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Phenotypic Characterization of Indigenous Goat Population in Southern, Ethiopia

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Abstract: Indigenous goat populations in Ethiopia contain a number of significant genetic features, including the ability to function better under limited input and climatic stress, resistance to viral illnesses and parasites, as well as heat stress. Molecular or phenotypic characterisation is required to offer comprehensive database information of variance among goat populations for sensible utilization of this crucial trait and goat resources. Even though genetic characterization for Arsi-Bale and Woyito-Guji breeds have been done, which are distributed in southern part of Ethiopia, due to overlapping of the distribution of these two breeds in the study area the present phenotypic characterization of indigenous goat was initiated. Despite the studies done, information on phenotypic characteristics and production systems of some indigenous goat populations in study area is still scanty. Besides, there was little intervention works so far on the improvement of production and productivity of local goat breeds in the area. A study was conducted at Abaya and Yirgachafe districts to characterize indigenous goat types phenotypically. Data were collected through field measurements and visual observation of qualitative traits. Totally 540 goats were used for metric and morphometric measurement. Results of the study revealed that the goat populations found in Abaya and Yirgachafe district were different characteristics which are physically Abaya goats were closest with Arsi-Bale whereas yirgachafee with Woyto-Guji which are mostly distributed goat breeds in southern Ethiopia. The dominant coat color pattern in study area was plain, patchy, and spotted with proportions of 55.19, 37.04, and 7.78% and 46.67, 38.89, and 14.44% in Abaya and Yirgachafee district respectively. A strong and positive correlation (r = 0.83, 0.76) was observed between heart girth and body weight for male and female goat populations respectively. Generally, the indigenous goat population has its own difference in its morphological and morphometric traits. Traits have their own economic contribution. Therefore, identifying these important traits for further genetic improvements, conservation and sustainable utilization of the genetic resources of the diversified goat population is important.

Keywords: Linear Body Measurement, Qualitative Trait, Quantitative Trait

1. Introduction

Goats (Capra hircus) contribute significantly to the livelihood of resource-poor farmers in Ethiopia. Goats have a short reproductive cycle hence high multiplication rate as compared to large ruminants, which is ideal for poverty alleviation providing income, meat, milk, skin and manure, as aliving bank against the various environmental hazards (crop failure, drought and flooding) and have serve for socio-cultural values for diverse traditional communities [18, 2].

Ethiopian goats are classified in to eight genetically diverse breeds which adapted to a range of environments from arid lowlands (the pastoral and agro-pastoral production system) to the humid highlands (mixed farming systems) [20]. Ethiopia has about 32.74 million goats, of which about 70.49 percent are females and 29.51 percent are males and with respect to breed, almost all of the goats are indigenous breeds, which account about 99.97% [8].

Iindigenous goat populations generally dominate the goat flocks in Ethiopia and have developed certain valuable genetic traits such as ability to perform better under low input condition and climatic stress, tolerance to infectious diseases and parasites as well as heat stresses [1]. Their morphological differences have important socio-cultural and economic values to the Ethiopian communities; as a result, most farmers have specific consideration and choices for goat coat colors followed by body sizes. For instance, black coat colored goat is less preferred in the Amhara Region and beyond [1].

A systematic description/characterization of the goat types and management systems should be considered as prerequisite for planning the rational use of indigenous goat resources. In addition breed characterization is the first step in the urgent task of genetic resource management and conservation of goat on the risk status [10]. Breed characterization can be done through performance evaluation, phenotypic characterization and DNA molecular characterization [11] which provide comprehensive database information of variation among the goat populations as to which of the populations represent homogenous populations and which of them are genetically distinct, these all information would generate understanding of the goat type.

Based on this genetic characterization of Arsi-Bale and Woyito-Guji breeds which is distribution overlap in the current study area of Abaya and Yirgachefe districts. Therefore, even though genetic characterization for Arsi-Bale and Woyito-Guji breeds have been done, which are distributed in southern part of Ethiopia, due to overlapping of the distribution of these two breeds in the study area the present phenotypic characterization of indigenous goat was initiated. Despite the studies done, information on phenotypic characteristics and production systems of some indigenous goat populations is still scanty. Besides, there was little intervention works so far on the improvement of production and productivity of local goat breeds in the area. Also farmers practice traditional type of goat production system in the area.

2. Material and Methods

2.1. Description of the Study Areas

The study was conducted in two National Regional States of Ethiopia: Oromia regional states (Abaya district) in West Guji zone and South nation nationality and peoples region (Yirgachafee district) of Gedio zone. Eventhogh only administrative demarcation makes, at different region unless districts are inter border and located southern part of Ethiopia. Abaya is one of the districts in the Oromia Region of Ethiopia. It is part of former Gelana-Abaya district that was divided later on as Abaya and Gelana districts. This district is located between latitude of 5°45′0″N- 6°45′00″N and longitude of 37°44′00″E-38°20′00″E. It is part of the West Guji zone, Abaya was bordered on the south by Bule Hora and on the west, north and east by Southern nations, nationalities, and peoples region (SNNP) and Lake Abaya, on the western. (District Agriculture and Natural resource office, 2019).

Yirgachafee is also one of district of Gedeo zone, in SNNP region of Ethiopia. This study area is located at about 395 km south of Addis Ababa, capital city of Ethiopia and 124km from Hawassa. Yirgachafee is bordered on the south by Kochore districts, west by the Abaya district of West Guji zone, and north by Wenago, east by Bule and southeast by Gedeb. The district is located at latitude between 6°4′00″N-6°15′00″N and longitude of 38°10′00″E-38°20′00″E. (District Agriculture and Natural resource office, 2019).

2.2. Sampling Techniques, Sample Size and Data Collection

Purposive sampling techniques were applied to select both study districts and Kebeles based up on the size of goat population obtained from respective agriculture and natural resource office. Each household from kebele was selected randomly from listed households based on year and experience of goat rearing at least two year. The site selection and the household baseline surveys were conducted from 1 September to beginning of December 2019.

A total of 540 (162 males and 378 female) goat were sampled for quantitative (Body weight (BW) and linear body measurements (LBM) like height at wither (HW), body length (BL), heart girth (HG), ear length (EL), pelvic width (PW), chest depth (CD) and scrotal circumference (SC) for male using measuring tape in level ground and weight of goat was taken using 50 kg spring balance using sack bag by hanging and ground balance for those who own coffee ground beam balance. Linear body measurements were taken on goats which have one and above pair of permanent (1PPI, 2PPI, 3PPI and >4PPI) and qualitative (coat color pattern, coat color type, head profile, back profile, rump profile, ear orientation, horn (presence, absence, shape and orientations), hair type, toggle, ruff; beard) using visual observations based on breed description list of [10].

2.3. Statistical Data Analysis

All data gathered during the study period were coded and recorded in Microsoft Excel 97-2003. The data were analyzed by SAS version 9.2 (2008). General linear model procedure (PROC GLM) of SAS was used for both metric and morphometric trait analysis. Tukey's comparison test was used to compare the sub factor brought significant difference. Descriptive statistics were also used to describe the results as percentages for all districts.

Body weight and linear body measurement (LBMs) for both sexes was analyzed using following model.

$$Y_{ijk}=\mu + D_i + A_j + S_k + (AS)_{jk} + e_{ijk},$$

where;

Y_{ijk} = the observed value of trait of interest,

μ = overall mean,

D_i = the effect of i^{th} district (i=1, 2),

A_j = the effect of the j^{th} age (dentition class) (j=1, 2, 3, 4 pairs of permanent incisor),

S_k = the effect of k^{th} sex (k = male, female),

AS_{jk} = Interaction effect of j^{th} age (dentition class) and k^{th} sex,

e_{ijk} = the residual random error.

The model employed for analyses of scrotal circumference and length:

$$Y_{ijk}=\mu + D_i + A_j + e_{ijk},$$

Where;

Y_{ijk} = the observed value of scrotal circumference and length,

μ = overall mean,
D_i = the effect of i^{th} district (i=1, 2),
A_j = the effect of the j^{th} age (dentition class) (j=1, 2, 3, 4),
e_{ijk} = the residual random error.

3. Result

3.1. Qualitative Traits

In this particular study, the overall coat color patterns for both sexes were plain (46.67% and patchy/pied (38.89). The overall observed coat color type for both sex were predominantly red (16.66%), followed by white dominant and grey (13.70%) and white (12.22%) in Abaya, whereas black dominant (14.81%), fawn (13.70%) and white dominant (13.33%) in Yirgachafee. Goat population in study district was unified with smooth hair followed by glossy and curly rough hair type with 40.74, 24.07 and 20% in Abaya where as 38.89, 23.70 and 20.7% smooth, long straight and curly rough in Yirgachafee respectively. In both districts 90-94% of the goat population had horn.

Table 1. *Description on qualitative traits of goat.*

Traits	Attributes	Abaya						Yirgachafee					
		M		F		Total		M		F		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
Coat color pattern	Plain	39	48.15	110	58.20	149	55.19	39	48.15	87	46.03	126	46.67
	Patchy	37	45.68	63	33.33	100	37.04	32	39.51	73	38.62	105	38.89
	Spotted	5	6.17	16	8.47	21	7.78	10	12.35	29	15.34	39	14.44
	X^2												133.6*
Coat color type	White	9	11.11	24	8.89	33	12.22	8	9.88	13	6.88	21	7.78
	Black	5	6.17	18	6.67	23	8.51	10	12.35	17	8.99	27	10.00
	Brown	3	3.70	4	1.48	7	2.59	10	12.35	14	7.41	24	8.89
	Fawn	11	13.58	19	7.04	30	11.11	9	11.11	28	14.81	37	13.70
	Grey	16	19.75	21	7.78	37	13.70	6	7.41	15	7.94	21	7.78
	Red	12	14.81	33	17.46	45	16.66	4	4.94	17	8.99	21	7.78
	Roan	7	8.64	12	6.35	19	7.04	7	8.64	8	4.23	15	5.56
	White dominant	9	11.11	28	14.81	37	13.70	10	12.35	26	13.76	36	13.33
	Black dominant	4	4.94	15	7.94	19	7.04	11	13.58	29	15.34	40	14.81
	Brown dominant	5	6.17	15	7.94	20	7.41	6	7.41	22	11.64	28	10.37
	X^2 value												29.07*
Hair type	Glossy	17	6.30	48	25.40	65	24.07	9	11.11	37	19.58	46	17.04
	Smooth hair	39	14.44	71	37.57	110	40.74	31	38.27	74	39.15	105	38.89
	Long straight hair	11	4.07	30	15.87	41	15.19	25	30.86	39	20.63	64	23.70
	Curly rough	14	5.19	40	21.16	54	20.00	16	19.75	39	20.63	55	20.37
	X^2 value												138.8*
Back profile	Straight	34	41.98	95	50.26	129	47.78	19	23.46	62	32.80	81	30.00
	Slopes up towards rump	14	17.28	33	17.46	47	17.41	13	16.05	34	17.99	47	17.41
	Slopes down from withers	30	37.04	52	27.51	82	30.37	25	30.86	56	29.63	81	30.00
	Dipped (curved)	3	3.70	9	4.76	12	4.44	24	29.63	37	19.58	61	22.59
	X^2 value												8.56*
Head (Facial) profile	Straight	12	14.81	38	20.11	50	18.52	24	29.63	48	25.40	72	26.67
	Concave	43	53.09	77	40.74	120	44.44	36	44.44	88	46.56	124	45.93
	Convex	24	29.63	65	34.39	89	32.96	17	20.99	43	22.75	60	22.22
	Markedly convex	2	2.47	9	4.76	11	4.07	4	4.94	10	5.29	14	5.19
	X^2 value												180.34*
Ear orientation	Erect	11	13.58	23	12.17	34	12.59	20	24.69	48	25.40	68	25.19
	Semi-pendulous	41	50.62	88	46.56	129	47.78	32	39.51	80	42.33	112	41.48
	Pendulous	6	7.41	19	10.05	25	9.26	2	2.47	7	3.70	9	3.33
	Carried horizontally	23	28.40	59	31.22	82	30.37	27	33.33	54	28.57	81	30.00
	X^2 value												172.66*
Horn	Present	76	93.83	180	95.24	256	94.81	78	96.30	166	87.83	244	90.37
	Absent	5	6.17	9	4.76	14	5.19	3	3.70	23	12.17	26	9.63
	X^2 value												391.8*
Horn shape	Scurs	6	7.41	14	7.41	20	7.41	3	3.70	11	5.82	14	5.19
	Straight	22	27.16	62	32.80	84	31.11	25	30.86	49	25.93	74	27.41
	Curved	33	40.74	48	25.40	81	30.00	33	40.74	53	28.04	86	31.85
	Spiral	15	18.52	52	27.51	67	24.81	13	16.05	42	22.22	55	20.37
	Corkscrew	0	0.00	5	2.65	5	1.85	4	4.94	17	8.99	21	7.78
	Polldnes	5	6.178	8	4.23	13	4.81	3	3.70	17	8.99	20	7.41
	X^2 value												88.4*
Horn orientation	Lateral	14	17.28	19	10.05	33	12.22	6	3.17	28	14.81	34	12.59
	Obliquely upward	20	24.69	71	37.57	91	33.70	37	45.67	90	47.61	127	47.03
	Back ward	47	58.02	99	52.38	146	54.07	38	46.91	71	37.56	109	40.37
	X^2 value												63.34*

3.2. Live Body Weight and Linear Measurement

In the study area, overall mean of live body weight, heart girth, height at wither, body length, scrotal length, scrotal circumference were 31.1 kg, 71.8cm, 58.9cm, 52.2cm, 22.87cm, 16.10 cm, respectively.

Location effect:-There was significant difference ($p<0.05$) in body weight and all linear body measurements except HL, FC and FH between both districts.

Sex effect:- Heart girth, bodyweight, pelvic width, chest depth and neck length was significantly affected by sex.

Age effect:- Age has significant ($p<0.05$) differences for all linear body measurements except forecanon circumstance and fore canon height. In this study body weight (BW) and some linear body measurements significant difference were observed among age groups. The scrotal circumference and length was also significantly ($p<0.05$) affected by age.

Sex by Age group:-The interaction of sex and age group was not significantly ($p>0.05$) different for body weight and other body measurements except body length, chest depth and fore canon circumstance. Bucks at age category of 1PP and 4PP are higher in body length than does in the respective age.

Table 2. *Live body weight and linear body measurement of goat.*

Effect &level	N	HG	HW	BL	BW	PW	HL	EL
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Over all	540	71.8±0.4	58.9±0.3	52.2±0.3	31.1±0.3	15.24±0.1	10.9±0.2	12.9±0.1
%CV	540	8.4	10.4	11.9	14.6	19.8	17.3	19.4
R^2	540	0.51	0.40	0.28	0.34	0.14	0.19	0.08
Sex		*	Ns	Ns	*	*	Ns	Ns
Male	162	73.28^{a}±0.7	59.52^{a}±0.6	52.38^{a}±0.6	32.41^{a}±0.5	15.5^{a}±0.3	11.1^{a}±.3	12.8^{a}±0.2
Female	378	70.34^{b}±0.4	58.45^{a}±0.3	52.05^{a}±0.3	29.8^{b}±0.3	14.9^{b}±0.1	10.7^{a}± 0.1	12.9^{a}±0.1
Location		*	*	*	*	*	Ns	*
AB	270	73.18^{a} ± 0.4	62.71^{a} ±0.46	53.81^{a} ±0.49	31.84^{a}±0.39	14.56^{b}±0.27	10.88^{a}±.23	13.52^{a}±0.16
YC	270	70.44^{b} ±04	55.24^{b} ±0.47	51.23^{b} ±0.48	30.45^{b}±0.39	15.88^{a}±0.28	11.05^{a}±0.23	12.31^{b}±0.17
Age		*	*	*	*	*	*	*
1pp	137	61.95^{c}± 0.51	53.32^{d}±0.52	46.62^{d}±0.53	26.78^{d}±0.38	13.61^{d}±0.25	9.38^{c}±0.29	12.23^{c}±0.21
2pp	195	69.66^{b}±0.48	57.62^{c}±0.49	50.56^{c}±0.50	29.42^{c}± 0.36	14.80^{c}±0.24	10.60^{b}±0.33	12.92^{b}± 0.20
3pp	142	77.07^{a}±0.58	61.19^{b}±0.59	54.12^{b}±0.60	32.43^{b}±0.56	15.56^{b}±0.29	10.92^{b}±0.27	12.67^{bc}±0.24
4pp	66	78.56^{a}± 0.85	63.77^{a}±0.87	57.55^{a}±0.88	36.63^{a}±0.82	17.02^{a}±0.42	12.96^{a}±0.48	13.84^{a}±0.35
Sex by Age		Ns	Ns	*	Ns	Ns	Ns	Ns
Male, 1pp	61	62.07^{c}±0.76	53.76^{d}±0.77	47.67^{de}±0.78	26.88^{e}±0.56	13.18^{f}±0.38	9.05^{e}±0.43	11.98^{c}±0.31
Male, 2pp	51	69.83^{b}±0.83	57.28^{c}±0.85	48.94^{d}± 0.86	30.20^{c}±0.62	14.34^{de}± 0.41	11.23^{bc}±0.47	12.73^{bc}±0.34
Male, 3pp	34	78.12^{a}±0.22	61.83^{ab}±0.14	53.85^{bc}±0.15	32.42^{b}±0.76	15.26^{bcde}±0.51	10.57^{cd}±0.58	12.37^{bc}±0.42
Male, 4pp	16	79.12^{a}±0.49	65.15^{a}±0.51	59.06^{a}±0.58	36.62^{a}±1.1	16.93^{ab}±0.74	13.81^{a}±0.85	14.43^{a}±0.62
Female, 1pp	74	61.84^{c}±0.69	52.95^{d}±0.70	45.58^{e}±0.71	26.78^{e}±0.51	14.04^{ef}±0.34	9.72^{de}±0.39	12.48^{bc}±0.29
Female, 2pp	146	69.50^{b}±0.49	57.96^{c}±0.50	52.17^{c}±0.51	28.64^{d}±0.36	15.26^{cd}±0.24	10.60^{cd}±0.28	13.11^{b}±0.20
Female, 3pp	108	76.02^{a}±0.57	60.44^{b}± 0.58	54.39^{b}±0.59	32.31^{b}±0.42	15.86^{bc}±0.28	10.64^{cd}±0.32	12.97^{b}±0.24
Female, 4pp	50	78.01^{a}±0.84	62.35^{ab}±0.85	56.06^{a}±0.86	35.42^{a}±0.62	17.10^{a}±0.42	12.12^{ab}±0.48	13.24^{ab}±0.35

Effect & level	N	SC	SL	RH	CD	NL	TL	FH	FC
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Over all	540	22.87±0.3	16.10±0.29	59.35±0.3	25.15±0.1	19.5±0.2	12.14±0.1	13.45±0.1	8.4±0.04
%CV	540	15.6	20.86	10	10.4	16.6	21.45	17.3	10.1
R^2	540	0.15	0.27	0.45	0.19	0.18	0.2	0.03	0.08
Sex				Ns	*	*	Ns	Ns	Ns
Male	162	22.87±0.3	16.10±0.29	59.8^{a}±0.5	24.8^{a}±0.2	20.07^{a}±0.4	12.2^{a}±.2	13.5^{a}± 0.2	8.4^{a}±0.04
Female	378	-	-	58.9^{a}±0.3	25.5^{b}±0.1	18.9^{b}±0.2	12^{a}±0.1	13.3^{a}±0.1	8.4^{a}±0.07
Location		*	*	*	*	*	*	Ns	Ns
AB	270	22.11^{b}±0.42	14.65^{b}±0.39	63.6^{a} ±0.3	24.1^{b}±0.1	20.57^{a}±0.30	12.48^{a}±0.20	13.09^{a}±0.16	8.52^{a}±0.06
YC	270	23.66^{a}±0.41	17.52^{a}±0.38	55.1^{b} ±0.4	26.3^{a}±0.1	18.09^{b}±0.30	11.74^{b}±0.21	13.80^{a}±0.16	8.3^{a}±0.06
Age		*	*		*	*	*	Ns	Ns
1pp	137	21.23^{b}±0.45	14.28^{c}±0.41	54.01^{c}±0.50	24.48^{b}±0.21	17.84^{c}±0.27	11.51^{a}±0.24	13.09^{a}±0.20	8.17^{b}±0.08
2pp	195	22.87^{ab}±0.88	15.69^{b}±0.45	58.15^{b}±0.47	25.35^{a}±0.25	19.52^{b}±0.25	12.40^{a}±0.22	13.28^{a}±0.18	8.31^{b}±0.07
3pp	142	23.12^{a}±0.49	17.12^{ab}±0.81	61.73^{a}±0.57	25.36^{a}±0.37	19.97^{ab}±0.31	12.21^{a}±0.27	13.48^{a}±0.22	8.63^{a}±0.09
4pp	66	24.33^{a}±0.61	17.24^{a}±0.56	63.74^{a}±0.84	25.44^{a}±0.22	20.63^{a}±0.45	12.48^{a}±0.40	13.96^{a}±0.33	8.60^{a}±0.13
Sex by Age		Ns	Ns	Ns	*	Ns	Ns	Ns	*
Male, 1pp	61	21.23^{b}±0.45	14.28^{c}± 0.41	54.34^{d}± 0.75	24.21^{d}±0.36	18.05^{bc}±0.40	11.51^{bc}±0.35	13.10^{a}±0.29	8.22^{cd}±0.10
Male, 2pp	51	22.87^{ab}±0.88	15.69^{b}± 0.45	57.55^{c}±0.82	24.62^{cd}±0.33	20.25^{a}± 0.44	12.57^{a}±0.39	13.26^{a}± 0.32	8.33^{cd}±0.11
Male, 3pp	34	23.12^{a}±0.49	17.12^{ab}± 0.56	62.80^{ab}±0.11	24.93^{abcd}±0.65	21.99^{a}±0.54	12.39^{abc}±0.47	13.49^{a}±0.39	8.81^{ab}± 0.14
Male, 4pp	16	24.33^{a}±0.61	17.24^{a}±0.81	64.87^{a}±0.47	25.50^{abc}±0.45	21^{a}±0.79	12.43^{abc}±0.69	14.18^{a}± 0.57	8.31^{bcd}±0.21
Female, 1pp	74	-	-	53.68^{d}±0.68	24.76^{cd}±0.21	17.64^{c}± 0.37	11.50^{c}±0.32	13.07^{a}±0.26	8.10^{d}±0.09
Female, 2pp	146	-	-	58.74^{c}±0.48	25.20^{bc}±0.25	18.78^{b}±0.26	12.23^{abc}± 0.23	13.30^{a}±0.19	8.28^{cd}±0.07
Female, 3pp	108	-	-	60.66^{b}±0.56	25.79^{ab}±0.36	18.96^{b}±0.30	12.02^{abc}±0.26	13.47^{a}±0.22	8.44^{c}±0.08

Effect & level	N	SC	SL	RH	CD	NL	TL	FH	FC
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Female, 4pp	50	-	-	62.62^{ab}±0.82	26.26^{a}±0.30	20.27^{a}±0.44	12.53^{ab}±0.39	13.74^{a}±0.32	8.89^{a}±0.11

a, b, c, d. means with different superscripts within the same column and class are significantly different (P<0.05); ns Non-significant (P>0.05); *significant at (P<0.05); HG=Heart girth, BW= Body weight, HW= height at wither, RH= Rump height, PW= Pelvic Width, NL=Neck Length; TL=Tail Length; FH= Fore canon Height; FC= Fore canon Circumference; SC= Scrotal circumference, SL= Scrotal length, CD=chest depth, HL=Horn length, and EL=Ear length 0PPI, 1PPI, 2PPI and 3PPI = 1, 2, 3 and 4 pair of permanent incisors, respectively; N=Number of sample goat.

Stepwise Discriminate Analysis

Stepwise discriminate analysis procedure identified five variables for buck and these are rump height (RH), chest depth (CD), forecanon height (FH), height at wither (HW) and Scrotal length (SL) and six for doe rump height (RH), chest depth (CD), forecanon height (FH), body weight (BW), neck length (NL) and ear length (EL) as most significant discriminating traits.

Table 3. *Summary of stepwise selection of traits for buck and does.*

Sex	Step	Trait	Partia R^2	F-value	Wilk's Lambda	Pr>F
Male	1	RH	0.92	1896.57	0.077	<.0001
	2	CD	0.49	158.30	0.038	<.0001
	3	FH	0.03	5.67	0.037	0.0184
	4	HW	0.02	4.41	0.036	0.0373
	5	SL	0.01	3.06	0.035	0.0823
Female	1	RH	0.94	6894.0	0.051	<.0001
	2	CD	0.30	161.37	0.036	<.0001
	3	FH	0.01	6.33	0.035	0.0123
	4	BW	0.01	4.91	0.035	0.0273
	5	NL	0.01	4.23	0.034	0.0403
	6	EL	0.009	3.69	0.0343	0.0556

3.3. Prediction of Body Weight from Linear Body Measurements

All body measurements were fitted into the model and through elimination procedures, the optimum model was identified heart girth (HG), height at wither (HW), body length (BL), pelvic width (PW) and horn length (HL) for male whereas body length (BL), heart girth (HG), height at wither (HW) and pelvic width (PW) was the best fitted model for female. Heart girth, height at wither, body length, pelvic width and horn length were include in the model in order of importance and they account 63% of the total variability and heart girth alone accounts for 39% variation in the body weight for buck.

In female sampled goat population four variables were positively contributing to the prediction of model which include heart girth, height at wither, body length and pelvic width were fitted as first, second, third and fourth which account 84% of total variability and heart girth alone also accounts 51% of variation in body weight. The predicted equation of body weight for both male and female are presented below: - Body Weight = -5.98 +0.17 HG + 0.25 HW + 0.24 BL + 0.06 PW +0.05 HL for Male Body Weight = 12.25 + 0.15 HG +0.01HW+ 0.16 BL + 0.15 PW for Female where HG, HW, BL, PW and HL explanatory or independent variables.

Table 4. *Multiple linear regression analysis of live body weight on different LBMs for male and female goat in all age groups.*

Model	I (B_0)	B_1	B_2	B_3	B_4	B_5	B_6	B_7	R^2	Adj R^2	C(P)	AIC	Root MSE	SBC
Male														
HG	-7.44	0.23							0.4	0.39	28.08	611.39	6.04	617.56
HG+HW	-6.65	0.37	0.48						0.65	0.56	7	594.22	6.20	609.48
HG+HW+BL	-6.06	0.24	0.27	-0.05					0.56	0.47	11	595.94	3.02	608.29
HG+HW+BL+PW	-5.84	0.33	0.42	-0.23	-0.05				0.6	0.51	13.02	597	6.23	613.38
HG+HW+BL+PW+HL	-5.98	0.17	0.25	0.24	0.06	0.05			0.71	0.63	5.11	589.9	3.2	608.03
HG+HW+BL+PW+HL+RH	-13.59	0.14	0.15	-0.18	-0.39	0.16	0.05		0.41	0.38	7	591.7	6.08	613.4
Female														
HG	-11.42	0.15							0.62	0.51	83.3	1339	5.31	1346
HG+HW	-15.42	0.15	0.16						0.24	0.24	71.46	1334	5.13	1346.2
HG+HW+BL	-13.42	0.45	0.23	0.07					0.7	0.6	72.16	1330	3.2	1346
HG+HW+BL+PW	12.25	0.15	0.01	0.16	-0.15				0.92	0.84	70.14	1272	3.0	1226
HG+HW+BL+PW+HL	-16.23	0.06	0.12	0.01	0.32	0.42			0.23	0.51	70.23	1279	4.32	1231
HG+HW+BL+PW+HL+RH	-17.23	0.4	0.12	0.03	0.2	0.23	0.36		0.45	0.52	73.03	1276	3.21	1256
HG+HW+BL+PW+HL+RH+NL	-12.32	0.13	0.12	0.42	0.14	0.42	-0.32	0.63	0.62	0.71	76.2	1285	3.12	1236

HG= Heart Girth; HW= Height at wither; BL=Body Length; PW = Pelvic Width; HL= Horn length; RH=Rump height; I(β0) = Intercept; β1- β7 = Regression coefficients; R^2=R-square; Adj. R^2=Adjusted R^2; C (P) =The Mallows C parameters; AIC=Alkaike's Information Criteria; Root MSE=Root Mean square of error; SBC=Schwarrz Bayesian Criteria.

4. Discussion

In this particular study, the overall coat color patterns for both sexes were plain (46.67%) and patchy/pied (38.89%) in both districts. Different authors reported different coat color patterns. For instances [1, 6] reported spotted and patchy for North Amhara goat population while it was plain coat color patterns for Arsi-Bale goats [5]. [21] also reported similar coat color patterns for Woyto Guji goats in SNNP indicating that Abaya and Yirgachafee goats share common coat color patterns with Woyto Guji and Arsi-Bale goats probably as a result of gene flow between these two neighboring populations.

Information on body and testicle size of specific goat breed at constant age has paramount importance in the selection of genetically superior animals for production and reproduction purpose. The fact that physical linear traits have medium-to high heritability and are well correlated with BW indicates their importance for effective selection [14].

Location effect:-There was significant difference ($p<0.05$) in body weight and all linear body measurements except HL, FC and FH between both districts. The reason for the significant difference of live body weight and other linear body measurement across districts was due to availability of feed in the free browsing areas of Abaya district. The current finding of body weight of sampled goat was comparable with report of [12] who reported for Bati and Borena goat population but higher than short ear Somali goat 33.97±0.49kg, 31.49±0.23kg and 24.67±028kg respectively.

Sex effect: - Heart girth, bodyweight, pelvic width, chest depth and neck length was significantly affected by sex. In species having sexual dimorphism, the two sex may vary in color, size, or some other traits [13]. The same was true in this study where males were superior to females in body weight, heart girth, pelvic width, and chest depth and neck length. The sex related differences might be partly a function of the sex differential hormonal effect on growth [16].

The effect of age shows that as age increase body weight and other linear body measurements were increases. According to [15] reported that body size and shape of animal rises until the animal reaches the optimal growth. Maximum value was observed in age class of three and four as compared to one and two. The present finding agree with that of [17] who report body weight and linear body measurement were increased as age of animal became old. The scrotal circumference and length was also significantly ($p<0.05$) affected by age. The size of scrotal circumference and length increases as age increase from one pair of permanent incisor to fourth pair of permanent incisors. This finding is consistent with the study [15] described that breed, age and their interaction significantly affected by BW, body condition score (BCS), scrotal circumference (SC) and testicular weight (TW).

Scrotal circumference is the most heritable components of fertility that should be included for evaluation of breeding soundness [15]. The scrotal circumference at the age of 3PP in this study was lower than Bati and Borena (27cm) bucks but comparable with Short eared Somali bucks (25cm) [12]. The observed difference of SC between bucks in the study area and Bati and Borena bucks were may be due to the higher body weight exhibited in Bati and Borena Bucks. Besides, the study [15] explained that scrotal traits were directly influenced by agro−climatic conditions and this may be the cause for variation. The SC is an important trait that is closely associated with the testicular growth and sperm production capacity of domestic animals. Thus, selecting males based on their SC would result in larger testes, potentially with the capacity to produce more spermatozoa [7, 9].

The stepwise discriminate analysis procedure identified five variables for buck and these are rump height (RH), chest depth (CD), forecanon height (FH), height at wither (HW) and Scrotal length (SL) and six for doe rump height (RH), chest depth (CD), forecanon height (FH), body weight (BW), neck length (NL) and ear length (EL) as most significant discriminating traits. The result was compared with study of [19] who explain seven (HL, BW, EL, CG, HW, CW and PW) for does and five (HW, HL PW, CG and EL) for bucks discriminating traits of Bati, Borena and Short Eared Somali Goat Populations.

The relative importance of the identified traits in discriminating both goat populations was assessed at 5% level of significance. Wilk's Lambda value, the partial R^2 dropped down as significant discriminating variables added chronologically, describing the amount of variability in each variable accounted by the population differences. As represented by the respective partial R^2 and F-values; RH was found to have the highest discriminating power in buck followed by CD, FH, HW, and SL in descending order. In the meantime, RH had the highest discriminating power in female followed by CD, FH, BW, NL and EL from the highest to lowest. This implies that bucks required slightly fewer traits measurements to differentiate bucks of the two districts than does which require more variables. This result is inconsistence with report of [12] who report HL and HW highest discriminating power in does and buck respectively in Bati, Borena and Short Eared Somali goat Populations.

Body Weight has been the pivot on which animal production thrives. Regression of body weight over quantitative traits, which have higher correlation with body weight, was done to set adequate model for the prediction of body weight separately for each sex. Regression analysis is commonly used in animal research to describe quantitative relationships between a response variable and one or more explanatory variables such as body weight and linear body measurements especially when there is no access to weighing equipment [6]. To predict the best fitted variables to estimate live body weight and their contribution. Best fitted equation was selected using higher value of adjusted coefficient determination ($R^{2\ adjusted}$) which represent the total variability explain by the model and smaller value of mallows C(P) statistics, Akaike information criterion (AIC), root mean square error (RMSE) and Schwarz Bayesian information criterion (SBC) at different age class and sex categories.

In female sampled goat population four variables were positively contributing to the prediction of model which include heart girth, height at wither, body length and pelvic width were fitted as first, second, third and fourth which account 84% of total variability and heart girth alone also accounts 51% of variation in body weight. Multi linear regression model showed that female had higher adjusted R^2 (84%) than male goat population (63%). This indicates that those linear body measurement might predict more accurate in female than male [4]. This study shows that heart girth was more reliable in predicting body weight than other linear body measurements. In this regard, study [19] described that the better association of body weight with heart girth was possibly due to relatively larger contribution of heart girth, which consists of bones, muscles and viscera.

5. Conclusion and Recommendation

A systematic description/characterization of the goat types and management systems should be considered as prerequisite for planning the rational use of indigenous goat resources. A coat color pattern varies from population to population depending up on the agro-climatic differences, preferences by their herders and other factors such as the genetic makeup of populations. This study indicates that goats in study area has share common coat color patterns with Woyto Guji and Arsi-Bale goats probably as a result of gene flow between these two neighboring populations. The result in this study also revealed that the smaller mean values for most morphometric measurements dictated the least differentiation between Abaya and Yirgachafee 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 two 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 (HG, BL, HW, HL and PW), selection of one or more of these traits may increase live body weight of these goat populations. Stepwise discriminate analysis procedure was identified RH is highest discriminating power in both does and buck.

The present phenotypic characterization of goats in the study areas has to be further supported with molecular characterization, particularly for their high prolificacy to make use of these peculiar goat populations. Adaptive traits which community acquired through generation have to be improved by applying community based breeding program.

Ethics Approval and Consent to Participate

The manuscript does not contain clinical studies or patient animals/Goat.

Consent for Publication

Not applicable.

Availability of Data and Materials

Data was available in the hands of Corresponding Author.

Conflict of Interest Statement

The authors declare that they have no competing interests.

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Authors' Contributions

The authors designed all of the research and wrote the manuscript.

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