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Husbandry practices and phenotypic characteristics of indigenous goat populations in Ethiopia

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The present study was conducted with the objective to characterize the husbandry practices and phenotypic characteristics of mature Bati, Borana and Short-eared Somali goats kept under traditional management systems so that the information generated can be used in designing breeding programs. The study covered five districts in four administrative zones of Ethiopia representing Bati (in Oromia Zone) and Kalu (in South Wollo Zone) for Bati goats; Yabello (in Borana Zone) for Borana goats and Shinille and Erer (in Siti Zone) for Short-Eared Somali goats. A total of 345 households interview was made and phenotypic measurements were taken on 601(468 females and 133 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, in number, goats accounted for 72.01, 50.93 and 47.38% of other livestock species in Siti, around Bati and Borana, respectively. The least square mean (±SE) of goat flock size (44.02±3.33) per household in Siti was significantly ($p<0.05$) higher than those observed in Borana (23.08±1.94) and Bati area (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 Borana 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 Borana goats were not significant ($p>0.05$),whereas Short-eared Somali goats remained significantly ($p<0.05$) lower for most of the body measurement characteristics. The canonical analysis done on phenotypic measurements also put Bati and Borana goats closer by discriminating Short-eared Somali goat populations. The similarities between Bati and Borena goats and significance divergence of Short-eared Somali goats in phenotypic measurements suggested that the need of further molecular characterization study to validate information from phenotypic characterization. Correlation coefficient was consistently highest between live weight and chest girth in both sexes across the goat populations. Hence, linear measurements could be valuable to estimate live body weight for those farm communities where sensitive weighing scales are not readily available.

Key words: Ethiopia, husbandry practices, phenotypic characteristics, indigenous goats.

INTRODUCTION

Ethiopia has a large population of goats (approximately 29 million) mainly of indigenous breeds (CSA, 2015). FARM-Africa (1996) identified 12 goat types in the country. The description of goat type refers to goats which have certain phenotypic characteristics and geographic location. Alemu (2004) has also classified the indigenous goat types in to 8 distinct genetic units using genetic DNA markers, These are: Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergalle, Afar, Highland goats (Central and North West Highland goats) and the eighth unit (Hararghe Highland, Short-eared Somali and Long-eared Somali goats).

In Ethiopia, farmers/pastoralists kept goats for food, income generation, socio-cultural considerations and source of other valuable non-food products such as skin and manure (Tsegaye, 2009; Gebreyesus, 2010; Tadesse et al., 2013). Despite the large size, wide distribution and diversified functions, the Ethiopian goat population productivity is relatively low. This is due to different factors such as poor nutrition, prevalence of diseases, and lack of appropriate breeding strategies and poor understanding of the production system.

To increase and sustain the productivity of indigenous 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 (FAO, 2012). 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 (FAO, 2007).

In Ethiopia, various goat characterization studies for different goat populations had been executed (FARM Africa, 1996; Gebreyesus, 2010; Hassen et al., 2012). Despite the studies done, information on husbandry practices as well as phenotypic characteristics for indigenous goat populations such as Bati, Borana and short-eared Somali 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. Husbandry practice involves management, feeding and breeding aspects and it is among the factors which cause the phenotypic characteristics of animals. This indicates that description of husbandry practices and phenotypic characteristics of a particular animal population/breed are complementary procedures to be addressed in a characterization study. Therefore, this study was designed to provide husbandry practice and phenotypic characteristic information of Bati, Borana and Short-eared Somali indigenous goat populations in Ethiopia so that the information provided through the characterization of husbandry practices and phenotypic characteristics of the indigenous goats enable the interested groups to make informed decisions on breeding programmes.

MATERIALS AND METHODS

Description of study areas

The study covered five districts in four administrative zones: representing Bati and Kalu for Bati goats in Oromia and South Wollo zones respectively; Yabello for Borana goats in Borana zone; Erer and Shinille from Siti (the previous Shinille) zone for Short-Eared Somali goats.

South Wollo and Oromia zones (referred to as 'Bati area' hereafter) have varied topography, from the dry plains 1000 m above sea level to the high peaks about 3500 m above sea level altitude. The main rain is in the '*kremt*' (July-September) and the mean rainfall is 726 mm per annum (LPAR, 2007). The annual temperature ranges from 23 to 32°C (BDARDO, 2014).

Borana zone is 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 minimum and maximum average annual rainfall ranges between 350 and 900 mm with considerable variability in quantities and distribution. The average maximum temperature is 29°C and the minimum average temperature is about 13°C (Lasage et al., 2010).

Siti zone is mostly lowland and is arid or semi-arid. The altitude ranges from 950 to 1350 m above sea level. The minimum and maximum 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 700 mm (Save the Children UK and Disaster Preparedness and Prevention Agency, 2008).

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' Development Agents (DAs) and leaders, a total of 14 peasant associations (5 in Bat area; 5 in Siti; 4 in Borana) were selected. During selection of districts and peasant associations, production potential of the targeted goat type and accessibility were considered. A total of 345 households (98 in Bati, 132 in Borana and 115 in Siti) were interviewed. Pre-tested semi-structured questionnaire adopting a questionnaire prepared by International Livestock Research Institute and Oromia Agricultural Development Bureau for survey of

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Table 1. Number of heads (least square mean ±SE) per household according to species and area of survey.

Specie	Bati area (N=98)		Borana (N=132)		Siti (N=115)	
	LSM±SE	%	LSM±SE	%	LSM±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 $p<0.05$).

livestock breeds in Oromia (Ayalew and Rowlands, 2004), was used. Information on livestock composition, holding pattern, and goat flock structure, management practices, breeding system, feeding and watering strategies, production constraints and other related information were collected. Phenotypic Records were taken on 601(162 Bati (128 females and 34 males), 246 Borana (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 FAO (2012) 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), 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 (FAO, 2012).

Statistical analyses

The percentage of each level of qualitative data was obtained using PROC FREQ procedure of SAS (2008). 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. Proc mean of the SAS software packages (SAS, 2008) was used to analyze the quantitative data (separately for males and females) fitting goat type 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 goat type by sex.

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

Where: Y_{ij} = observed quantitative measurement of trait of interest ; μ = population mean ; β_i = i^{th} goat type 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, Borana and Bati area, 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 Borana (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. The LSM (±SE) number of breeding does per household was 9.30±0.78, 13.30±0.84 and 3.51±0.91 in Borana, Siti and Bati area, respectively. The proportion of adult females (30.23%) and kids less than 6 months old (29.62%) in Siti were slightly smaller than their counterparts in Bati area and Borana. On the other hand, comparing with Borana and Bati, the share of kids between 6-12 months age (23.86%) and intact males older than one year (12.64%) in the flocks of Siti were higher. The contribution of castrated males in Siti, Borana and Bati area were 3.65, 0.95 and 3.52%, 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 Borana and Siti, respectively, had their own breeding buck, uncontrolled natural mating system was

Table 2. Frequency (N) and percent (in brackets) of type of natural mating systems and sources of breeding buck.

Particular	Bati area	Borana	Siti
Natural mating system			
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.

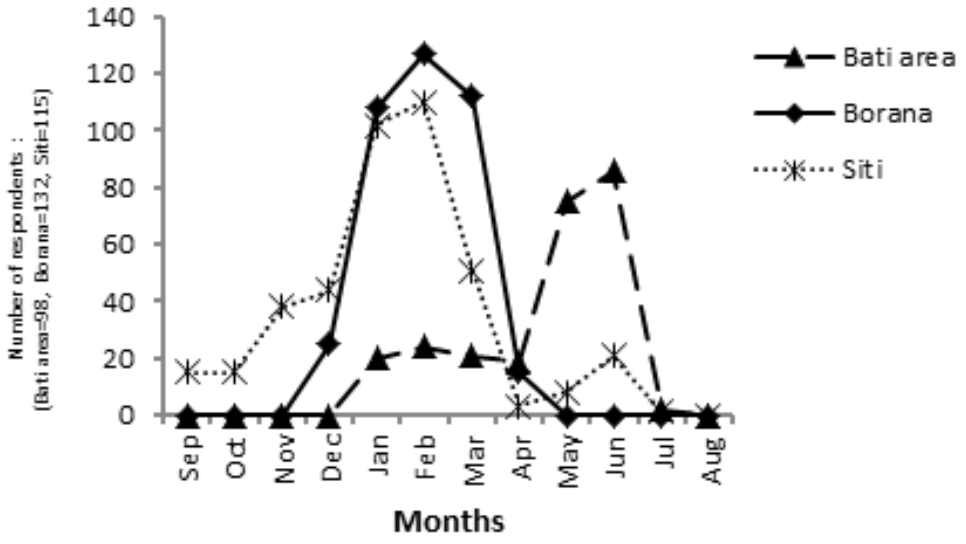

Figure 1. Feed shortage by months.

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 in Bati, Borana and Siti, respectively. Owners kept bucks on average until 2.4, 4.9 and 5.8 years of age in Bati, Borana and Siti, respectively, with a maximum stay of 4, 8 and 10 years in the same order.

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 (Figure 1) 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, crop residues, collected and standing hay in Bati area, and migration of adult and healthy animals in Borana and Siti. 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.

As presented in Table 3, the majority of goat owners in Bati area provides water to their goats every day and few individuals once in two days. Because of lack of surface water in Borana, almost all of the goat owners take their goats to the watering points once in three or two days.

Table 3. Watering frequency (N) and percent (in brackets) during dry season in the study areas.

Particular	Bati area	Borana	Siti
Frequency of watering			
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.

Constraint	Bati area				Borana				Siti			
	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.

However, in Siti, 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). In 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 Borana. 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. Almost all of the respondents did not rank lack of appropriate genotype as a constraint.

Qualitative characteristics

When appraised visually goats from the three areas were different (Figure 2).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 Borana; and 45.08% plain, 39.90% patchy/pied and 15.03% spotted in Short-eared Somali goat populations. Most of Bati goats (87.5% females and 67.7% males) had straight head profile and about 14% (11.7% females and 23.5% males) were with slight concave head. Almost all (99%) of male and female Borana 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 Bati, Borana and Short-eared Somali goats, respectively. The reminder proportions in each sampled population, except 8.9% of Borana does which displayed some rudimentary horns were polled.

The majority of Bati and Borana 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% Borana) 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 Borana and 4.7% of Short-eared Somali does, wattle was totally absent in all bucks of the three populations and in Bati does. It was found that about 56, 69 and 37% of Bati, Borana and Short-eared Somali bucks, respectively had ruff. Over 90% of Borana and Short-eared Somali and 67.7% of Bati bucks

Figure 2. Physical appearances of Ethiopian adult goats: Bati (left), Borana (middle) and Short-eared Somali (right).

had beard while about 25% of Bati and Borana as well as 17.9% of Short-eared Somali does were bearded.

Quantitative characteristics

Least square means for body weight, body condition score and other quantitative measurements of Bati, Borana 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±0.16 cm) among the three goat types. As compared with Borana does, Bati does varied significantly ($p<0.05$) in only three measurements (body weight, chest width and horn length) of the 9 measurements, otherwise they were comparable in most of their body dimensions (body length, height at 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 Borana 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 Borana 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 Borana contemporaries. 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 goat types 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 Figure 3. In both sexes, CAN1 discriminated Borana from Short-eared Somali goat populations effectively, keeping Borana and Bati populations closer on the right side of the X-axis. Though Bati goats put closer to Borana goats, they positioned more or less between Borana 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

Coefficients of correlation between body weight and studied traits in this study varied from strong (0.86) to low (0.18) and highly significant ($p<0.01$) to non-significant

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

Variable	Class level	Bati			Borana			Short-eared Somali		
		Female	Male	Total	Female	Male	Total	Female	Male	Total
		N (%)			N (%)			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.

Variable	Class level	Bati			Borana			Short eared Somali		
		Female	Male	Total	Female	Male	Total	Female	Male	Total
		N (%)			N (%)			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 orientation	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)

Table 6. Contd.

Ear orientation	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.

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

Sex	Trait	Bati (N=128)		Borana (N=201)		Short-eared N=139)		Over all mean	
		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

Table 7. Contd.

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); BW = Body weight, 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.

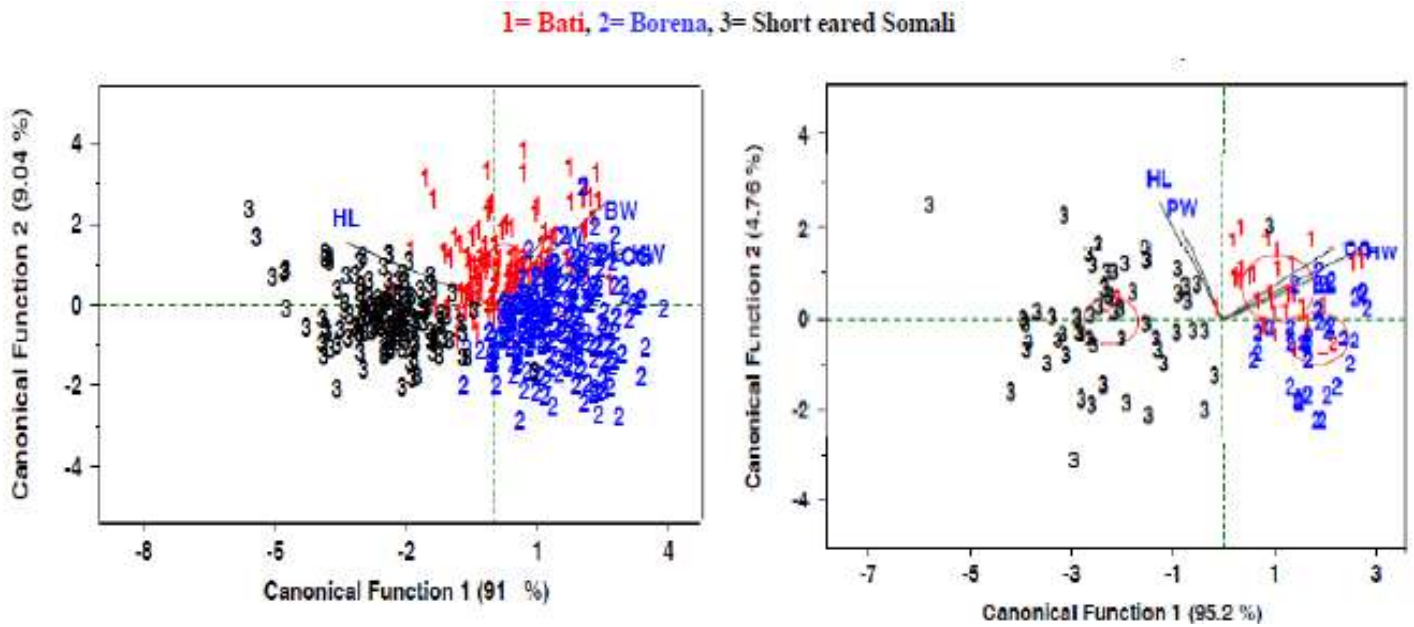

Figure 3. Spatial distributions of does (left) and bucks (right) on the first two canonical variants.

(Table 8). Most variables (BC, BL, HW, CG, CW, RL and PW) 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

Table 8. Pearson's correlation coefficients of quantitative traits for bucks (above diagonal) and does (below diagonal).

Population	Trait	BW	BC	BL	HW	CG	CW	RL	PW	SC
Bati	BW		0.57**	0.61**	0.58**	0.85**	0.47**	0.55**	0.47**	0.55**
	BC	0.52**		0.59**	0.27^{NS}	0.54**	0.44**	0.14^{NS}	0.27^{NS}	0.34^{NS}
	BL	0.62**	0.35**		0.46**	0.77**	0.47**	0.41*	0.40*	0.40*
	HW	0.40**	0.17*	0.48**		0.54**	0.01^{NS}	0.44**	0.66**	0.54**
	CG	0.82**	0.34**	0.57**	0.51**		0.50**	0.71**	0.62**	0.56**
	CW	0.68**	0.30**	0.46**	0.33**	0.61**		0.40*	0.34*	0.31^{NS}
	RL	0.62**	0.29**	0.43**	0.41**	0.59**	0.59**		0.57*	0.60**
	PW	0.53**	0.32**	0.39**	0.32**	0.49**	0.52**	0.51**		0.60**
Borana	BW		0.36*	0.80**	0.79**	0.86**	0.55**	0.76**	0.78**	0.53**
	BC	0.40**		0.27^{NS}	0.51**	0.30*	0.10^{NS}	0.11^{NS}	0.22^{NS}	0.10^{NS}
	BL	0.67**	0.27**		0.77**	0.76**	0.28^{NS}	0.66**	0.71**	0.37*
	HW	0.50**	0.08^{NS}	0.50**		0.80**	0.43**	0.66**	0.75**	0.35*
	CG	0.82**	0.25**	0.56**	0.54**		0.40**	0.74**	0.75**	0.63**
	CW	0.71**	0.31**	0.56**	0.50**	0.67**		0.52**	0.53**	0.24^{NS}
	RL	0.57**	0.19**	0.58**	0.58**	0.60**	0.62**		0.76**	0.50**
	PW	0.54**	0.19**	0.53**	0.43**	0.58**	0.50**	0.54**		0.49**
Short-eared Somali	BW		0.69**	0.46**	0.79**	0.79**	0.53**	0.55**	0.26^{NS}	0.56**
	BC	0.62**		0.49**	0.44**	0.56**	0.49**	0.28*	0.25^{NS}	0.43**
	BL	0.25**	0.31**		0.51**	0.50**	0.25^{NS}	0.24^{NS}	0.20^{NS}	0.38**
	HW	0.37**	0.13^{NS}	0.17*		0.68**	0.40**	0.40**	0.24^{NS}	0.46**
	CG	0.73**	0.44**	0.25**	0.32**		0.61**	0.59**	0.43**	0.66**
	CW	0.40**	0.16^{NS}	0.07^{NS}	0.01^{NS}	0.53**		0.50**	0.12^{NS}	0.37**
	RL	0.34**	0.19*	0.11^{NS}	0.30**	0.45**	0.33**		0.42**	0.52**
	PW	0.24**	0.24**	0.03^{NS}	0.12^{NS}	0.40**	0.18*	0.26**		0.44**

BC = Body condition, BL = Body length, HW = Height at wither, CG = Chest girth, CW = Chest width, RL = Rump length, PW = Pelvic width, SC = Scrotum circumference; NS = Non Significant: *p < 0.05, ** p< 0.01.

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 Nega et al. (2009) 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. Gizaw et al. (2010) 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 Getachew et al. (2006) 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 Tilahun et al. (2006) and Gebreyesus (2010) who reported 34±23.54 and 10.08±0.8 heads per household for the same goat type in rural peasant associations of 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 study 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 (Gizaw et al., 2010). In our findings the breeding does were the major followed by kids less than 6 months in all goat populations. This is in agreement with findings of other researchers in Ethiopia (Tsedeke, 2007; Tsegaye, 2009).

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 Kosgey (2004), 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 (Saico and Abul, 2007). Use of bucks for long period in a flock in Borana and Siti areas depicts inbreeding problem in the flocks (Jimmy et al., 2010).

Feeding and watering strategies

Goat production in communal production systems is highly dependent on rangeland resources (Homann et al., 2007). 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 Borana 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 Tadesse et al. (2013). According to Urge (2007), 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 (Homann et al., 2007). Though, water shortage has impact on productivity of goats, in this study, Borana and Short-eared Somali goats showed relatively more drought tolerance and not affected adversely by water shortage as compared with Bati goats.

Major constraints

Major goat production and productivity challenges in the communal production systems include feed shortage, disease occurrences and water scarcity (Markos, 2006; Gizaw et al., 2010). The major constraints of goat rearing found 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 (FAO, 2012). These characteristics are important in breed identification, classification, genetic improvement (selection) implementation and sustainable utilization and conservation (Salako and Ngere, 2002).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, Hassen et al. (2012) and Gebreyesus (2010) 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) programmes. The most important coat color preferences in Bati area for both sexes were brown whereas plain white coat color was the most preferred by both Borana and Siti pastoralist and agro pastoralists. Not for their production or reproduction traits rather due to low price in the local markets, black coat color goats were not preferred by the producers in all study areas. The higher proportions of polled bucks than does across the studied goat types 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 Gebreyesus (2010) for short eared Somali goats and Tsegaye et al. (2013) in Hararghe highland goats. According to Hagan et al. (2012), 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. Leng et al. (2010) 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 studied goat populations.

The similarity of most body measurements between Bati and Borana goat 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 Hassen et al. (2012) and Getachew et al. (2006). 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±1.10 cm in bucks and 17.51±0.34 cm in does). According to FAO (2012), 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 Mavule et al. (2013),

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 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, Nsoso et al. (2003) 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, Hassen et al. (2012) and Gebreyesus (2010) for some Ethiopian goats; and Mavule et al. (2013) 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.

Conclusion

Goats 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, traits for selection preferred by 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 least square mean values for most body measurements distinguished Short-eared Somali goats while it dictated the least differentiation between Bati and Borana goats. Therefore, molecular genetic approach is necessary to evaluate the phenotypic results. 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 and linear measurements could be used to estimate live body weight for those farm communities where sensitive weighing scales are not readily available.

Conflict of Interests

The authors have not declared any conflict of interests.

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