.019	5	11	16	0.067	17	6	28	0.131
Disease	26	20	31	0.260	84	18	14	0.379	19	43	31	0.251
Predator	4	4	7	0.047	1	4	7	0.023	0	2	2	0.009
Market	0	3	0	0.010	0	0	1	0.001	0	0	3	0.004
Labor problem	10	7	7	0.089	0	0	0	0	0	0	1	0.001

R=Rank

As presented in Table 3, the majority of goat owners in Bati area provide water to their goats every day and few individuals once in two days. Because of lack of surface water in Borena area, almost all of the goat owners take their goats to the watering points once in three or two days. However, in Siti area, watering frequency ranged from every day to once in three days based on availability.

Major Constraints Associated with Goat Production: Though the major constraints facing goat production were mostly similar, their importance varied across the study areas (Table 4). Around Bati area, feed shortage, disease occurrences and drought were ranked 1st, 2nd and 3rd, while disease occurrences, feed shortage and recurrent drought were the major constraints in Borena. Recurrent drought, disease, feed as well as water shortage have been perceived by the respondents as the most influencing constraints that hindering goat production in Siti area. Almost all of the respondents did not rank lack of appropriate genotype/breed as a constraint.

Qualitative Characteristics: The frequency and percent for each level of qualitative traits of the three indigenous goat populations for both buck and does are presented in Tables 5 and 6. The observed overall coat color patterns for both sexes were 64.20% plain, 33.33% patchy/pied and 2.47% spotted in Bati; 72.36% plain, 23.98% patchy/pied and 3.66% spotted in Borena; and 45.08% plain, 39.90% patchy/pied and 15.03% spotted in Short-eared Somali goat populations. Most of the Bati goats (87.5% females and 67.7% males) had straight head profile and about 14%

Table 5: Frequency (N) and percent (in brackets) of color and color pattern of indigenous goats by population

		Bati			Borena			Short-eared Somali		
Variable	Class level	Female N (%)	Male N (%)	Total N (%)	Female N (%)	Male N (%)	Total N (%)	Female N (%)	Male N (%)	Total N (%)
Coat color pattern	Plain	85(66.41)	19(55.88)	104(64.2)	144(71.64)	34(75.56)	178(72.36)	57(41.01)	30(55.56)	85(45.08)
	Patchy/pied	39(30.47)	15(44.12)	54(33.33)	48(23.88)	11(24.44)	59(23.98)	54(38.85)	23(42.59)	77(39.90)
	Spotted	4(3.13)	0	4(2.47)	9(4.48)	0	9(3.66)	28(20.14)	1(1.85)	29(15.03)
Coat color type	White	12(9.38)	6(17.65)	18(11.11)	140(69.68)	36(80.00)	176(71.54)	42(30.22)	28(51.85)	70(36.27)
	Dark red/brown	40(31.25)	8(23.53)	48(29.63)	1(0.5)	0	1(0.41)	5(3.60)	1(1.85)	8(4.15)
	Black	4(3.13)	0	4(2.47)	0	0	0	7(5.04)	1(1.85)	6(3.11)
	Gray	1(0.78)	0	1(0.62)	5(2.49)	0	5(2.03)	11(7.91)	2(3.70)	13(6.74)
	Light red	30(23.44)	6(17.65)	36(22.22)	2(1.00)	0	2(0.81)	9(6.47)	2(3.70)	11(5.70)
	White +Brown	15(11.72)	3(8.82)	18(11.11)	4(1.99)	0	4(1.63)	1(0.72)	4(7.41)	5(2.59)
	White +Black	3(2.34)	3(8.82)	6(3.7)	14(6.97)	3(6.67)	17(6.91)	30(21.58)	11(20.37)	41(21.24)
	White+ Light brown	23(17.97)	8(23.53)	31(19.14)	35(17.41)	6(13.33)	41(16.67)	34(24.46)	5(9.26)	39(20.21)

N= Number of goats.

Table 6: Frequency (N) and percent (in brackets) of incidence for some qualitative features of indigenous goats by population

		Bati			Borena			Short eared Somali		
Variable	Class level	Female N (%)	Male N (%)	Total N (%)	Female N (%)	Male N (%)	Total N (%)	Female N (%)	Male N (%)	Total N (%)
Facial profile	Straight	112(87.5)	23(67.65)	135(83.33)	199(99.00)	45(100)	244(99.19)	58(41.73)	42(77.78)	100(51.81)
	Slightly concave	15(11.72)	8(23.53)	23(14.2)	1(0.50)	0	1(0.41)	81(58.27)	12(22.22)	93(48.19)
	Slightly convex	1(0.78)	3(8.82)	4(2.47)	1(0.50)	0	1(0.41)	0	0	0
Horn	Present	126(98.44)	27(79.41)	153(94.44)	163(81.09)	31(68.89)	194(78.86)	128(92.09)	28(51.85)	156(80.83)
	Absent	2(1.56)	7(20.59)	9(5.56)	16(7.96)	14(31.11)	30(12.2)	11(7.91)	26(48.15)	37(19.17)
	Rudimentary	0	0	0	22(10.96)	0	22(8.94)	0	0	0
Horn orie- ntation	Lateral	0	0	0	30(18.18)	2(6.45)	32(16.33)	9(7.03)	4(14.29)	13(8.33)
	Up ward	41(32.54)	2(7.41)	43(28.1)	37(22.42)	6(19.35)	43(21.94)	40(31.25)	4(14.29)	44(28.21)
	Back ward	85(67.46)	25(92.59)	110(71.9)	76(46.06)	22(70.97)	98(50.00)	77(60.16)	19(67.86)	96(61.54)
	Pointing forward	0	0	0	22(13.13)	1(3.23)	23(11.73)	2(1.56)	1(3.57)	3(1.92)
Ear orie- ntation	lateral	77(60.16)	20(58.82)	97(59.88)	156(77.61)	38(84.44)	194(78.86)	22(15.83)	7(12.96)	29(15.03)
	Forward Erected	1(0.78)	6(17.67)	7(4.32)	16(7.96)	3(6.67)	19(7.72)	117(84.17)	47(87.04)	164(84.97)
	Hanged down	50(39.06)	8(23.53)	58(35.8)	26(12.94)	4(8.89)	30(12.20)	0	0	0
	Pendulous	0	0	0	3(1.49)	0	3(1.22)	0	0	0
Wattle	Present	0	0	0	4(1.99)	0	4(1.63)	9(6.47)	0	9(4.66)
	Absent	128(100)	34(100)	162(100)	197(98.01)	45(100)	242(98.37)	130(93.53)	54(100)	183(94.82)
Beard	Present	32(25)	23(67.65)	55(33.95)	51(25.37)	41(91.11)	92(37.4)	25(17.99)	49(90.74)	74(38.34)
	Absent	96(75)	11(32.35)	107(66.05)	150(74.63)	4(8.89)	154(62.60)	114(82.01)	114(82.01)	119(61.66)

N= Number of goats

(11.7% females and 23.5% males) were with slight concave head. Almost all (99%) of male and female Borena goats had straight head profile. From the total sampled Short-eared Somali goats, 41.7% females and 77.8% males had straight head profile. In studied populations the horned goats (does and bucks) accounted for 94.4, 78.9 and 80.8% of the Bati, Borena and Short-eared Somali populations, respectively. The reminder proportions in each sampled population, except 8.9% of Borena does which displayed some rudimentary horns were polled.

The majority of Bati and Borena goats were characterized by lateral/sideway ear orientation accounting for a total of 59.9 and 78.9%, respectively, followed by hanged down ears observed in 35.8 and 12.5% of individuals in that order. Very small proportion of goats (4.3% Bati and 7.7% Borena) was also with forward erected ears. Large proportion (>84%) of forward and small proportion (15%) of lateral ear orientations distinguished Short-eared Somali goats from the two populations. Except for 2% of Borena and 4.7% of Short-eared Somali does, wattle was totally absent in all bucks of the three populations and Bati does. It was found that about 56, 69 and 37% of Bati, Borena and Short-eared Somali bucks, respectively had ruff. Over 90% of Borena and Short-eared Somali and 67.7% of Bati bucks had beard while about 25% of Bati and Borena as well as 17.9% of Short-eared Somali does were bearded.

Quantitative Variations: Least square means for body weight, body condition score and morphometric traits of Bati, Borena and Short-eared Somali goats are presented in Table 7. Bati does were significantly ($p<0.05$) heavier (33.97±0.49 kg) and had widest chest (17.10±0.16cm) among the three populations. As compared with Borena does, Bati does varied significantly ($p<0.05$) in only three measurements (body weight, chest width and horn length) of the 9 measured traits, otherwise they were comparable in most of their body dimensions (body length, height at

Table 7: Least square means for body weight (kg), body condition score and other body measurements (cm) for does and bucks as affected by population

		Bati (N=128)		Borena (N=201)		Short-eared N=139)		Over all mean	
Sex	Trait	LSM±SE	CV	LSM±SE	CV	LSM±SE	CV	CV	R^2
Does	BC	2.65±0.08^a	35.0	2.62±0.07^a	38.0	2.32±0.07^b	33.7	36.1	0.02
	BW	33.97±0.49^a	16.2	31.49±0.36^b	16.4	24.67±0.28^c	13.2	15.9	0.38
	BL	62.97±0.27^a	4.9	62.48±0.23^a	5.3	57.85±0.41^b	8.3	6.2	0.23
	HW	68.74±0.29^a	4.7	68.91±0.22^a	4.5	62.88±0.25^b	4.7	4.6	0.44
	CG	73.55±0.36^a	5.6	73.59±0.27^a	5.1	67.27±0.28^b	4.9	5.2	0.38
	CW	17.10±0.16^a	10.4	16.37±0.12^b	10.6	15.35±0.14^c	10.7	10.6	0.13
	RL	15.25±0.08^a	6.3	15.10±0.07^a	6.3	14.07±0.08^b	6.7	6.4	0.22
	PW	14.36±0.09^a	6.9	14.17±0.07^a	6.9	13.73±0.13^b	11.0	8.3	0.04
	HL	13.87±0.24^b	19.0	8.59±0.26^c	40.8	17.51±0.34^a	22.0	26.7	0.56
	EL	15.65±0.12^a	8.3	15.34±0.12^a	10.7	12.99±0.10^b	8.9	9.6	0.39
Bucks	BC	3.06±0.16^a	30.1	3.02±0.11^a	23.9	3.22±0.10^a	23.1	25.2	0.01
	BW	41.30±0.85^a	11.9	40.04±1.21^a	20.3	30.62±0.67^b	16.1	17.0	0.39
	BL	65.59±0.59^a	5.2	65.13±0.63^a	6.5	57.28±0.69^b	8.9	7.1	0.45
	HW	76.09±0.68^a	5.2	74.84±0.66^a	6.0	64.98±0.67^b	7.6	6.4	0.57
	CG	81.25±0.95^a	6.8	79.49±0.78^a	6.6	71.24±0.73^b	7.6	7.0	0.42
	CW	18.12±0.29^a	9.5	18.49±0.41^a	15.0	16.37±0.30^b	13.4	13.1	0.15
	RL	16.41±0.21^a	7.5	16.22±0.16^a	6.8	15.44±0.23^b	11.1	8.9	0.09
	PW	15.94±0.27^a	9.9	14.73±0.20^b	9.1	15.91±0.30^a	13.6	11.4	0.09
	HL	18.57±0.73^a	21.3	13.05±0.75^b	32.2	19.92±1.10^a	30.2	28.1	0.29
	EL	14.50±0.43^a	17.3	14.31±0.27^a	12.9	12.01±0.32^b	19.6	16.7	0.22
	SC	27.07±0.36^a	7.8	27.02±0.30^a	7.5	25.81±0.37^b	10.6	8.9	0.06

Means with different superscripts (^{abc}) within the same row are statistically different (at least $p<0.05$); BC= Body Condition, BL=Body Length, HW=Height at Wither, CG=Chest Girth, CW=Chest Width, RL=Rump Length, PW=Pelvic Width, HL=Horn Length, EL=Ear Length, SC=Scrotum Circumference; LSM =Least squares means, SE=standard errors, CV=Coefficient of Variations and R^2=magnitude of population effect.

Table 8: Pearson's correlation coefficients between body weight (kg) and linear measurements (cm)

Population	Sex	BC	BL	HW	CG	CW	RL	PW	HL	EL	SC
Bati	bucks	0.57**	0.61**	0.58**	0.85**	0.47**	0.55**	0.47**	0.40*	-0.18^{NS}	0.55**
	does	0.52**	0.62**	0.40**	0.82**	0.68**	0.62**	0.53**	0.32**	0.18*	-
Borena	bucks	0.36*	0.80**	0.79**	0.86**	0.55**	0.76**	0.78**	0.69**	-0.19^{NS}	0.53**
	does	0.40**	0.67**	0.50**	0.82**	0.71**	0.57**	0.54**	0.33*	-0.13^{NS}	-
Short eared Somali	bucks	0.69**	0.46**	0.79**	0.79**	0.53**	0.55**	0.26^{NS}	0.69**	0.15^{NS}	0.56**
	does	0.62**	0.25**	0.37**	0.73**	0.40**	0.34**	0.24**	0.14^{NS}	0.12^{NS}	-

BC= Body Condition, BL=Body Length, HW=Height at Wither, CG=Chest Girth, CW=Chest Width, RL=Rump Length, PW=Pelvic Width, HL=Horn Length, EL=Ear Length, SC=Scrotum Circumference; NS= Non Significant; *p < 0.05, ** p< 0.01

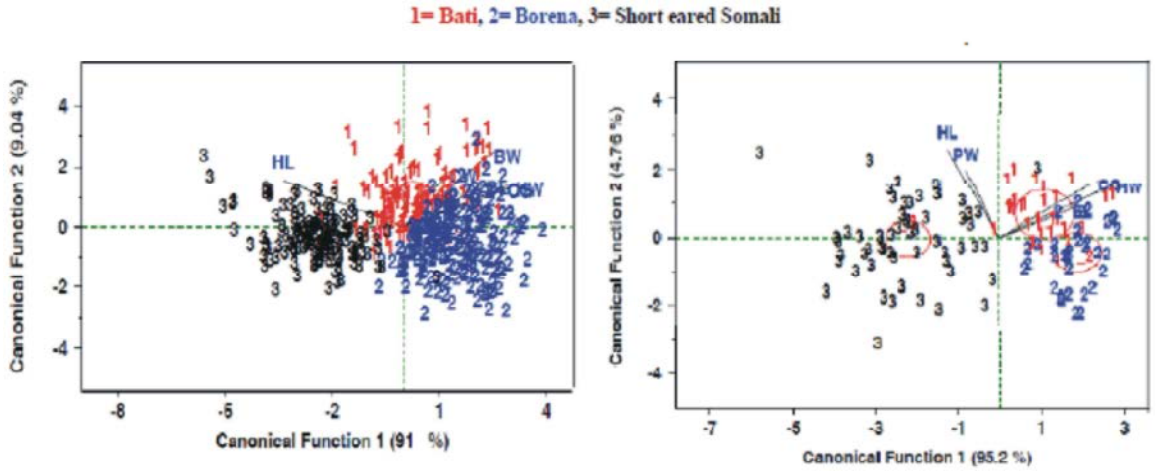

Fig. 3: Spatial distributions of does (left) and bucks (right) on the first two canonical variats

wither, chest girth, rump length, pelvic width and ear length) and body condition score. The Short-eared Somali does remained significantly ($p<0.05$) smallest in body weight, body condition score and other body measurements except horn length.

Though most traits showed higher average values in Bati bucks, differences with Borena bucks were not significant ($p>0.05$) for most of body characteristics except pelvic width and horn length which were significantly ($p<0.05$) lower for Borena bucks. Most of the body measurements in Short-eared Somali bucks were significantly ($p<0.05$) lower as compared with their counterparts in Bati and Borena. Despite the other measurements the average values of pelvic width and horn length between Bati and Short-eared Somali; and body condition score in the three populations were not different.

Differentiation Between Three Goat Types Using Discriminant Analysis: The stepwise discriminant analysis procedure identified seven (HL, BW, EL, CG, HW, CW and PW) most significant discriminating traits between does while it was five (HW, HL PW, CG and EL) in bucks. The canonical analysis was carried out to observe the spatial distribution of sample populations on canonical variables by means of graph. It was conducted using those traits which shown significant discriminating power. The spatial distributions of the three populations for both sexes are presented in Fig. 3. In both sexes, CAN1 discriminated Borena from Short-eared Somali goat populations effectively, keeping Borena and Bati populations closer on the right side of the X-axis. Though Bati goats put closer to Borena goats, they positioned more or less between Borena and Short-eared Somali goats. CAN2 is not effective in separating the three populations of both sexes except biasing Bati goats to the right side of X-axis.

Relationships Between Body Weight and Other Linear Body Measurements: Table 8 describes the relationship between body weight and other linear body measurements. Most variables (BC, BL, HW, CG, CW, RL PW and HL) depicted positive and highly significant ($p<0.01$) correlation with live body weight. Correlation coefficient was consistently the highest between live body weight and chest girth in both sexes for the populations. However, for Short-eared Somali bucks equally the highest correlation coefficient was found for chest girth and height at wither with body weight. Even though the correlation of body weight with chest girth was positive and significant for both sexes, higher values were observed in bucks as compared with does within the population.

DISCUSSION

Livestock Composition, Holding Pattern and Flock Structure: The major livestock species in the study areas were goats, sheep, cattle, camels and donkeys. Goats constitute the largest share (in number) among other livestock species in all study areas. According to [15] the probability of keeping livestock is strongly correlated with agro-climatic conditions. In the present study, households in the lowland areas keep goats as the primary animal because of their ability to survive in a harsh environment. [14] stated that flock sizes vary with the production system and the environment. Likewise, in this study, average flock size per household showed significant deviation ($p<0.05$) across study areas. The average number of goats holding per household found around Bati area (8.99±0.59) was comparable with the previous report of [30] in the same area (7.79± 4.54) and in Shewarobit area (9.6±2.68). On the other hand, the average number of goats per household in Siti area (44.02±3.33) was relatively higher than those reported by [16] and [6] who reported 34±23.54 and 10.08±0.8 heads per household for the same goat type in rural peasant associations of and Siti and Dire Dawa Administration Council, respectively. These results indicated the existence of variation in the number of goats per household among the districts, years and seasons implying the need of characterization in short time interval for specific area.

The proportion of different classes of animals reflects the management decisions of the producers which in turn are determined by their production objectives [14]. In our findings the breeding does were the major followed by kids less than 6 months in all population. This is in agreement with findings of other researchers in Ethiopia [7, 17].

Breeding Management: Even though majority of the producers in the present study practiced breeding stock selection and possessed their own breeding buck, the traditional (communal) production systems in the study areas lead to uncontrolled mating making it difficult to control flock reproduction. According to [18], an advantage of natural uncontrolled mating is that it allows for all year round breeding. On the other hand,

uncontrolled mating together with small flock sizes and poor/absent record keeping scheme on pedigree are expected to result in severe inbreeding which leads to poor growth rates [19]. Use of bucks for long period in a flock in Borena and Siti areas depicts inbreeding problem in the flocks [20].

Feeding and Watering Strategies: Goat production in communal production systems is highly dependent on rangeland resources [21]. In line with this statement, free natural pasture (shrubs and bushes) was the predominant feed resource among the other mentioned feed resources in both dry and wet seasons, particularly in Borena and Siti areas. The availability of water was not consistent particularly in the dry season. This also enforced the animals to stay for about three days without water as found in this study and also reported by [5]. According to [22], Short- eared Somali goats deprived water for about three days in dry season showed 22% milk yield reduction as compared to goats with water access every day. Therefore, watering is an important management component, which is often not addressed [21], which needs further research to be carried out to assess the impact of watering frequency on productivity of goats in the dry areas of Ethiopia.

Major Constraints: Major goat production and productivity challenges in the communal production systems include feed shortage, disease occurrences and water scarcity [23, 14]. The major constraints facing goat production systems in this study were similar with the constraints listed by the above authors, but their importance varied across the study areas.

Phenotypic Characteristics: Phenotypic characteristics of a breed include qualitative, quantitative and economic traits [8]. These characteristics are important in breed identification, classification, genetic improvement (selection) implementation and sustainable utilization and conservation [24]. Though the frequencies of some coat colors were small in a population, the current study demonstrated that the studied goat populations have a wide range of coat colors. Similarly, [6, 10], reported wide range of coat colors for different Ethiopian goat populations. The availability of wide range of coat colors in a population might be attributed to lack of systematic selection program and would definitely offer opportunity for setting up breeding (selection) programs. The higher proportions of polled bucks than does across the three populations might be due to either producers' interest in polled bucks or the higher frequency of short-horned allele (HoP) for males. In this study the presence of beard was dominant in bucks while the presence of wattle was rare for both sexes. Similar results were also reported by [6] for short eared Somali goats and [25] in Hararghe highland goats. According to [26], in addition to the thermoregulatory functions, the presence of wattle and beard is associated with reproduction traits such as higher prolificacy, higher milk yield, higher litter size, fertility and conception rate. [27] also reported greater association ($p< 0.01$) of heavier body weights and body measurements with the presence of wattles of Longling Yellow Goats in China. Therefore, the incidence of wattle and beard can be used as selection criteria by farmers for improved performance.

In the present study, except ear length which was shorter, most traits showed higher average values in males compared to females in all three populations. Similarly, different researchers reported higher mean value of body measurements in adult males than females for different goat breeds [25, 28, 27]. The higher mean value for males could be attributed to differences of the sex-hormonal actions which lead to differential growth rates [28]. However, [29] on adult goats reported that there were no sexual dimorphisms in conformation traits. Bati does were found heavier than Borena and Short-eared Somali does. The similarity of most body measurements between Bati and Borena populations might be due to equivalence of measurements between populations since the probability of intermingling between the studied populations is very low due to big geographical distance between their habitats. As compared with the result found in the present study, slightly lower mean values of body weight, body length, height at wither and chest girth for mature Bati female goats were reported earlier by [10, 30]. The variations could be due to different age of animals included in the sample and season of measurement. The longer horn was observed in Short-eared Somali goats (19.92±1.10cm in bucks and 17.51±0.34cm in does). According to [8], size of horns is known to be relevant to the dissipation of excess body heat. Traits like BC, BW, CW and HL in females and BC, BW, CW, PW, HL and EL in bucks were found to have over 10% overall CV value for all three goat types. According to [31], large variation observed in body measurements is a result of absence of selection, or the body parts are affected more by the environment than others.

Relationships Between Body Weight and Other Linear Body Measurements: The observed positive and highly significant correlations between body weights and other linear body measurements and body condition score indicates that traits in combination or individually could be measured to predict live body weight. Particularly, chest girth would provide a good estimate for predicting live body weight. However, [32] noted inconsistencies between the relationship of body condition score and live body weight under extensive management system in dry and wet seasons. Therefore, body condition score appeared to be a more useful trait in assessing nutritional consequences than live weight body prediction under extensive management systems. In agreement with the present study, [6] and [10] for some Ethiopian goats; and [31] for sheep reported the highest correlation between body weight and chest girth. This shows that chest girth might be the best trait to predict live body weight for both goats and other livestock species. There was no significant correlation between ear length and body weight except in Bati does which was significant ($p<0.05$). According to [31], such traits are determined by non-additive genetic effects and are most probably less influenced by the environment; therefore, selecting them in breeding programs will not lead to significant improvement of body weight and other measurements that are of economic importance.

CONCLUSIONS

The present study indicated that in terms of number, indigenous goats are predominant species in the studied areas and they provided diversified functions for the small scale producers despite the presence of several constraints. The importance of identified constraints varied among the study areas as well as between seasons. Similarly the traits for selection preferred by the goat producers in different areas varied. These aspects highlight the need to develop different strategies for the development of breeding programs according to the area with actions defined with the involvement of communities. The result in this study also revealed that the smaller mean values for most morphometric measurements distinguished Short-eared Somali goats while it dictated the least differentiation between Bati and Borena goats. However, a diversity of qualitative traits like coat color, facial and back profile, presence or absence of horn, wattle, ruff and beard was observed among the three goat types. Since the breeders (producers) can easily distinguish desirable phenotypic characteristics, the variability of those traits could be useful in selection program. Due to high and positive correlation coefficients found between body weight and other linear body measurements (BL, HW, CG, CW, RL and PW), selection of one or more of these traits may increase live body weight of these goat populations.

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