

## On Farm Phenotypic Characterization of Local Cattle Populations in Hadiya Zone, Southern Region, Ethiopia

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### Abstract

This study was conducted to phenotypically characterize local cattle populations in Hadiya zone, southern Ethiopia. The zone was categorized into three category based on agro ecology, cattle population size and the distinctness of the cattle types. Three districts (Shashogo, Misha and Soro) were purposively selected from each category. Six focus group discussions with key informants as well as phenotypic data from adult animals were used to generate data on quantitative and qualitative traits from 360 animals. Results from analysis of variance (ANOVA) on continuous variables showed highly significant ( $p < 0.0001$ ) differences between district and sex except for hock circumference. Canonical discriminant (CANDISC) analysis showed quantitative traits and Mahalanobis' distances between districts were significant ( $p < 0.0001$ ). The stepwise discriminant (STEPDISC) analysis for both female and male populations showed that most quantitative variables had significant ( $p < 0.0001$ ) power in explaining phenotypic variation. The results from focus group discussions and multivariate discriminant analysis led to identification of two cattle populations that appear to be distinct types (highland and lowland). Thus, studied indigenous cattle population of Hadiya zone was found to be not homogenous on their phenotypic features, and genetic characterization of the population is recommended.

**Keywords:** Hadiya zone; Local cattle populations; Phenotypic characterization; Southern Ethiopia

**Abbreviations:** AnGR: Animal Genetic Resource; CANDISC: Canonical Discriminant Analysis; DAD-IS: Domestic Animals Diversity Information System; DAGRIS: Domestic Animal Genetic Resource Information System; DISCRIM: Discriminant; FAO: Food and Agricultural Organization; GDP: Gross Domestic Product; GLM: General Linear Model; ILCA: International Livestock Centre for Africa; ILRI: International Livestock Research Institute; masl: Meters Above Sea Level; MoA: Minister of Agriculture; SAS: Statistical Analysis System; SPSS: Statistical Package for Social Sciences

### Introduction

Ethiopia has diverse ecology favoring diversification of livestock resources. The livestock sector of Ethiopia has been contributing considerable portion to the economy of the country, and promising to rally round the economic development of the country. At the level of the national economy, the livestock sector contributes 26 percent of the agricultural gross domestic product (GDP) and 12 percent to the national GDP as cited in Chenchu et al. [1].

Assessing the diversity of AnGR is made more difficult by the existence of many animal populations that are not assigned to any recognized breed. Even though parts of these "non-descript" populations are known to be multiple crosses of recognized breeds, some animals may belong to (relatively) homogenous groups distinguishable from neighboring populations on the basis of identifiable and stable phenotypic characteristics (among which some may be unique with valuable attributes) that warrant their being distinguished as separate breeds. Based on the available information as summarized in Domestic Animal Genetic Resources Information System (DAGRIS) database DAGRIS there are 33 recognized indigenous cattle breeds in Ethiopia. Breeds incorporated into the database in recent years include Gamo highland and Gamo lowland in southern Ethiopia [1] Wegera, Dembia and Mahiberesilassie breeds in the north-west [2], Abergalle, Irob and Medenes cattle breeds in the north [3,4], Gojjam Highland zebu and

Fogera breeds in the central highlands and Wollo Highland, Raya Sanga and Afar Sanga in the north-east [5].

Phenotypic as well as genetic characterization of indigenous livestock genetic resources provides the basis for any livestock development intervention. Clearly, sustainable utilization of local breeds is the best means of conserving these genetic resources. The first essential step towards sustainable utilization of these resources is to identify the major breed types, establish their population size as well as their geographical distribution and describe their typical qualitative and quantitative phenotypic traits. Phenotypic characterization is therefore fundamental to the establishment of national inventories of AnGR, to effective monitoring of AnGR populations and to the establishment of early-warning and response systems for AnGR [6].

Phenotypic characterization is a prerequisite for effective assessment of AnGR diversity, and to determine whether or not such unique populations are being eroded. In order to ensure proper conservation and utilization of indigenous breeds, it is necessary to evaluate genetic variations that exist within and among breeds. A large proportion of indigenous livestock populations in the developing world have not yet been characterized or evaluated at phenotypic and genetic levels [7]. Understanding the diversity, distribution, basic characteristics, comparative performance and the current status of a country's animal

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genetics resources is essential for their efficient and sustainable use, development and conservation [8]. However, only a small number of recognized cattle breed types have a fair description of their physical appearance, indications of their level of production, reproduction and genetic attributes [9].

Different local cattle population characterization and production system characterization have been undertaken in Ethiopia even if they have been far from complete. Local cattle of Hadiya zone in Ethiopia, which may have some special attributes, has rarely been found in literature and no studies have been conducted so far in characterization of this local cattle in the Hadiya zone. Therefore, the present study was conducted to characterize local cattle population in Hadiya zone and to ascertain the distinctness of animals among the population based on phenotypic differences in the studied traits.

## Materials and Methods

### Description of the study area

The study was conducted in Hadiya zone; Southern Ethiopia. The zone is located at a distance of 232 km to the south of Addis Ababa. Ecologically, 24% of the Zone is “Dega” (highland), 65% is “woynadega” (mid altitude) and 11% is “kolla” (lowland). Average Annual rainfall of the zone is 1260 mm; its altitude ranges from 540-2940 masl, and the average annual temperature 22.02°C (Hadiya zone Agricultural office). Hadiya zone consists of a total of 11 districts which was categorized in to three category on the bases of agroecology, cattle population size and local knowledge on existing cattle types.

### Sample size and sampling method

Hadiya zone was surveyed through single rapid exploratory field visits to the study area for gathering available secondary information from the district experts of the rural and agricultural development office and the farmers’ representatives to define the sampling frame and available background information on the existence of phenotypically unique cattle populations. Three districts were selected purposively. Then three rural kebeles were selected randomly from each district and forty (40) adult animals from each kebele with different age category were selected randomly.

### Data collection methods

**Focus group discussion and questionnaire:** Preliminary field visits were conducted for gathering secondary data from local livestock extension staffs and offices about the type and distribution of indigenous cattle types in the study area. Then key informant focus group discussions were held with representatives of farmer groups, extension staff and the district sector administration officers. A total of six focus group discussions were held – two per district, each having 8-12 farmers plus a representative of the extension staff. The discussions were facilitated by the researcher at all districts.

**Morphological and linear body measurements:** Quantitative data (body measurements and qualitative morphological characters) were collected and recorded on the format adopted from the standard description list developed by FAO. The standard breed descriptor list for the cattle developed by FAO was closely followed in selecting morphological variables. Quantitative traits including body length, height at wither; heart (chest) girth, horn length, ear length, tail length, rump length, hock circumference and muzzle circumference were measured (cm) using measuring tape (Figure 1). The age of the animals (for both female and male) was estimated by dentitions and information from cattle owners from adult animals and classified into three age



**Figure 1:** Chest girth measurement at Misha district.

classes based on Chenchu et al. where age in years was categorized as 3-5=1, >5-7=2 and >7 years =3. Forty (40) adult animals from each kebele, with a total of 40 x 9 =360 animals were taken randomly from the sampled households.

### Statistical analysis

**Descriptive statistics:** The SPSS statistical computer software was used to analyze qualitative data. Quantitative variables measured were analyzed using statistical analysis system. Descriptive statistics, chi-square tests, univariate, multivariate analysis and associations of categorical variables using phi coefficient, Cramer’s V and contingency coefficient were carried out.

**Univariate analysis:** A general linear model procedure (PROC GLM) of the statistical analysis system (SAS 9.2, version 2008) was employed for quantitative variables to detect statistical differences among sampled cattle populations. Mean comparisons were made for variables showing significant differences between sampled populations.

$$Y_{ijkl} = \mu + A_i + S_j + B_k + (AS)_{ij} + (AB)_{ik} + (SB)_{jk} + e_{ijkl}$$

Where:  $Y_{ijkl}$  = the observed  $l^{th}$  linear body measurements in the  $i^{th}$  age group of  $j^{th}$  sex of the  $k^{th}$  cattle type of the district

$\mu$  = overall mean

$A_i$  = the effect of  $i^{th}$  age categorized as 3-5 = 1, >5-7 = 2 and >7 years = 3

$S_j$  = the effect of  $j^{th}$  sex (male and female)

$B_k$  = the effect of  $k^{th}$  cattle type of the district (three)

$(AS)_{ij}$  = the effect of interaction of  $i^{th}$  age group with  $j^{th}$  sex

$(AB)_{ik}$  = the effect of interaction of  $i^{th}$  age group with  $k^{th}$  cattle type of the district

$(SB)_{jk}$  = the effect of interaction of  $j^{th}$  sex group with  $k^{th}$  cattle type of the district

$e_{ijk}$  = random residual error.

As the interaction effects  $(AS)_{ij}$ ,  $(AB)_{ik}$  and  $(SB)_{jk}$  were found not significant the following model was used for analyzing quantitative phenotypic variation separately for female and male sample populations by considering age and cattle type of the district as fixed main effects:

$$Y_{ijk} = \mu + A_i + B_j + e_{ijk}$$

Where:  $Y_{ijk}$  = the observed  $k^{th}$  (linear body measurements) in the

$i^{\text{th}}$  age and  $j^{\text{th}}$  district

$\mu$ =overall mean

$A_i$ = the effect of  $i^{\text{th}}$  age categorized as 3–5 = 1, >5–7 = 2 and >7 years = 3

$B_j$  = the effect of  $j^{\text{th}}$  cattle type of the district (three)

$e_{ijk}$  = random residual error

**Multivariate discriminant analysis:** The quantitative variables (linear body measurements) from female and male animals were separately subjected to multivariate discriminant analysis and canonical discriminant analysis to ascertain the existence of population level phenotypic differences in the studied traits in the study area. The analysis was performed taking individual animals as a unit of classification. The step wise discriminant analysis procedure (PROC STEP DISC SAS version 9.2, 2008) was performed to rank the variables by their discriminating power.

## Results and Discussions

### Qualitative variation in sampled population

The populations were plain (60.83%), patchy (20%) and spotted (22.50) in Shashogo; plain (75.83%), patchy (14.17) and spotted (10%) in Misha and plain (58.33%), patchy (25%) and spotted (16.67) in Soro district. The hair texture was mostly shiny or smooth and medium across the districts having larger proportion in Shashogo and Soro than Misha district. The chi-square tests for body hair coat color pattern, body hair coat color, coat texture, eyelid color, horn color, horn shape, hair length, hump size and tail length showed significant ( $p < 0.05$ ) difference between districts. All other variables were not significant between districts. Associations of categorical variables with districts were variable and ranged from 0.042 to 0.394 for horn presence and tail length, respectively, using phi coefficient and Cramer's V; 0.042 to 0.367 using Contingency coefficient (Table 1).

### Quantitative variation in sampled population

**District and sex effect:** All the quantitative dependent variables were significantly affected by sex of the animals (Table 2). No interaction was found statistically significant for district and sex. The phenotypic variation in all quantitative dependent variables (ear length, body length, chest girth, muzzle circumference, rump height, height at withers, hock circumference and pelvic width) were significantly ( $p < 0.0001$ ) affected by district and sex of the animals. Variables viz. horn length, tail length and cannon bone circumference were significantly ( $p < 0.05$ ) affected by district and sex (Table 3). In sample populations, coefficients of variability ranged from 6.3 for body length to 35.01 for horn length. This indicates that as compared to body length, horn length showed more variability in the population. The smallest (11.89%) coefficient of determination ( $R^2$ ) was obtained for horn length and the highest (40.57%) coefficient determination ( $R^2$ ) was obtained for height at wither. The coefficient of determination ( $R^2$ ) calculated for variables were low in general which could be because male and female populations were considered together. However, when the populations were analyzed separately (Tables 4 and 5) the  $R^2$  values increased.

Comparisons of the least square means for the variables between districts (Table 6) revealed that sample populations from Shashogo district had the largest values for tail length, chest girth, horn length, muzzle circumference, wither height, pelvic width. Soro district had largest values for body length, ear length and hock circumferences. The Table 7 also shows that the smallest least square means in all variables

were recorded for Misha district. This shows that cattle populations sampled from lowland and mid land districts were larger in their linear measurements than highland ones. Values obtained for sample population from mid-altitude (Soro) was mostly in between highland (Misha) and lowland (Shashogo) districts. This is mainly due to the presence of semi-pastoral communities who owned the cattle type of highland and lowland, and undertake seasonal movement between lowland and midland as well as high land in Soro district. In addition to this, as indicated during focus group discussions there is high cattle movement in Soro district that causes the animals to share the features of highland and low land cattle type. Farmers also send their animals other than milking cows to low land area when they face feed shortage. Similarly Chench et al. revealed that cattle populations of the mid-altitude areas did not show distinct features that make them different from those of the highland and lowland areas, and instead appeared to have intermediate features of other two types.

### Quantitative variation for the male population

The phenotypic variation in all quantitative dependent variables was significantly ( $P < 0.05$ ) affected by district and age class of animals (Table 8). The smallest coefficient of determination ( $R^2$ ) was calculated for height at wither and pelvic width. The highest (89.85%) coefficient of determination ( $R^2$ ) was calculated for ear length. In male sample populations, coefficients of variability ranged from 3.39 for chest girth to 21.08 for horn length. Similarly high coefficients of variability was reported for horn length by Chench et al. in Gamo highland and lowland population in male sample.

### Quantitative variation for the female population

The overall phenotypic variation in all quantitative traits in females was highly significant ( $P < 0.0001$ ) between districts and age class of the animals except for height at wither in age class and body length between districts which were significantly ( $p < 0.05$ ) different (Table 6).  $R^2$  ranged from 32.81% to 68.31% for horn length and hock circumferences, respectively. Coefficient of variability of female sample population explained by the model ranged from 4.22% for body length to 30.29% for horn length, respectively.

### Multivariate analysis

Quantitative variables varied between sex groups and multivariate analysis was calculated separately for female and male sample populations.

### Discriminant analysis for female

The overall average error count estimate was 23.67% for all observations from all districts, which means that 76.33 per cent of the samples were correctly classified. This result indicated higher correct classification than Chench et al for Gamo highland and low land local cattle female sample population for which overall average error count estimate was 36.85 percent for all observations and 63.15 percent of the samples correct classification. The correct classification ranged from 71% to 85% in the case of female population. The highest correct classification percentages were calculated for Misha district and the lowest correct classification percentages were calculated for Soro and Shashogo districts. Fasil and Workneh revealed that the correct classification for female sample population ranged from 62.6% to 97.0% for Gojam highland and Fogera local cattle population and correct classification in this study for female sample population is mostly in agreement.



Variable	P-value	Phi Coefficient	Contingency Coefficient	Cramer's V
Body hair coat color pattern	0.01	0.191	0.188	0.135
Body hair coat color	0.006	0.350	0.331	0.248
Coat texture	<0.0001	0.322	0.306	0.322
Body skin color	0.069	0.125	0.124	0.125
Muzzle color	0.099	0.115	0.115	0.115
Eyelid color	0.030	0.138	0.137	0.138
Hoof color	0.078	0.153	0.151	0.108
Horn presence	0.825	0.042	0.042	0.042
Horn color	0.006	0.197	0.193	0.139
Horn attachment	0.205	0.098	0.097	0.098
Horn shape	0.036	0.210	0.206	0.146
Horn orientation	0.364	0.174	0.172	0.123
Hair length	<0.0001	0.310	0.296	0.310
Ear shape	0.619	0.059	0.059	0.059
Ear orientation	0.849	0.081	0.081	0.057
Hump size	<0.0001	0.254	0.246	0.180
Facial profile	0.397	0.076	0.076	0.076
Tail length	<0.0001	0.394	0.367	0.394

**Table 1:** Chi-square tests and levels of association of districts with the categorical variables.

Dependent variables	Male (N=60)	Female (N=300)	Sex
Ear length	18.23 ± 0.21	16.64 ± 0.09	p<0.0001
Body length	109.65 ± 0.84	102.28 ± 0.38	p<0.0001
Chest girth	145.75 ± 0.66	136.96 ± 0.52	p<0.0001
Horn length	20.51 ± 0.82	17.87 ± 0.37	P<0.0037
Tail length	84.40 ± 0.87	81.65 ± 0.39	P<0.0045
Muzzle circumference	38.91 ± 0.33	36.75 ± 0.15	p<0.0001
Rump length	32.96 ± 0.35	29.65 ± 0.15	p<0.0001
Height at withers	107.61 ± 0.90	99.02 ± 0.40	p<0.0001
Hock circumference	33.53 ± 0.45	28.37 ± 0.20	p<0.0001
Pelvic width	33.93 ± 0.39	29.43 ± 0.17	p<0.0001
Cannon-bone circumference	14.63 ± 0.17	14.14 ± 0.08	P<0.015

**Table 2:** Least square means ± SE of quantitative body measurements (cm) for all districts by sex.

Dependent variables	Mean values	District	Sex	R <sup>2</sup>	CV
Ear length	16.90	P<0.0001	p<0.0001	33.15	9.6
Body length	105.5	P<0.0001	p<0.0001	20.07	6.3
Chest girth	138.43	P<0.0001	p<0.0001	18.19	6.5
Horn length	18.31	P<0.0001	p<0.0037	11.89	35.01
Tail length	82.10	P<0.0001	p<0.0045	20.93	8.27
Muzzle circumference	37.11	P<0.0001	p<0.0001	20.69	6.96
Rump length	30.20	P<0.0001	p<0.0001	25.76	9.05
Height at withers	100.45	P<0.0001	P<0.0001	40.57	6.96
Hock circumference	29.23	P<0.0030	p<0.0001	27.18	12.13
Pelvic width	30.18	P<0.0001	p<0.0001	34.52	10.09
Cannon-bone circumference	14.22	P<0.0001	P<0.0125	19.99	9.7

**Table 3:** Level of significance of district and sex for each of the variables and associated R<sup>2</sup> (%) values for the sample population.

## Canonical discriminant analysis for female sample population

The pair-wise squared Mahalanobis' distances between districts for female sample populations were highly significant (P<0.0001) across the districts. This shows that female populations have distinct and measurable group differences across the districts. The shortest distance (3.49) was measured between Misha and Soro district and (4.39) was measured between Soro and Shashogo. The longest distance (6.34) was measured between Shashogo and Misha. This indicates that sample populations from Soro were failing in between Shashogo and Misha in group quantitative features under consideration.

The multivariate statistics for differences between the districts was also significant (P<0.0001) in all of the four multivariate tests (Wilks' lambda, Pillai's trace, Hotelling-Lawley trace and Roy's greatest root) for female sample population (Table 7). Wilks' lambda, the ratio of within-group variability to total variability on the discriminator variables, is an inverse measure of the importance of the discriminant functions [10-13]. The Wilks' lambda test for the female sample populations was 0.31 (Table 6). This shows that most (69 percent) of the variability in the discriminator variables was because of differences between populations rather than variation within populations. Values close to 1 indicate

Dependent variable	Shashogo (1)	Soro (3)	Misha (2)
	(N=120)	(N=120)	(N=120)
Ear length	17.97 <sup>a</sup>	18.20 <sup>a</sup>	16.13 <sup>b</sup>
Body length	106.93 <sup>a</sup>	107.92 <sup>a</sup>	103.04 <sup>b</sup>
Chest girth	145.19 <sup>a</sup>	141.38 <sup>ab</sup>	137.49 <sup>b</sup>
Horn length	21.34 <sup>a</sup>	20.46 <sup>a</sup>	15.77 <sup>b</sup>
Tail length	85.41 <sup>a</sup>	85.80 <sup>a</sup>	77.86 <sup>b</sup>
Muzzle circumference	39.20 <sup>a</sup>	37.95 <sup>ab</sup>	36.35 <sup>b</sup>
Rump length	32.03 <sup>a</sup>	32.19 <sup>a</sup>	29.70 <sup>b</sup>
Height at withers	110.44 <sup>a</sup>	101.23 <sup>b</sup>	98.29 <sup>b</sup>
Hock circumference	30.95 <sup>a</sup>	32.01 <sup>a</sup>	29.90 <sup>a</sup>
Pelvic width	33.77 <sup>a</sup>	30.49 <sup>b</sup>	30.78 <sup>b</sup>
Cannon-bone circumference	14.74 <sup>a</sup>	14.96 <sup>a</sup>	13.45 <sup>b</sup>

a, b, ab Least squares means with different superscripts within the same row are significantly (P< 0.0001) different.

**Table 4:** Least square means of body measurements (cm) by districts.

Dependent variable	Mean values	District	Sex	R <sup>2</sup>	CV
Ear length	16.90	P<0.0001	p<0.0001	33.15	9.6
Body length	105.5	P<0.0001	p<0.0001	20.07	6.3
Chest girth	138.43	P<0.0001	p<0.0001	18.19	6.5
Horn length	18.31	P<0.0001	p<0.0037	11.89	35.01
Tail length	82.10	P<.0001	p<0.0045	20.93	8.27
Muzzle circumference	37.11	P<0.0001	p<0.0001	20.69	6.96
Rump length	30.20	P<0.0001	p<0.0001	25.76	9.05
Height at withers	100.45	P<0.0001	P<0.0001	40.57	6.96
Hock circumference	29.23	P<0.0030	p<0.0001	27.18	12.13
Pelvic width	30.18	P<0.0001	p<0.0001	34.52	10.09
Cannon-bone circumference	14.22	P<0.0001	P<0.0125	19.99	9.7

**Table 5:** Level of significance of district and age class for quantitative variables and their associated R<sup>2</sup> values for the male sample population.

Dependent variable	Mean values	District	Age class	R <sup>2</sup>	CV
Ear length	18.23	p<0.0001	p<0.0001	89.85	3.66
Body length	109.65	P<0.0143	p<0.0001	63.46	3.94
Chest girth	145.75	P<0.0003	p<0.0001	72.16	3.39
Horn length	20.51	p<0.0174	p<0.0001	68.73	21.08
Tail length	84.40	P<0.0022	p<0.0001	61.03	6.70
Muzzle circumference	38.91	P<0.0002	p<0.0001	64.41	4.56
Rump length	32.96	P<0.005	p<0.0001	83.00	4.56
Height at withers	107.61	P<0.0038	p<0.0001	41.97	10.54
Hock circumference	33.53	P<0.0071	p<0.0001	80.25	6.42
Pelvic width	33.93	P<0.0029	P<0.0006	34.35	11.34
Cannon-bone circumference	14.63	p<0.0001	p<0.0001	78.00	4.87

**Table 6:** Level of significance of district and age class for each of the variables and associated R<sup>2</sup> (%) values for the female sample population.

Statistic		Value	F Value	Num DF	Den DF	Pr>F
Wilks' Lambda		0.31	20.27	22	574	p<0.0001
Pillai's Trace		0.86	19.76	22	576	p<0.0001
Hotelling-Lawley Trace		1.59	20.79	22	487.93	p<0.0001
Roy's Greatest Root		1.08	28.31	11	288	p<0.0001

can	Eigen Value	Difference	Proportion	Cumulative	Likelihood ratio	Approximate F value	Num DF	Den DF	Pr>F
1	1.0814	0.565	0.6767	0.6767	0.32	20.27	22	574	p<0.0001
2	0.5166		0.3233	1.0000	0.66	14.88	10	288	p<0.0001

**Table 7:** Multivariate statistics and F approximations of female population.

that almost all of the variability is due to within-group differences (differences between cases in each group); values close to 0 indicate that almost all of the variability in discriminator variables is due to group differences [14]. The procedure for canonical discriminant analysis

extracted two canonical variates for female sample populations, of which the first canonical variate (can1) accounted for about 67.67% of the total variation. The second canonical variate (can2) accounted for 32.33 percent of the total variance.

Statistic			Value		F Value	Num DF		Den DF	Pr>F
Wilks' Lambda			0.20760753		5.1	22		94	p<0.0001
Pillai's Trace			1.08471607		5.17	22		96	p<0.0001
Hotelling-Lawley Trace			2.40872216		5.06	22		76.587	p<0.0001
Roy's Greatest Root			1.41033888		6.15	11		48	p<0.0001
can	Eigenvalue	Difference	Proportion	Cumulative	Likelihood ratio	Approximate Fvalue	Num DF	Den DF	Pr>F
1	1.4103	0.412	0.5855	0.5855	0.20760753	5.1	22	94	p<0.0001
2	0.9984		0.4145	1	0.50040451	4.79	10	48	p<0.0001

**Table 8:** Multivariate statistics and F approximations of male population.

The first canonical variate (can1) best separated Shashogo district female sample populations from Misha district females and Soro district female sample population falling in between the two. The second canonical variate (can2) further separated female sample population of Soro from Shashogo and Misha. Eigen values indicate the ratio of between-groups variability to within-groups variability for a canonical discriminant function. The larger the eigen value, the better at accounting for group differences (Howard and Brown, 2000). For female sample populations, the ratio of between-groups variability to within-groups variability (Eigen value) detected by canonical variate1 (can1) was much larger than canonical variate2 (can2). The first canonical variate (can1) separation was due to the highest between group variability as eigenvalue was higher and the second canonical variate (can2) accounted for within groups variability as eigen value is lower. In second canonical variate (can2) separation of Soro's district female sample population from Shashogo and Misha districts female sample population might be due the existence of highest within group's variation in Soro district. Hence Soro district female sample population shares the features of highland and lowland female sample population and there are farmer owned cattle type from highland and lowland districts which could result in possessing high within group variation relative to the rest of the two districts. Based on these results, the CANDISC procedure of SAS classified female sample populations into two distinct populations' highland and lowland types.

### Stepwise discriminant analysis for female population

All 11 quantitative variables for female were subjected to the STEPDISC procedure of SAS and 7 variables were identified as best discriminating variables on Stepwise selection summary. Stepwise discriminant analysis is used in an effort to discover the 'best' subset of discriminator variables to use in discriminating groups [14]. Wilks' lambda test shows that all the traits considered were highly significant ( $p<0.0001$ ) contributors to discrimination of the total population into separate groups. The best variables that discriminated the sample female population were height at wither, ear length, pelvic width, tail length, rump height, body length and chest girth. Heart girth, wither height and pelvic width were also reported as highly significant contributors to discrimination of the total population into separate groups [15].

### Discriminant analysis for male population

The overall average error count estimate was 10 percent for all observations (Appendix table 40) from all districts, which means that 90 percent of the samples were correctly classified. The correct classification ranged from 85 to 100 for male population. The highest correct classification percentage was obtained for Misha district and the lowest correct classification percentage was obtained for Soro and Shashogo districts similarly as like in case of female population.

### Canonical discriminant analysis for male sample population

The pair-wise squared Mahalanobis' distances between districts for

male sample populations were highly significant ( $P<0.0001$ ). This shows that male populations across the districts have distinct and measurable group differences. But the distances between the districts are not higher as indicated in (Table 4). These narrower distances between the districts in male population is partly because of the smaller sample sizes. In the case of male sample populations, the squared Mahalanobis' distance for the districts was slightly higher than it was for female populations. The shortest distance (5.96) was observed between Soro and Misha districts. This indicates that the male sample populations were not highly distant in between Soro and Misha as compared to distance between male sample population of Shashogo and Misha.

The multivariate statistics for differences between the districts was also significant ( $p<0.0001$ ) in all of the four multivariate tests (Wilks' lambda, Pillai's trace, Hotelling-Lawley trace and Roy's greatest root) for male sample population. The Wilks' lambda test for the male sample populations was 0.20 (Table 8). This shows that most (80 percent) of the variability in the discriminator variables was because of differences between populations rather than variation within populations.

The procedure for canonical discriminant analysis extracted two canonical variates for male sample populations, of which the first canonical variate (can1) accounted for about 58.55 percent of the total variation. Like the female sample populations, the eigenvalues for male populations were larger for can 1 than can 2 indicating their better discriminating capacities. The first canonical variate (can1) separated Shashogo district from Misha and Soro based on between group variability. The second canonical variate (can2) separated Misha district from Soro and Shashogo based on within group variability. In both cases (can1 and can2) Soro district male sample population falling in both Shashogo and Misha districts. This indicates that Soro male sample population shares the feature of Shashogo and Misha district male sample populations. The canonical discriminant analysis revealed that the total variation (58.55 percent) for first canonical variate (can1) was not as much larger than total variation (41.45 percent) unlike in case of female sample population which might be due to low sample size in case of male sample population.

### Stepwise discriminant analysis for male sample population

All 11 quantitative variables for male were separately subjected to the STEPDISC procedure of SAS and 6 variables were identified as best discriminating variables on Stepwise selection summary. Wilks' lambda test shows that all the traits (Canon bone circumference, pelvic width, chest girth, hock circumference, height at wither, and muzzle circumferences) considered were highly significant ( $P<0.0001$ ) contributors to discrimination of the total population into separate groups. These all quantitative variables in male sample population were also similarly reported by Chench et al. as highly significant contributors to discrimination of the total population in to separate groups. Pelvic width, chest girth, height at withers and muzzle circumferences were



also reported by Fasil and workneh. Values associated with each trait against Wilks' Lambda were significant ( $p < 0.0001$ ).

### Description of the identified cattle type

Results from focus group discussions, field observations on discrete phenotypic features and univariate as well as multivariate analyses revealed that there are two major cattle types identified in the study area. These are termed as highland and lowland local cattle populations taking into account their phenotypic differences as well as their geographic distribution. Both have well-developed humps and express zebu characteristics and hence both could be considered to be zebu-type cattle. During focus group discussion with agricultural office experts, representatives of farmer's group and extension staffs, they tend to associate origin of the local cattle with that of the ethnic group (Hadiya) maintaining the cattle and had been descended with the society while they occupied the area formerly and known to be native. Also they revealed that highland and lowland local cattle of Hadiya zone were reported to be found in neighboring highland and lowlands areas of other zones like Guraghe, Siltie and Kembata areas.

### Highland local cattle

These cattle were known by their high adaptability behavior to highland production environment which is characterized by a cold climatic condition. They cannot adapt heat and insect biting as compared to low land population. Insect biting may be mostly related to their black color which attracts insects to sit on. Crop residue, natural vegetation and enset are major sources of feedstuffs (Figure 2). Animals are housed together with humans. They are multiple purpose cattle mainly kept for milk, manure, cash, traction and meat purposes. Their physical distinctness is explained by small compact body sizes which have lower quantitative variable measurements than lowland cattle type. This cattle type are known for their temperament and best adapted for cut and carry utilization and tethering. They are also known to be adapted with feeding of house leftover. Their coat texture is rough than lowland cattle type.

### Lowland local cattle

This type of cattle adapts to the hotter climatic conditions of lower altitude areas with long dry season. Some of these areas are infested with tsetse flies. The dominant production system is livestock–crop mixed, and communal grazing on natural bushy pastures is common. These types of animals take longer time to adapt feeding on cut grasses and tethering (Figures 3 and 4). Prevalence of various diseases and heavy parasitic infestations, expansion of crop farming at the expense of pastures, seasonal feed scarcity and lack of genetic improvement programme of existing local cattle are the major constraints identified. Majority of their color are dark/light red and fawn color with shiny or smooth coat texture, tails are long, facial profile is predominantly straight and few animals were recorded with concave facial profiles. Ears are longer, straight edged (92.5%) and laterally oriented (93.33%).

### Conclusion and Recommendation

ANOVA on continuous variables showed significant ( $p < 0.0001$ ) differences between districts, both for females and males populations except hock circumference which was significant at ( $p < 0.01$ ) level. Chi-square tests for categorical variables between districts showed significant ( $p < 0.05$ ) differences for most of the variables. The phenotypic measurements of quantitative traits and qualitative traits enabled classification of indigenous cattle into two distinct types. Based on results of the discriminant analysis, sample populations were



**Figure 2:** Cattle grazing on natural pasture at Soro district



**Figure 3:** Cattle feeding on crop residues at Soro district.



**Figure 4:** Oxen at Shashogo district.

classified into two: highland and lowland cattle populations, which were also confirmed by results of the canonical discriminant analysis. Results of the stepwise discriminant analysis also confirmed the distinct aggregate phenotypic differences between highland- and lowland-type cattle populations. These statistical results confirmed outcomes of the focus group discussions in which consensus was built on clear differences in body form and size between cattle populations of the highland and lowland areas in Hadiya zone. Thus the highland- and lowland types of cattle were found to be significantly different in their phenotypic characteristics that merit further genetic and molecular

studies not only to investigate their breed identity but also to ascertain genetic differences between the studied populations and to lay out the basis for sustainable utilization and improvement of this indigenous genetic resource through selective breeding.

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#### Conflict of Interest Declaration Statement and Authors Agreement

This statement is to certify that all Authors have seen and approved the manuscript being submitted. We warrant that the article is the Authors' original work. We warrant that the article has not received prior publication and is not under consideration for publication elsewhere. On behalf of Co-Author, the corresponding Author shall bear full responsibility for the submission.

This research has not been submitted for publication nor has it been published in whole or in part elsewhere. We attest to the fact that all Authors listed on the title page have contributed significantly to the work, have read the manuscript, attest to the validity and legitimacy of the data and its interpretation, and agree to its submission to the *Advances in Dairy Research*.

#### References

1. Chebo C, Ayalew W, Wuletaw Z (2013) On-farm phenotypic characterization of indigenous cattle populations of Gamo Goffa zone, Southern Ethiopia. *Animal Genetic Resources Information Bulletin* 52: 71-82.
2. Wuletaw Z (2004) Survey of indigenous cattle genetic resources, husbandry practices and cattle breeding objectives in North Gondar, Ethiopia. MSc thesis, Alemaya University.
3. Zerabruk M, Vangen O (2005) The Abergelle and Irob cattle breed of North Ethiopia: Description and on-farm characterization. *Animal Genetic Resources Information Bulletin* 36: 7-20.
4. Zerabruk M, Vangen M, Haile M (2007) The status of cattle genetic resources in North Ethiopia: On farm characterization of six major cattle breeds. *Animal Genetic Resources Information Bulletin* 40: 15-32.
5. Tadesse D (2005) On-farm phenotypic characterization of cattle genetic resources and their production systems in south and north Wollo zones of Amhara region, north eastern Ethiopia. (Unpublished MSc thesis, Alemaya University).
6. FAO (2012) Phenotypic characterization of animal genetic resources. FAO Animal Production and Health Guidelines No 11. Rome.
7. Hannotte O, Jianlin H (2005) Genetic characterization of livestock populations and its use in conservation decision making. In: Ruane, J. and A. Sannino. The role of biotechnology in exploring and protecting genetic resources, Rome. ILRI.
8. FAO (2007) Global plan of action for animal genetic resources and the Interlaken declaration. Rome, Italy
9. Getachew F, Ayalew W (2014) On-farm phenotypic characterization of indigenous cattle populations of Awi, East and West Gojjam Zones of Amhara Region, Ethiopia. *Res J Agric Environ Manage* 3: 227-237.
10. Tatsuoka M (1970) Discriminant analysis: The study of group differences. Champaign, IC: The Institute for Personality and Ability Testing.
11. Huberty CJ (1994) Why multivariable analyses. *Educational and Psychological Measurement* 54: 620-627.
12. Betz NE (1987) Use of discriminant analysis in counseling psychology research. *J Counseling Psychology* 34: 393-403.
13. Brown MT, Tinsley HEA (1983) Discriminant analysis. *J Leisure Res* 15: 290-310.
14. Howard EA, Brown SD (2000) Handbook of Applied Multivariate Statistics and Mathematical Modelling. Academic Press, California, USA.
15. Domestic Animal Genetic Resources Information System (2011). ILRI. Addis Ababa, Ethiopia.