J Genet Resour2021;7(1): 36-48 *Homepage: http://sc.journals.umz.ac.ir/*

RESEARCH ARTICLE *DOI: 10.22080/jgr.2020.19954.1211*

J|G|R

On-Farm Phenotypic Characterization of Indigenous Chicken, in Dire and Yabello Districts, Borena Zone, Oromia Regional State, Ethiopia

Dabasa Duba Wario [1], Tadesse Yosef [2] and Shashi Bhushan Singh Yadav [2]

[1] Bonga University College of Agriculture and Natural Resources, Bonga, Ethiopia
[2] Haramaya University School of Animal and Range Science, Haramaya, Ethiopia

ARTICLE INFO

Article history:
Received 27 August 2020
Accepted 28 October 2020
Available online 10 November 2020

Keywords:
Borena zone
Characterization
Morphological trait
Morphometric traits
Multivariate
Plumage
Scavenging
Univariate

****Corresponding authors:***
✉ D. Wario
warduba42@gmail.com

p-ISSN 2423-4257
e-ISSN 2588-2589

ABSTRACT

This study was conducted in two districts of Borena zone (Ethiopia), with the objectives to characterize phenotypically the indigenous chicken types in the study sites. The study involved both qualitative and quantitative types of research. A total of 480 chickens (144 male and 336 female) aged more than 6 months for the quantitative study were considered in this study. Descriptive statistics, frequency procedures, general linear model, univariate and multivariate analysis were used with SAS 9.1.3 to analyze the data. SPSS package was used to analyze qualitative data. Qualitative traits such as plumage color, comb type, shank color, eye, earlobe color, and skin color were used for the study. Quantitative traits included: body weight and linear morphometric measurements such as shank length, body length, wattle length, wingspan, chest circumference, comb width, and comb length. The result of this study revealed that white, red, and brown plumage color was dominated in the study area. The local chickens possessed variants in shank color, skin color, comb type, and eye color. White shanks, white skin, single combs, and red earlobe color were predominately seen across both the study districts. The mean body weights of indigenous male and female chickens were 1.623± 0.229 kg and 1.313 ± 0.81 kg, respectively. Large comb, wattle, and long legs were observed in the study areas. Generally, morphological and morphometric variations were observed between and within the indigenous chicken populations, which suggests that there is an opportunity for genetic improvement through selection.

Please cite this paper as: Wario. D, Yosef T, Yadav S. 2021. On-farm phenotypic characterization of indigenous chicken, in Dire and Yabello Districts, Borena Zone, Oromia Regional State, Ethiopia. *J Genet Resour* 7(1): 36-48. doi: 10.22080/jgr.2020.19954.1211.

Introduction

Ethiopia is the eighths largest livestock population in the world, and the first largest in Africa (FAO, 2014). Livestock contributes 21% to the total GDP of Ethiopia, supports livelihoods of 80-85 % of the population, and generates about 16-19% of the foreign exchange earnings of the country (CSA, 2014/15). The total chicken population at the country level is 59.55 million. Concerning the blood level of chicken, 94.31%, 3.21%, and 2.49% of the total poultry were reported to be local, hybrid, and exotic, respectively (CSA, 2016/17). Chicken includes cocks, cockerels, pullets, laying hens, non-laying hens, and chicks. Consequently, most of the poultry are chicks (41.35%), followed by laying hens (32.18%). Pullets are estimated to be about 5.85 million in the country. Cocks and cockerels are also estimated separately and are 5.32 million and about 3.11 million, respectively. The others are non-laying hens that make up about 2.53 percent (1.51 million) of the total poultry population in the country (CSA, 2016/17). The local chicken strain is a general term given to the multipurpose and unimproved scavenging birds with unidentified descriptions kept in the free-range (Mengesha, 2012). Farmers in Africa gave these chickens names like; family chickens, bush chickens, or African hen (Gueye, 2009). Besbes *et al.* (2012) stated that families to get food, income, and employment rear family chickens. Local chickens contribute significantly to the livelihood of rural farmers by providing them with high-quality animal protein in the form of eggs and meat (Molla, 2010). Local chickens ease poverty and provide their owners with income and nutritional benefits (Reta, 2009). Food security ensures that members of a household have access to enough diet to lead to an active and normal life (Moreki *et al*., 2010).

History, migration, and spread of chickens across the African continent from the center of domestication is a subject of debate and speculation among researchers (Hassaballah *et al.,* 2015). Dueppen (2011) documented the origin of domestic chickens in developing countries, but their introduction into the African regions unknown. Woldekiros and D'Andera, (2017) from Mezber (Aksum, northern Ethiopia) invented that the Mezber specimens predate the earliest known Egyptian (400BC) chickens by at least 550 years and draw attention to early exotic faunal exchanges in the Horn of Africa during the early first millennium BC. The diversity in agro-ecology, climatic conditions, and variation in chicken rearing practices in different regions and production environments in the tropics are believed to contribute to the current high diversity in chicken genetic resources (Dessie *et al*., 2011). However, genetic improvement or evaluation schemes in the tropics on local chicken genetic resources are at an infant stage. Instead, in most instances, developing countries look for high-yielding commercial lines that are developed under the context of intensified management systems (Dessie *et al*., 2011). This has been done to increase egg and meat production of local chickens through crossbreeding and to exploit the advantage of the resulting heterosis. There is an apparent lack of information on the existing indigenous chicken ecotypes. It is, however, important to maximize the use of the existing genetic diversity by improving the current level of production (Tadelle, 2003). This is particularly true in developing countries where breeds or ecotypes have not yet been fully recognized and characterized.

Improvement of local chicken productivity through selection and cross-breeding is vital for all developing countries, especially for Ethiopia, since there is a dynamic increment of human population and incompatibility of demand and supply of animal protein. However, the existing chicken types their morphometric and unique characteristics should be defined before developing a breeding program. Subsequently, different conservation programs should be carried out to reduce the loss of this typical feature of local chicken. In this regard, many studies (Duguma, 2006; Mogesse, 2007; Dana *et al*. 2011) explained the presence of several adaptations and morphological variations among Ethiopian local chicken.

Though work on the characterization of local chicken in Ethiopia has been carried out by several researchers covering a larger area of Ethiopia and the Oromia region, poultry characterization studies are scanty in the Borena zone. Given the high potential for poultry production and the presence of diverse ecotypes, it is imperative to conduct comprehensive studies that can cover the entire characteristics of morphological and morphometric characteristics of local chicken in the study areas. This was intended to serve as a foundation for proper utilization, conservation, and genetic improvement program. This research was, therefore designed with the following main objectives: one to characterize and identify the morphometric and morphological variation of local chicken in the study areas. To develop baseline information for future genetic improvement

Materials and Methods

Brief description of the study area

The research was conducted in the Yabello and Dire districts of the Borena zone. Borena Zone is one of the areas frequently and severely affected by recurrent drought. The zone is geographically located between $3^0$24'20" and $6^0$36'01"N latitude and $36^0$42'58" and $40^0$46'31"E longitude (EMA, 1987). The altitude of the zone ranges between 350m to 2400m above sea level. The two districts were selected purposively based on accessibility and having the potential of local chicken populations.

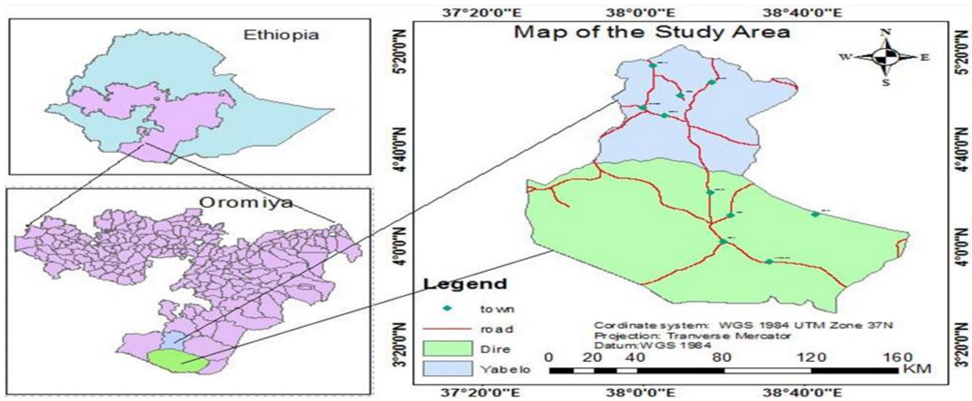

Fig. 1. Map of the study areas and the geographical location.

Sampling techniques for data collection

The research was conducted in the Dire and Yabello districts of the Borena zone. A rapid field survey was done before the main survey to validate the geographical distribution, concentration, and populations of local chicken ecotypes. Secondary data, which was useful for sampling was collected from the District Agricultural Office. A total of four rural kebeles having high numbers of the chicken population were selected purposively based on the information from the respective agricultural office. Thirty-households per kebeles and a total of 120 households was selected purposively based on the chicken they own. Four chickens per households and a total of 480 adult chickens (144 adult male and 336 adult female) in the proportion of 30 male: 70 female was picked up randomly from 120 selected households excluding sick, brooding, and laying chickens.

Data collection procedure

The data were collected through observation (for qualitative traits), employing linear body measurements (i.e. body weight, shank length, earlobe length/width, body length, wingspan, chest/breast circumference, comb length/height). Qualitative data such as plumage color, comb type, feather morphology, feather distribution, shank color, earlobe color, eye color, and head shape were gathered based on a standard format breed descriptor list (FAO, 2012). Spring balance and measuring tape were used for taking data on body weight and other morphometric traits.

Data analysis and management

After data were collected, it was entered into a computer in Ms-excel sheet and made ready for analysis. All the collected data were double-checked for any types of errors that occurred during data collection and entry. Then appropriate statistical data analysis was done depending on the characteristics of data as follows. The model of $Y_{ijk} = \mu + S_i + A_j + e_{ijk}$ were used to investigate the effects of district difference and sex. In this model: Y_{ijk}= observed body weight or linear measurements made on k^{th} bird belonging to i^{th} sex and j^{th} district; μ = Overall mean; S_i= Fixed effect of i^{th} sex (i = 1, 2; male and female); A_j = Fixed effect of j^{th} districts (j =1, 2; Yabello and Dire); and e_{ijk} = Residual error corresponding to the bird Y_{ijk}.

Descriptive statistics

Simple descriptive statistics such as average, standard deviation, and standard error of the mean for quantitative data and frequencies and tabulations for qualitative attributes were applied by the Statistical analysis system (SAS 9.1.3. version 2008 and SPSS 20). Chi-square tests were employed to test the assumption of equal proportion between the variables.

Univariate analysis

Variations were seen with univariate analyses by considering individual variables. A general linear model procedure (PROC GLM) of SAS was employed for quantitative variables to detect statistical differences among sampled local chicken populations. Mean comparisons were made using Tukey's studentized range test method at p< 0.05 for variables showing significant differences between sample populations.

Multivariate analysis

Multiple correlations were used to estimate the correlation between body weight and linear body measurement, and also multivariate analysis was used to investigate the morphological variables and quantify differences between sex and populations. A stepwise discriminate procedure was applied using PROCSTEPDISC to determine which morphological traits have more discriminating power than the others do or to gain information about traits particularly important in the separation of sub-populations.

Canonical discriminant analysis

CANDISC procedure was employed to calculate the Mahalanobis distance between chicken populations of the two districts. The quantitative variables from female and male birds were subjected to discriminant analysis (PROC DISCRIM of SAS) and canonical discriminant analysis (SAS9.1.3. version 2008) to ascertain the existence of population-level phenotypic differences in the study area.

Results

Phenotype characterization of local chickens

Qualitative traits of local chicken ecotypes in the study areas are shown in Table 1and Fig.2. The results indicated that there were large variations in morphological appearances. The local chicken was mostly normally feathered distribution with a few showing naked neck appearances. In the present study, a total of eleven distinct plumage colors were identified in which white, red, brown and red-brown were the predominant ones. The results indicated that there were large variations in morphological appearances. The local chicken was mostly normally feathered distribution with a few showing necked neck appearances. The feather morphology of the studied chicken populations was normal in both study districts. The single comb was the predominant comb-type in the surveyed districts followed by rose, pear, and walnut. White skin color birds were prominent over yellow skin in local chickens of both districts (Table1). About four eye colors were found in the study areas. Yellow (48.60%), red (30.56%) and orange (16.67%) eye colors were the dominant eyes in the study areas (Table1). The current study noted various shank colors in the chicken population of the study area. Overall, the white shank was the most frequent, followed by yellow and brownish shanks in Yabello and yellow and red in Dire district. No feathered shank chickens were found in the study area in both sexes (Table 2). In the present study, a total of 5 distinct earlobe colors were identified in which red, white, white, and red mix were the predominant ones.

Table 3 indicates Morphometric variation (least square mean ± SD) of local chickens in the study districts. Comb length, comb height, shank circumferences, chest circumferences, and body weight showed significant differences ($P<0.05$) between the two study sites. Male and female chickens' population in Dire district had morphometric features of heavier bodyweight, higher chest circumference, higher shank circumference, larger comb length, and comb height as compared to chicken populations in Yabello district. Female chickens in the Yabello district had slightly longer neck length in contrast to the hens in the Dire district.

Multivariate analysis

Measurement of the magnitude and direction of the relationship between two or more variables is called correlation. Correlation is a measure of the degree to which variables vary together or a measure of the intensity of the association between different variables in an experiment. Multiple correlations were used to estimate the correlation among linear body measurements and to estimate the linear association between body weight and other linear body measurements. Table 4 shows the Pearson correlation coefficients for all measured quantitative traits.

Discriminant analysis

The number of observations and percent classified in the chicken populations of the two districts are observed in tables 5 and 6.

Canonical discriminate analysis

Univariate statistical techniques such as analysis of variance may not sufficiently explain how populations differ when all measured variables are considered jointly (Buttigieg and Ramette, 2014). In canonical discriminant analysis a multivariate statistical technique, all variables are considered simultaneously in the differentiation of population. This approach results in a more powerful comparison of the population that cannot be achieved with univariate analysis, provided the variables are correlated.

Table 1. Qualitative characteristics of local chicken ecotypes in the study areas.

Parameter	Districts				X^2
	Yabello		Dire		
	Female(n=168)	Male(n=72)	Female(n=168)	Male(n=72)	
Feather distribution					
Normal	160(95.24)	69(95.83)	165(98.21)	69(95.83)	1.034^{ns}
Naked neck	8(4.76)	3(4.17)	3(1.79)	3(4.17)	
Feather morphology					
Normal	168(100)	72(100)	168(100)	72(100)	1.002^{ns}
Head shape					
Crested	4(2.38)	2(2.78)	7(4.17)	-	0.079^{ns}
Plane	164(97.62)	70(97.22)	161(95.83)	72(100)	
Skin color					
White	91(54.17)	36(50.00)	96(57.15)	42(58.33)	7.793*
Red	46(27.38)	23(31.94)	33(19.64)	14(19.45)	
Yellow	16(9.52)	7(9.72)	16(9.52)	5(6.94)	
Brown	15(8.93)	6(8.33)	23(13.69)	11(15.28)	
Comb type					
Single	123(73.23)	49(68.06)	115(68.45)	52(72.22)	4.256^{ns}
Rose	27(16.07)	13(18.06	31(18.45)	12(16.67)	
Pea	18(10.71)	10(13.89)	18(10.71)	8(11.11)	
Walnut	-	-	4(2.39)	-	
Shank color					
White	82(48.81)	33 (45.83)	68(40.47)	26(36.11)	12.715*
Yellow	44(26.19)	20(27.78)	55(32.73)	22(30.56)	
Brown	20(11.90)	13(18.06)	13(7.74)	7(9.72)	
Red	14(8.33)	3(4.17)	17(10.12)	12(16.67)	
Green	2(1.19)	-	4(2.38)	2(2.78)	
Black	6(3.57)	3(4.17)	11(6.55)	3(4.17)	
Eye color					
Yellow	78(46.43)	32(44.45)	79(47.02)	35(48.60)	7.142^{ns}
Red	67(39.88)	29(40.28)	61(36.31)	22(30.56)	
Orange	23(13.69)	11(15.27)	25(14.88)	12(16.67)	
Purple	-	-	3(1.79)	3(4.17)	
Plumage color					
White	48(28.57)	21(29.17)	50(29.76)	19(26.39)	8.273^{ns}
Red	37(22.02)	15(20.83)	40(23.81)	19(26.39)	
Brown	28(16.67)	13(18.06)	29(17.26)	10(13.89)	
Red brownish	18(10.71)	6(8.33)	16(9.52)	5(6.94)	
White brown	15(8.93)	11(15.28)	14(8.33)	8(11.11)	
White and red mix	5(2.98)	2(2.78)	3(1.79)	2(2.78)	
White and black mix	2(1.19)	-	1(0.60)	2(2.78)	
Black	1(0.59)	1(1.39)	3(1.79)	2(2.78)	
Grayish white	-	-	2(1.19)	1(1.39)	
Multicolor	11(6.55)	3(4.17)	10(5.95)	3(4.17)	
Wheaten	3(1.79)	-	-	1(1.39)	

X^2 = Pearson chi-square value; * significant difference at ($p<0.05$) between the two districts; ns= non-significant.

Canonical discriminant analysis can separate among population effect from the within-population effect by maximizing discrimination among the population when tested against the variation within the population. After determination of the among-population variability, the Mahalanobis distance (D^2) statistics can be used as an indication of the difference between populations (Marty *et al.*, 2007). The discriminant function is estimated by measuring the generalized squared distance. The Mahalanobis distance between Yabello and Dire district chicken was 2.1907 for females and 7.4253 for males (Table 7).

Table 2. Earlobe color variation and binomial traits in sampled chicken populations

Parameter	Districts				
	Yabello(n=240)		Dire(n=240)		
	Female(n=168)	Male(n=72)	Female(n=168)	Male(n=72)	
Earlobe color					
Red	75(44.64)	28(38.89)	68(40.48)	41(56.94)	5.208^{ns}
White	63(37.50)	28(38.89)	60(35.71)	16(22.22)	
White and red mix	18(10.71)	13(18.06)	20(11.90)	11(15.28)	
Yellow	9(5.36)	3(4.17)	12(7.14)	2(2.78)	
Yellow with red mix	3(1.79)	-	8(4.77)	2(2.78)	
Shank feather					
Feathered	-	-	-		
Not feathered	168(100%)	72(100%)	168(100%)	72(100%)	
Spur presences					
Present	-	72(100%)	-	72(100%)	
Absent	168(100%)	-	168(100%)	-	

X^2= Pearson chi-square value; ns= no significant difference between the two districts

Stepwise discriminant analysis

A stepwise discriminate procedure was applied using PROCSTEPDISC to determine which morphological traits have more discriminating power than the others do in the separation of sub-populations. The stepwise discriminate analysis is the most important technique for discriminating the investigated ecotypes and is used to identify the 'best' subset of discriminator variables to use in discriminating groups. The results of the stepwise discriminant analysis are presented in Table 9. Five standard canonical discriminant traits were extracted in the study. The significant ($p<0.001$) differences between means of shank circumference, comb height, body weight, and back length producing high F values (Table 9) indicated that these variants have high discriminating power and better ability to differentiate the groups. By comparing the F-value and the P-value statistics for each significant explanatory variable, we can conclude that 'shank circumference, comb height, and body weight has the highest amount of significant discriminative potential, while neck length has the least significant discriminative power in differentiating the chicken populations sampled from the two districts.

Discussion

The local chicken populations studied in the two districts had significantly different plumage color within and between populations. As observed in the study area diversity of plumage colors was higher (Table 1). In this regard, Crawford (1990) described that several genes determine feather colors and patterns and in the absence of selection on a preferred phenotype, they do segregate in the population (Lauvergne *et al.*, 1993). The diverse morphological traits noted in the current study are also consistent with those of Faruque *et al.* (2010), who stated that variation in phenotypes is exactly the characteristics of unimproved local chickens. Besides, Fotsa (2016) supported those plumage colors are a highly heritable trait that can transmit from parents to offspring and caused by a few numbers of genes effect. According to Melesse and Negesse (2011), multi-colorations of plumage in local chickens have some advantages to chickens, which include camouflage against predators. The single comb was the predominant comb-type in the surveyed districts followed by rose, pea, and walnut. These observations agreed with the findings made by Eiki (2016) which showed that single comb was the commonest type than the other comb types in the lowland of central Namibia. Natural selection and adaptation of certain genes to a particular environment caused differences in comb types (Melesse and Negesse, 2011). Overall, white shank color was the most frequent, followed by yellow and brownish shanks in Yabello and yellow and red in Dire district (Table 1).

Table 3. Morphometric variation (LSM ± SD in kg for body weight and in cm for all other parameters) of local chickens in the study districts

Parameter	Districts		Overall mean	P value
	Yabello	Dire		
Wing span				
F	65.756 ^{b} ± 2.802	67.036 ^{a} ± 3.015	66.388 ± 2.985	0.208
M	71.667 ^{a} ± 2.921	72.275 ^{a} ± 2.968	71.989 ± 2.951	0.309
Body weight(kg)				
F	1.276 ^{b} ±0.144	1.35 ^{a} ± 0.214	1.313 ± 0.186	0.004
M	1.3682 ^{b} ± 0.139	1.700^a ± 0.329	1.623 ± 0.229	0.002
Body length				
F	35.241 ^{b} ± 2.247	35.652 ^{a} ± 2.742	35.246 ± 2.511	0.422
M	39.585 ^{a} ± 2.498	40.442 ^{a}± 3.078	40.039 ± 2.824	0.567
Chest circumference				
F	24.574 ^{b} ± 2.057	25.665 ^{a} ± 2.440	25.103 ± 2.319	0.204
M	27.433 ^{b} ± 2.449	28.188 ^{a} ±3.166	28.701 ±2.831	0.109
Shank length				
F	11.030 ^{a} ± 1.014	10.494 ^{a} ±1.431	10.60 ± 1.643	0.289
M	11. 792 ^{a} ± 1.387	11.625 ^{a} ± 1.667	11.700 ± 1.536	0.278
Shank circumference				
F	2.914 ^{b} ± 0.259	3.063 ^{a} ± 0.205	2.989 ± 0.270	0.032
M	3.155 ^{b} ± 0.239	3.563 ^{a} ± 0.359	3.104 ± 0.313	0.001
Neck length				
F	11.140 ^{a} ± 0.770	10.869 ^{b} ± 0.914	11.005 ± 0.857	0.019
M	11.993 ^{a} ± 1.278	11.835 ^{a} ±1.430	11.281 ± 1.408	0.456
Back length				
F	17.006 ^{a} ± 1.285	17.440 ^{a} ± 2.080	17.223 ± 1. 739	0.126
M	19.582 ^{a} ± 1.246	19.654 ^{a} ± 1.680	19.641 ± 1.474	0.234
Wattle length				
F	2.016 ^{a} ± 0.507	1.946 ^{a} ± 0.489	1.981 ± 0.498	0.145
M	3.077 ^{b} ± 0.292	3.516 ^{a}± 0.552	3.296 ± 0.492	0.005
Wattle depth				
F	1.233 ^{a} ± 0.457	1.244^a± 0.517	1.241 ± 0.488	0.156
M	2.804 ^{a} ± 0.556	2.939^a ± 0.506	2.8703 ± 0.534	0.387
Comb length				
F	3.145 ^{b} ± 0.640	3.409 ^{a}± 0.636	3.279 ± 0.652	0.045
M	4.658 ^{b} ± 6.412	5.285^a ± 1.266	4.971 ± 4.974	0.002
Comb height				
F	1.098 ^{b} ± 0.394	1.445^a ± 0.594	1.263 ± 0.532	0.013
M	2.600 ^{b} ± 0.745	3.340 ^{a} ± 0.852	2.978 ± 0.865	0.023

a,b, Means in a row with different superscript letters denote significant differences between populations or sampling districts ($p < 0.05$).

This contradicts with the findings of Egahi *et al*. (2010) and Eiki (2016), who reported dominant black shank color in Nigerian and Namibian local chickens, respectively. According to Cabarles *et al.* (2012), a combination of pigments in the upper and lower layers of the skin determines shank colors in local chickens. According to Bell (2002), the shanks and most of the feet are covered with scales of various colors. The yellow color is due to dietary carotenoid pigments in the epidermis when the melanin pigment is absent. In the complete absence of both of these pigments, the shanks become white. White, red, brown, and yellow skin colors were observed in both studied districts. Among these most of the local chickens had white skin color followed by red, yellow, and brown in Yabello and red, brown, and yellow in Dire districts for both sexes. White skin color birds were prominent over yellow skin in local chickens of both districts (Table1) and this finding was supported by Bhuiyan *et al*. (2004) in Bangladesh and Dana *et al*. (2011) in Ethiopia.

Table 4. Pearson correlation coefficient analysis for linear body measurements.

Variable	WS	BW	BL	ChC	NL	BAL	WL	WD	CL	CH
WS	1.00	0.467	0.563**	0.452**	0.258*	0.380*	0.504**	0.552**	0.545**	0.529**
BW		1.00	0.768**	0.722**	0.205*	0.435*	0.334*	0.399*	0.441**	0.344*
BL			1.00	0.682**	0.261*	0.505*	0.457*	0.570**	0.516**	0.427**
ChC				1.00	0.189*	0.414*	0.305*	0.366*	0.389*	0.300*
NL					1.00	0.190*	0.327**	0.267*	0.313*	0.200*
BAL						1.00	0.477**	0.482**	0.378*	0.408**
WL							1.00	0.651**	0.547**	0.633**
WD								1.00	0.573**	0.634**
CL									1.00	0.550**
CH										1.00

Where; **and * correlation indicate significance level at (P<0.01 and 0.05) respectively, WS= wing span; BW= body weight; BL = body length; ChC = chest circumference; NL = neck length; BAL = back length; WL = wattle length; WD = wattle depth; CL =comb length; CH = comb height.

Table 5. Classification of female chicken sampled population from the two sites by Discriminant analysis.

From district	Yabello	Dire	Overall
Yabello	131(77.98)	37(22.02)	168(100)
Dire	42(25)	126(75)	168(100)
Total	173(51.49)	163(48.51)	336(100)
	Error count estimates		
Hit rates	0.22	0.25	0.23

Figures inside parentheses refer to percent of observations and figures outside parentheses refer to the number of observations.

Table 2. Classification of male chicken sampled population from the two sites by discriminant analysis.

District	Yabello	Dire	Overall
Yabello	69(95.83)	3(4.17)	72(100)
Dire	5(6.944)	67(93.06)	72(100)
Total	74(51.38)	70(48.61)	144(100)
	Error count estimates		
Hit rates	0.048	0.070	0.059

Figures inside and outside parentheses refer to percent and number of observations respectively.

Table 7. Squared Mahalanobis distance between districts for the females above diagonal and males below diagonal of sampled local chicken populations.

Districts	Yabello	Dire
Yabello	++++++++	2.1907
Dire	7.4253	++++++++

Table 8. Total sample standardized canonical coefficients and canonical correlation.

Variables	**Can1**
Wing span	0.0831
Body weight	3.2531
Body length	-0.1189
Chest circumferences	0.03012
Shank length	0.10996
Shank circumference	2.18761
Neck length	-0.21132
Back length	-0.18904
Wattle length	0.194114
Wattle depth	0.017258
Comb length	0.153507
Comb height	0.672917
Yabello	**-0.784725**
Dire	**0.784725**

Table 3. Summary of discriminate stepwise selection among the two districts chickens.

Steps	Variables	Partial R^2	F-statistics	Significant	Wilki λ	Pr < λ
1	SC	0.1207	65.47	<0.001	0.88	<0.001
2	CH	0.0890	46.40	<0.001	0.83	<0.001
3	BW	0.0846	43.83	<0.001	0.76	<0.001
4	BAL	0.0365	17.93	<0.001	0.69	<0.001
5	NL	0.0111	5.29	0.0219	0.66	<0.001

SC=shank circumference; CH=comb height; BW=body weight; BAL=back length; NL neck length;λ=lambda

Fig. 2. Typical male and female chicken pictures in study districts: A) Male in Yabello district; B) Female and male in Yabello District; C) Female in Dire district; D and E) Male in Dire district.

Morphometric variation (least square mean ± SD) of local chickens in the study districts are indicated in table 3. Dire chickens are higher in most traits and this might indicate the presence of ecotype/ line difference and availability of scavenging and supplementary feed resources in the Dire district. The result of the current study is in line with the report of mean body weight (1.7 to 2.1 kg) of central Namibian semi-arid region local chickens by Eiki (2016) and range of 1.6 to 2.18 kg as reported by Alabi *et al.* (2012).

The average shank length of males found in this study is greater than the reported average value of 11.3 cm in Horro and 10 cm in Jarso ecotypes in mid-altitude (Eskinder (2013) and 8.2 for Farta, 8.4 for Mandura (Dana *et al.,*2010). The current study is in line with the report of average comb height, comb length, and wattle length (2.05 and 0.76), (5.52 and 2.18), and (3.19 and 0.73) for males and females in Raya-azebo by Nigussie *et al.* (2015). The average comb length and comb height found in this study are higher than the reported value of 1.56 and 1.25, average comb height and 2.95 and 2.45 average comb length of male and female chickens by Agide, (2013) in north Showa zone of Amhara Region. longlegs, large combs, and wattles which were observed in the study districts are important morphological traits that allow better heat dissipation in the tropical hot environment as it helps for 40% of the major heat losses through radiation and convection of heat produced from body surfaces at the environmental temperature above 26.7^0 C (Fayera, 2016).

The differences in body weight and other linear body measurements between cocks and hens shows the presence of sexual dimorphism (the difference in size in male and female) in chickens. Hormonal differences between males and females could be causing the superiority of cocks noted in the current study.

The result of this study on the variation of the two sexes is consistent with the findings discovered in Nigeria by Yakubu*,* (2010) and in Ethiopia by (Dana *et al.* 2011). Hens use more energy for maintenance and producing eggs than for growth, while cocks use most energy for growth (Mearg, 2016). This variation might be also the attribute of the stronger foraging behavior and over computation nature of males than females and females gone through egg-laying and brooding behavior (Tadelle, 2003).

Generally, a wide range of morphological measurement, phenotypic and other performance variations of local chicken populations are observed in the current study, which might be attributed by many factors, mainly due to the variations in management practices between households, the effect of ecotype, and the availability of scavenging feed resources and feed supplements. Thus, the presence of high variations in phenotypes of the local chicken population indicates an opportunity for genetic improvement through the selection of the local chicken genetic resources.

Table 4 shows the Pearson correlation coefficients for all measured quantitative traits. Traits like BAL, BL, ChC, WL, WD, CL, and CH have high correlation coefficients with body weights. Apuno *et al*. (2011) also found a significant correlation between body weight, back length, and chest circumference in Nigerian local chicken.

Discriminant analysis showed that the lower error count estimate was exhibited for the Yabello chicken ecotype (Tables 5 and 6). The overall classification rates (hit rate) of the male and female sample population were 16.00% and 25.00% for females and 0.048 and 0.070 for males in Yabello and Dire district respectively. While 77.98 % of Yabello female chickens were classified into their source population and 75% of Dire chickens were correctly assigned to their source genetic group.

About 22.02% of female chickens that belong to the Yabello district were classified into the Dire district while 25 % that belong to the Dire district were classified into the Yabello district. This might be due to genetic exchange through marketing between the two districts. Yabello is the capital of the zone; therefore, more chicken might be transported to it for the market.

Pair-wise squared Mahalanobis distances between sites for male sample populations below diagonal were higher (Table 7). Female chicken ecotypes had a shorter genetic distance in comparison with those of male ecotypes. These long distances among male ecotypes reflected small numbers of male chicken's population in both study areas and the number of samples for the male is small. As sample size decreases variation might increase. This revealed to the male population from each district has its measurable differences from other male populations. Farmers used mostly female chickens as a foundation by buying from the local market and female chickens often obtained by getting a gift from relatives. This might be the factor why female chickens in the two districts are related as revealed by pair-wise squared Mahalanobis distances between the sites. Similarly, the study Al-Atiyat *et al*. (2017) also

reported the long distances among the male of five ecotypes in the KSA region of Saud Arabia.
Table 8 presents the total-sample standardized canonical coefficient, canonical correlation, and total variation explained by each canonical variable. The first canonical variable or fisher linear discriminant function explained 78.47% of the total variation that can be considered reasonable. Accordingly, body weight, shank circumference, comb height, and wattle length had higher weighing in extracting CAN1. The canonical variable presented high weighing for bodyweight demonstrating its importance in both to discriminate and to classify the population; a similar result was reported by Ogah *et al*. (2011) in Nigeria and Al-Altiyat (2009) in Jordan chicken, attaching importance to live weight as a tool in population discrimination.
The current study identified local chicken traits which are recognized as a large variation with long legs, predominant white plumage color, large and single comb type, better reproductive and productive performance with high potential of genetic resource of local chicken. Significantly, longer legs, large combs, and wattles observed in the current study for both male and female chicken populations are important morphological traits that allow better heat dissipation in the tropical hot environment. The average body weight of adult males and females showed a significant ($p<0.05$) difference between the study districts. Males and females in the Dire district were significantly heavier compared to its counterparts in the Yabello district. In the current study, a wide range of morphological, phenotypic, and other performance variations in local chicken populations are observed, which suggested a good opportunity for genetic improvement through selection. Based on the conclusion the following recommendations were forwarded as the major future work and scopes that might be done on local chicken in the studied districts: Local chicken characteristics need conservation because some of their traits are of future importance in being vigorous and adapted to the harsh environment. Advanced characterization at the molecular level is recommended to assert their advantage of maintaining genetic diversity and adaptability. Research in studying the effect of plumage color on productive performances and intra-population selection is highly recommended.

Acknowledgment

Our heart touch thank goes to the Ethiopian minister of science and higher education for providing financial support for the successful completion of this research manuscript.

Conflicts of interest

We have no conflict of interest.

References

Agide Y. 2013. On-Farm Phenotypic Characterization of Indigenous Chicken and chicken Production Practices in North Shewa Zone, Amhara, Ethiopia (Doctoral dissertation, Harmaya University).

Alabi OJ, Ng'ambi JW, Norris D, Egena. 2012. SS. Comparative study of three indigenous chicken breeds of South Africa: body weight and linear body measurements. *Agric J* 7: 220-225.

Al-Atiyat RM, Aljumaah RS, Abudabos AM, Alotybi MN, Harron RM, Algawaan AS, Aljooan HS. 2017. Differentiation of free-ranging chicken using discriminant analysis of phenotypic traits. *Rev Brasde Zootec* 46:791-799.

Apuno AA, Mbap ST, Ibrahim T. 2011. Characterization of local chickens (*Gallus gallus domesticus*) in shelleng and song local government areas of Adamawa State, Nigeria. *Agr Biol J N Am* 2:6-14.

Bell DD, Weaver WD, North MO. 2002. editors. Commercial chicken meat and egg production. Springer Science and Business Media

Besbes BO, Thieme O, Rota A, Guèye EF, Alders RG. 2012. Technology and programmes for sustainable improvement of village poultry production. *Alternative systems for poultry: Health, welfare and productivity* 110-27.

Bhuiyan AK, Bhuiyan MS, Deb GK. 2004. Indigenous chicken genetic resources in Bangladesh: Current status and future outlook. *Anim Genet Resour Inf* 36:73-84.

Bogale K. 2008. In situ characterization of local chicken eco-type for functional traits and production system in Fogera district, Amhara regional state. *Submitted to the Department of Animal Science, Haromiya University (MSc thesis)*.

Buttigieg PL, Ramette A. 2014. A guide to statistical analysis in microbial ecology: a community-focused, living review of multivariate data analyses. *FEMS Microbiol Ecol* 90:543-50.

Cabarles JC, Lambio AL, Vega SA, Capitan SS, Mendioro MS. 2012. Distinct morphological features of traditional chickens (Gallus gallus domesticus L.) in Western Visayas, Philippines. *Anim Genet Resour* 51:73-87.

Crawford RD. 1990. Origin and history of poultry species. *Poultry Breed Genet* 1-41.

CSA (Central Statistical Agency). 2016/17. Report on Livestock and Livestock Characteristics (Private Peasant Holdings): Agricultural Sample Survey volume II, Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

CSA (Central Statistics Agency) (2015) Agricultural Sample Survey 2014/15. Volume II Report on Livestock and Livestock Characteristics (Private Peasant Holdings), Central Statistical Agency (CSA), Addis Ababa, Ethiopia, 188 p

Dana N, Van der Waaij LH, Dessie T, van Arendonk JA. 2010. Production objectives and trait preferences of village poultry producers of Ethiopia: implications for designing breeding schemes utilizing indigenous chicken genetic resources. *Trop Anim Health Prod* 42:1519-1529.

Dana N, Vander Waaij EH, Van Arendonk JA. 2011. Genetic and phenotypic parameter estimates for bodyweights and egg production in Horro chicken of Ethiopia. *Trop Anim Health Prod* 43:21-8.

Dessie T, Taye T, Dana N, Ayalew W, Hanotte O. . 2011. Current state of knowledge on phenotypic characteristics of indigenous chickens in the tropics. *Worlds Poult Sci J* 67:507-516.

Dueppen SA. 2011. Early evidence for chickens at Iron Age Kirikongo (c. AD 100-1450), Burkina Faso. *Antiquity* 85:142-157.

Duguma R. 2006. Phenotypic characterization of some indigenous chicken ecotypes of Ethiopia. *Development* 18.

Egahi JO, Dim NI, Momoh OM, Gwaza DS. 2010. Variations in qualitative traits in the Nigerian local chicken. *Int J Poult Sci* 9:978-979.

Eiki N. Determination of phenotypic characteristics, production systems, productivity, and contribution of local chickens to households in North-Central Namibia (Doctoral dissertation).

EMA (Ethiopia Mapping Agency). 1987. Topographic Map of Ethiopia:1:50,000. EMA, Addis Ababa.

Eriksson J, Larson G, Gunnarsson U, Bed'Hom B, Tixier-Boichard M, Strömstedt L, Jensen P. 2008. Identification of the yellow skin gene reveals a hybrid origin of the domestic chicken. PLoS Genet. 4(2):e1000010.

Eskinder A. 2013. On-farmPhenotypic Characterization of Indigenous Chicken and Chicken Production Systems in Horro and Jarso Districts, Oromia Regional State. Msc Thesis, Haramaya University, Haramaya, Ethiopia.

FAO (Food and Agriculture Organization of the United Nations). 2012. Phenotypic characterization of animal genetic resources. FAO Animal Production and Health Guidelines No.11. Rome. Available at http://www.fao.org/docrep/meeting/022/am651e.pdf.

FAO (Food and Agriculture Organization of the United Nations). 2014. Draft guidelines on phenotypic characterization. Intergovernmental technical working group on animal genetic resources for food and agriculture and commission on genetic resources for food and agriculture Rome. 24-26 November 2010. 87pp.

Faruque S, Siddiquee NU, Afroz MA, Islam MS. 2010. Phenotypic characterization of Native Chicken reared under intensive management system. *J Bangladesh Agril Univ* 8:79-82.

Fayera B. 2016. Phenotypic Characterization of Local Chicken and Their Production System in Gobu Sayo, Bako Tibe and Danno Districts of Western Oromia, Ethiopia. Msc. Thesis, Haramaya University, Haramaya, Ethiopia

Fotsa JC. 2016. Genetic diversity of Indigenous Chickens in Cameroon. *Anim Health Prod* 60:63-70.

Gueye EF. 2009. The role of networks in information dissemination to family poultry farmers. *Worlds Poult Sci J* 65:115-24.

Hassaballah K, Zeuh V, Lawal RA, Hanotte O, Sembene M. 2015. Diversity and origin of indigenous village chickens (*Gallus gallus*) from Chad, Central Africa. Adv Biosci Biotechnol 6:592-600.

Lauvergne JJ, Zafindrajaona PS, Bourzat D, Zeuh V Ngo T AC. 1993. Indices de primarité de chèvres au Nord Cameroun et au Tchad. *Revue Elev Méd Vét Pays Trop* 46: 651-665.

Marty Sapp ED, Obiakor FE, Gregas AJ, Scholze S. 2007. Mahalanobis distance: A multivariate measure of effect in hypnosis research. Sleep and Hypnosis. 9:67-70.

Merga FE. 2016. Phenotypic characterization of local chicken ecotypes in the central zone of Tigray in northern Ethiopia (M. ScThesis, Jimma University).

Melesse A, Negesse T. 2011. Phenotypic and morphological characterization ofindigenous chicken population in Southern region of Ethiopia. *Anim Genet Resour* 49:19-31.

Mengesha MA. 2012. Chicken production scenarios and the headway options for improvement in Ethiopia. *Worlds Poult Sci J* 68:299-305.

Mogesse HH. 2007. Phenotypic and genetic characterization of indigenous chicken populations in northwest Ethiopia (Doctoral dissertation, University of the Free State).

Molla M. 2010. Characterization of village chicken production and Marketing system in gomma woreda, jimma zone. Jimma University, Ethiopia. 110 pp (Doctoral dissertation, M. Sc. thesis).

Moreki JC, Dikeme R, Poroga B. 2010. The role of village poultry in food security and HIV/AIDS mitigation in Chobe District of Botswana. *Livest Res Rural Dev* 22:1-7.

Nigussie H, Kebede K Ameha N. 2015. Phenotypic and morphological characterization of Indigenous chicken populations in southern zone of Tigray, Ethiopia. *J Biol Agric Health* 5

Ogah DM, Momoh MO, Dim NI. 2011. Application of canonical discriminant analysis for assessment of genetic variation in Muscovy duck ecotypes in Nigeria. *Egypt Poult Sci* 31:429-436.

Reta D. 2009. Understanding the role of indigenous chickens during the long walk to food security in Ethiopia. *Livest Res Rural Dev* 21:116.

SAS Institute Inc. (2002-2003). SAS/STAT user’s guide (Version 9.1). Cary, NC: SAS Institute Inc.

SPSS. 2011. Statistical Package for Social Sciences (SPSS 20 for windows, release 20.

Tadelle D. 2003. Phenotypic and genetic characterization of chicken ecotypes in Ethiopia. Unpublished Ph. D Thesis, Humboldt University, Germany.

Woldekiros HS, D'Andrea AC. 2017. Early evidence for domestic chickens (*Gallus gallus domesticus*) in the Horn of Africa. *Int J Osteoarchaeol* 27:329-341.

Yakubu A. 2010. Indigenous chicken flocks of Nasarawa State, Nigeria: their characteristics, husbandry and productivity. *Trop Subtrop Agroecosyst* 12:69-76.