



Evaluation of Morphometric Differences among Indigenous Chicken Populations in Bale Zone, Oromia Regional State, Ethiopia

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Abstract

The study was conducted in five selected districts in Bale zone South East, Ethiopia to evaluate the morphometric difference among indigenous chicken populations. Simple random sampling method was used to select 400 households who owned indigenous chicken population. From these households, a total of 840 adult (more than 6 months of age) indigenous chickens (225 males and 615 females) were used for morphometric traits measurements. Linear measurements were taken to the nearest of 0.5 cm and body weight was recorded at a precision scale of 100 g. Multivariate variance analysis was used to determine major traits that differentiate chicken population. Canonical discriminant multivariate statistical analysis was conducted for more powerful traits comparisons. Stepwise discriminant analysis was conducted to check the discriminating power of the traits. Pairwise Mahalanobis analysis was carried out to see the distance between indigenous chicken in the study districts. The study revealed that there were significant variations in morphometric traits across the study districts except shank circumference and wing span in hens and shank length, comb height, comb length, beak length and wattle length in cocks. There were significant variations in linear body measurements between sexes. Pairwise Mahalanobis distances between indigenous chicken between most of study districts were significant. Generally, there were morphological traits variations observed among the indigenous chicken populations across the study districts and between sexes, which suggest that there is an opportunity for genetic improvement through selection. Thus, farmers should get technical supports how to select best indigenous chicken for breeding purpose and formulation of breeding plan should be implemented to conserve indigenous chicken genetic resources for genetic improvement strategies.

Introduction

Ethiopia is believed to have the largest livestock population in Africa. Livestock sector has been contributing considerable portion to the economy of the country, and still promising for economic development (CSA, 2015; Mekuanint *et al.*, 2017). Poultry production is one of integral parts of livestock farming activities in the

country. Indigenous chickens are owned by smallholder farmers and they are widely widespread almost in every rural areas of the country to supply eggs and meat (Yami and Dessie, 1997, Dessie, 2003, Aklilu, 2007). The total chicken population of the country excluding Addis Ababa City Administration is estimated to be about 56.87 million of which

95.86%, 2.79%, and 1.35% are indigenous, hybrid and exotic breeds, respectively (CSA, 2015). Most indigenous chicken populations are non-descriptive types. However, they showed a diverse variation in their production environment that may be due to their widespread distribution and adaptive response to different ecological conditions (Tadelle *et al.*, 2003; Hussen, 2007; Moges *et al.*, 2010; Getu *et al.*, 2013).

More than 90% of the national chicken meat and egg output is from indigenous chicken populations (Nigussie *et al.*, 2011; Hailu, 2012). However, the productivity of indigenous chicken is low (average annual egg production of 60 eggs) per hen as compared to exotic breeds (Moges *et al.*, 2010; Hailu, 2012). On the other hand, the live weight of indigenous chicken is about 1.6 kg and 1.3 kg for male and female, respectively at 6 months of age (Mekonnen, 2007).

Improvement of the productivity of indigenous chicken resource demands characterization of the available genotypes (Hailu, 2012). According to Olawunmi *et al.* (2008) and Gheisari *et al.* (2016), characterization of indigenous chicken populations and evaluating of their production traits characteristics are a necessary pre-requisite for indigenous breed development and rural poultry production. In Ethiopia, few phenotypic and very few genetic characterizations studies were conducted to generate useful information towards conservation of animal genetic resources. Even though, some of the studies conducted by (Mekonnen, 2007; Hussen, 2007; Kibret, 2008; Nigussie *et al.*, 2011; Moreda *et al.*, 2014) on indigenous chicken population characterization in smallholder poultry production systems in different parts of Ethiopia, most of previous studies did not included in Bale Zone of Oromia Regional State. Therefore, this study was designed to characterize the morphometric traits variations of indigenous chicken populations in five selected district of Bale zone.

Materials and Methods

Description of the study areas

The study was conducted in Berbere, Ginnir, Sinana, Dalo Mena and in Madda Walabu districts (Figure 1) of Bale Zone, Oromia National Regional State, South East Ethiopia. Berbere district had lowland agro-ecology with annual average temperature of 16.5°C. The annual average rainfall of the district is 850 mm

whereas the minimum and maximum rainfall is 1060 mm and 1150 mm, respectively. Ginnir district holds both lowland and mid-altitude agro-ecologies. The lowest altitude of the district is 1200 m below sea level and the highest altitude is 2406 m above sea. The annual average temperature of the district is 25.5°C and the annual average rainfall is 700 mm whereas the minimum and maximum rainfall is 200 mm and 1200 mm, respectively.

Sinana district had highland agro-ecology and has annual average temperature is 16.5°C. The annual average rainfall is 1105mm whereas the minimum and maximum rainfall is 1060 mm and 1150 mm, respectively. Dalo Mena district had lowland agro-ecology having the mean annual temperature of is 29.5°C. The mean annual rainfall is 701.5 mm whereas the lowest and highest rainfall is 628 mm and 775 mm, respectively. Madda Walabu district is located in the south-Western parts of the Bale zone. The district had lowland agro-ecology.

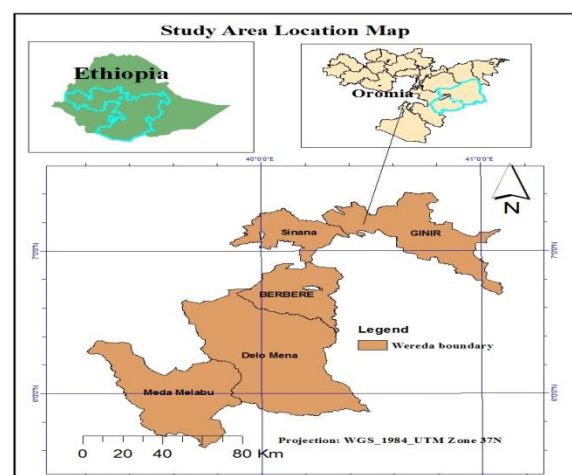


Figure 1. Map of study districts.

Sampling methods

Using purposive sampling technique, five study districts were selected by considering their larger indigenous chicken population potential and their agro-ecologies (lowland, mid-altitude and highland). Three *Kebeles* (Farmer Administrative areas) were selected from each district using simple random sampling techniques. The sample size of respondent households was determined using Arsham (2005) formula of $N=0.25/SE^2$ with the assumption of 2.5% standard error. A total of 400 households were selected using simple random sampling method. From each *Kebele* 45 males and 123 females, a

total of 840 adult (more than 6 months of age) indigenous chickens (225 male and 615 female) were selected to measure their morphometric traits measurements.

Data collection

Measuring tape meter and a spring balance (precision scale of 100gm) were used to measure linear body measurements and body weight of the chicken, respectively. Linear measurements

were taken to the nearest of 0.5cm. Ten linear body measurements (chest circumference, wing span, shank length, shank circumference, comb length, comb height, sternum length, beak length, wattle length and body length) and body weight morphometric data were recorded as defined in Table 1. To ensure accuracy of the body weight, measurement was taken early in the morning before the chicken were released for scavenging.

Table 1. Definition of quantitative traits measurements

| Quantitative traits | Definition |
|--------------------------|---|
| Shank length (cm) | Length from the hock joint to the spur of either leg |
| Body length (cm) | Length between the tip of the <i>Rostrum maxillare</i> (beak) to the <i>cauda</i> across the median plan |
| Wing span (cm) | Length between tips of right and left wings after both are full stretched |
| Chest circumference (cm) | taken at the tip of the <i>pectus</i> [hind breast] |
| Body weight (kg) | Live body weight measured early in the morning |
| Wattles length (cm) | Length of the wattle straight line from where it grows to down |
| Beak length (cm) | Length from the tip of the beak to insertion of the beak to the skull |
| Ear lobes length (cm) | Maximum length perpendicular to the neck. |
| Keel length (cm) | Distance between both vertices of the sternum (<i>processus carinae</i> and <i>processus xiphoides</i>) leaning the bird on its back. |
| Comb length (cm) | Distance between the insertions of the comb in the beak to the end of the comb's lobe. |
| Comb width (cm) | Distance from the tip of the central spike until insertion of the comb in the skull. |

Source: FAO (2012)

Data analysis

Collected data were coded and analyzed using SAS version 9.1 (SAS, 2002) and 9.2 (SAS, 2008) software packages. Statistical model was used to see correlation between traits, difference between sexes and districts. A general linear model procedure (PROC GLM) was used to distinguish statistical difference among sample chicken populations in the study districts. The model used to investigate the effects of district differences, sexes and their interaction was:

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

Where: Y_{ijk} = the value of the respective trait mentioned, μ = overall mean of the respect trait, A_i = the effect of i^{th} district on the respect trait, B_j = the effect of sex on the respective trait, AB_{ij} = interaction of districts and sex effects on respect trait, and e_{ijk} = random error.

Tuckey mean comparison test was used to test significant between those traits that showed significant difference in the study districts and t-test was used to compare trait means between sexes.

Univariate statistical variance analysis might not sufficient to explain how populations differ when all measured variables were considered

jointly. Thus, multivariate variance analysis was used to characterize major traits from a set of traits in order to differentiate chicken population. Canonical discriminant multivariate statistical analysis was conducted simultaneously for all traits in the differentiation of population for more powerful comparisons. Discriminant multivariate statistical procedure was used for special discriminant function to classify the study population (treatment sub-groups). Discriminant functions between sex groups and correct classification percentages were calculated separately for sample populations. Stepwise discriminant analysis (PROC STEPDISC) procedure (SAS, 2008) was employed to determine the best combination of variables that would separate between the chicken populations in the five districts.

Result and Discussion

Quantitative traits variation between sexes

Cocks body length, shank circumference, keel length, chest circumferences and body weight showed significant ($P < 0.0001$) differences in the studied districts (Table 2). Similarly, body

length, chest circumference, and body weight of hens showed significant ($P < 0.01$) differences among studied districts. The average shank length (8.5 cm) of the current study in female (hen) chicken population was comparable with Jarso's indigenous female chicken shank length (8.51 cm) but it was lower than female Horro indigenous chicken breed shank length (9.22 cm) reported by Aklilu *et al.* (2013) and Aklilu (2013). Longer average shank length (6.55 cm) of female indigenous chicken was reported in South eastern part of Ethiopia (Negassa *et al.*, 2014). Shank length of male indigenous chicken

population of the current study (10.30 cm) was lower than Horro cocks (11.32 cm) but comparable with Jarso's cocks (9.99 cm) (Aklilu *et al.*, 2013; Aklilu, 2013). Wider variation of traits obtained in the current study is important for breed identification and economic valuation for utilization where traits that show less variability within the chicken population indicate homogeneity and identity of those categories. In agreement, Assan (2013) reported that traits showing wider variation could be used for prediction purposes such as live weight prediction.

Table 2. Mean comparison of traits hens and cocks per District (Mean±SE)

| Trait | District | | | | | | CV | F-value | P-value |
|-------|-------------------------|-------------------------|-------------------------|------------------------|-------------------------|-----------|-------|---------|---------|
| | Madda | Delomena | Barbere | Ginnir | Sinana | Overall | | | |
| | Hens | | | | | | | | |
| BW | 1.1± 0.0 ^a | 1.0± 0.0 ^a | 0.9± 0.0 ^b | 0.8± 0.0 ^c | 0.9± 0.0 ^b | 1.0± 0.0 | 27.67 | 25.33 | <0.0001 |
| BDL | 35.5±0.2 ^a | 34.3 0.3 ^{bc} | 34.9±0.2 ^{ab} | 33.9±0.2 ^c | 34.4±0.2 ^{bc} | 34.6± 0.1 | 6.67 | 11.18 | <0.0001 |
| SL | 8.7± 0.1 ^a | 8.7 ± 0.1 ^a | 8.9± 0.1 ^a | 8.2±0.1 ^b | 8.2± 0.1 ^b | 8.5± 0.0 | 9.03 | 26.35 | <0.0001 |
| SC | 3.4± 0.0 | 3.5 ± 0.0 | 3.4 ± 0.0 | 3.4± 0.1 | 3.5±0.0 | 3.4± 0.0 | 12.68 | 0.85 | 0.4900 |
| KL | 9.7± 0.1 ^a | 9.7± 0.1 ^a | 9.4± 0.1 ^{ba} | 9.1±0.1 ^{bc} | 9.0± 0.1 ^c | 9.4± 0.0 | 12.01 | 12.25 | <0.0001 |
| CC | 25.6±0.2 ^{ba} | 25.9± 0.2 ^a | 25.1± 0.2 ^b | 24.2±0.2 ^c | 26.3± 0.2 ^a | 25.4± 0.1 | 9.83 | 15.29 | <0.0001 |
| WS | 40.0± 0.3 | 40.3± 0.3 | 40.1± 0.2 | 39.6± 0.2 | 40.5± 0.2 | 40.1± 0.1 | 7.681 | 2.01 | 0.0911 |
| CH | 1.06± 0.1 ^{ba} | 1.2 ± 0.1 ^a | 0.9± 0.1 ^b | 1.0±0.1 ^{ba} | 0.8± 0.1 ^b | 1.0± 0.0 | 77.10 | 4.48 | 0.0014 |
| CL | 3.1± 0.1 ^a | 3.1± 0.1 ^a | 2.7± 0.1 ^b | 2.8± 0.1 ^b | 2.8± 0.1 ^b | 2.9± 0.0 | 28.71 | 8.38 | <0.0001 |
| BL | 1.9 ± 0.0 ^b | 2.3± 0.0 ^a | 2.0± 0.0 ^b | 1.9±0 .0 ^b | 1.0± 0.0 ^b | 2.0± 0.0 | 19.48 | 24.07 | <0.0001 |
| WL | 1.2± 0.0 ^a | 1.2 ± 0.1 ^a | 0.7± 0.1 ^c | 1.0±0.0 ^{ba} | 0.9± 0.0 ^{bc} | 1.0± 0.0 | 54.21 | 16.76 | <0.0001 |
| | Cocks | | | | | | | | |
| BW | 1.3± 0.0 ^{ab} | 1.4± 0.1 ^{ab} | 1.6± .1 ^{ab} | 1.2± 0.1 ^b | 1.6± 0.1 ^a | 1.4± 0.0 | 23.35 | 3.64 | 0.0092 |
| BDL | 37.7±0.4 ^b | 41.3± 0.8 ^a | 38.4± 0.9 ^b | 39.2±0.6 ^{ab} | 39.9± 0.5 ^{ab} | 39.2± 0.3 | 6.89 | 4.07 | 0.0049 |
| SL | 9.9± 0.1 | 10.6± 0.2 | 10.5± 0.3 | 10.1± 0.2 | 10.3± 0.3 | 10.3± 0.1 | 9.50 | 1.40 | 0.2437 |
| SC | 3.8± 0.1 ^b | 4.5± 0.2 ^a | 4.3± 0.2 ^{ab} | 4.5± 0.2 ^a | 4.3± 0.1 ^{ab} | 4.7± 0.4 | 74.08 | 3.48 | 0.0116 |
| KL | 10.4± 0.2 ^{ab} | 11.2± 0.3 ^a | 10.5± 0.3 ^{ab} | 10.1± 0.2 ^b | 10.8± 0.2 ^{ab} | 10.6± 0.1 | 9.81 | 2.81 | 0.0312 |
| CC | 26.3± 0.3 ^{ab} | 27.8± 0.8 ^a | 26.7± 0.7 ^{ab} | 24.8± 0.4 ^b | 25.3± 0.4 ^{ab} | 26.2± 0.3 | 8.23 | 4.74 | 0.0018 |
| WS | 43.0± 0.3 ^b | 44.9± 0.9 ^{ab} | 45.6± 1.3 ^{ab} | 47.3± 0.4 ^a | 46.6± 0.7 ^a | 45.5± 0.4 | 7.16 | 4.17 | 0.0042 |
| CH | 3.2± 0.3 | 2.3 ± 0.4 | 2.5± 0.4 | 2.4± 0.3 | 3.3± 0.3 | 2.7± 0.2 | 46.40 | 2.05 | 0.0955 |
| CL | 6.9± 0.4 | 6.6± 0.4 | 7.3± 0.4 | 6.8± 0.3 | 7.4 ± 0.3 | 7.0± 0.2 | 21.32 | 0.83 | 0.5105 |
| BL | 2.2± 0.1 | 2.2± 0.1 | 2.2± 0.1 | 2.0± 0.1 | 2.3± 0.3 | 2.2± 0.1 | 30.61 | 0.36 | 0.8347 |
| WL | 3.3± 0.3 | 3.4± 0.2 | 3.9± 0.2 | 3.8± 0.3 | 4.3± 0.3 | 3.7± 0.1 | 27.09 | 1.98 | 0.1059 |

Means denoted by different superscripts within the row are significant; SE=Standard Error; CV=Coefficient Variation; BDL=Body Length; SL=Shank length; SC=Shank circumference; KL=Keel length; CC= Chest circumference; WS= Wing span; CH= Comb height; CL=Comb length; BL= Beak length; WL= Wattle length; BW= Body weight.

The body weight showed significance difference ($P < 0.001$) between sexes across the study districts. As indicated in Table 3, the mean body weight of hens (1.0 kg) and cocks (1.4 kg) were lower than hens (1.41 kg) and cocks (1.69 kg) in the central highlands of Ethiopian reported by Yami and Dessie (1997). The overall mean body weight of cocks and hens in the current study showed that the indigenous chicken in study districts were light. This indicates that they are less productive in terms of carcass production. This

agrees with there is strong correlation with meat yield and body weight as a proxy indicator of production (FAO, 2012). Most of linear body measurements of between sexes showed significance difference ($P < 0.0001$). This difference might be due to genetic factors and feed conversion efficiency of cocks to body gain where the two sexes were kept in the production systems of the study districts with similar feeding systems.

Table 3. Overall population summarized traits comparisons between sexes (Mean ±SE)

| Trait | Sex | | Overall | CV | F- value | P-value |
|-------|-----------|-----------|----------|-------|----------|---------|
| | Cock | Hen | | | | |
| BW | 1.4±0.0 | 1.0±0.0 | 1.0±0.0 | 28.85 | 214.06 | <0.0001 |
| BDL | 39.2±0.2 | 34.6± 0.1 | 35.0±0.1 | 6.92 | 262.84 | <0.0001 |
| SL | 10.27±0.1 | 8.5± 0.0 | 8.7±0.0 | 9.63 | 312.02 | <0.0001 |
| SC | 4.7±0.4 | 3.4±0.0 | 3.6±0.0 | 32.35 | 87.64 | <0.0001 |
| KL | 10.6± 0.1 | 9.4±0.0 | 9.5±0.0 | 12.14 | 81.69 | <0.0001 |
| CC | 26.2±0.3 | 25.4±0.1 | 25.5±0.1 | 10.08 | 6.70 | 0.0098 |
| WS | 45.5±0.4 | 40.0± 0.1 | 40.6±0.1 | 7.71 | 216.22 | <0.0001 |
| CH | 2.7±0.2 | 1.0± 0.0 | 1.2±0.0 | 72.2 | 307.42 | <0.0001 |
| CL | 7.0±0.2 | 2.9± 0.0 | 3.3±0.0 | 28.20 | 1438.18 | <0.0001 |
| BL | 2.2±0.1 | 2.0± 0.0 | 2.0±0.0 | 21.89 | 13.09 | 0.0003 |
| WL | 3.7±0.1 | 1.0± 0.0 | 1.3±0.0 | 49.53 | 1363.73 | <0.0001 |

SE=Standard Error; CV=Coefficient Variation; BL=Body Length; SL=Shank length; SC=Shank circumference; KL=Keel length; CC= Chest circumference; WS= Wing span; CH= Comb height; CL= Comb length; BL= Beak length; WL= Wattle length; BW= Body weight.

Correlation between traits

Body weight of hens' had significant ($P < 0.001$) and positive correlation with body length ($r=0.56$), shank length ($r=0.57$), keel length ($r=0.66$), chest circumference ($r=0.51$) and with wing span but it had very weak significant correlation with shank circumference ($r=0.03$), comb height ($r=0.12$) and beak length ($r=0.09$) but for cocks' body weight had significant and positive correlation with all traits (Table 4). In both sexes, body weight had significantly

positive correlation with body length, shank length, keel length, chest circumference, wing span and wattle length. The body weight significant correlations with most traits can enable us in predicting the values one trait based on the other trait without additional cost and time. Body length, shank length, keel length, chest circumference and wing span traits could be used to predicate the body weight of chicken easily.

Table 4. Pearson's correlation coefficients (r) of linear body measurement cocks (Above diagonal line break) and hens (Below the Diagonal break) for indigenous chicken sampled population

| Traits | BDL | SL | SC | KL | CC | WS | CH | CL | BL | WL | BW |
|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| BDL | | 0.39*** | 0.21*** | 0.45*** | 0.30** | 0.41** | 0.06ns | 0.18*** | -0.01ns | 0.24*** | 0.51*** |
| SL | 0.54*** | | 0.02ns | 0.34*** | 0.23*** | 0.44*** | 0.09* | 0.17*** | 0.27** | 0.40*** | 0.40*** |
| SC | 0.06ns | 0.05ns | | 0.21*** | 0.22*** | 0.16*** | -0.01ns | 0.08* | 0.08* | 0.11** | 0.23*** |
| KL | 0.55*** | 0.55*** | 0.05ns | | 0.35*** | 0.30*** | 0.12** | 0.31*** | 0.13** | 0.25*** | 0.39*** |
| CC | 0.54*** | 0.47*** | -0.04ns | 0.57*** | | 0.34*** | 0.08* | 0.21*** | 0.09* | 0.20*** | 0.43*** |
| WS | 0.55*** | 0.52*** | -0.07ns | 0.37** | 0.34** | | 0.08* | 0.12** | 0.17*** | 0.18*** | 0.45*** |
| CH | -0.11ns | 0.10ns | 0.11ns | 0.16ns | 0.09ns | 0.02ns | | 0.39*** | 0.03ns | 0.30** | 0.18** |
| CL | 0.17ns | 0.24* | 0.13ns | 0.35** | 0.25* | 0.26* | 0.52*** | | 0.15** | 0.48*** | 0.32*** |
| BL | -0.01ns | 0.14ns | -0.01ns | 0.23* | 0.02ns | 0.13ns | -0.07ns | 0.08ns | | 0.08* | 0.09* |
| WL | 0.23* | 0.26* | 0.01ns | 0.35** | 0.21** | 0.30*** | 0.33*** | 0.68*** | -0.07ns | | 0.40*** |
| BW | 0.56*** | 0.57*** | 0.03ns | 0.66*** | 0.51*** | 0.54*** | 0.12ns | 0.43*** | 0.09ns | 0.40*** | |

***= $P < 0.001$; **= $P < 0.01$; *= $P < 0.05$; ns=non-significant; BDL=Body Length; SL=Shank Length; SC=Shank circumference; KL=Keel length; CC= Chest circumference; WS= Wing span; CH= Comb Height; CL=Comb length; BL= Beak Length; WL= Wattle Length; BW= Body Weight.

Discriminant multivariate characterization

As it was expected to call each classified function of the traits whose coefficient were relatively higher and the grouped functions termed as discriminate trait relationship. As indicated in Table 5, most of the classification rates (hit rate) of cocks were lower than hens' classification rates across the study districts. The correct classification rates ranged from 0.13 (13%) to 0.56 (56%) for cocks and 0.45 (45%) to

0.57 (57%) for hens' population. Higher correct classification rates were found in Berbere and Madda Walabu districts for cock and for hen populations, respectively. However, lower correct classification rate was observed for cock's sample population in Madda Walabu and Ginnir compared to Berbere district. These indicate discriminate multivariate classification shows the presence of variation of traits between sexes in the study districts.

Table 5. Discriminant classification observations and percent classified (in bracket) for cocks and hens' sample indigenous chicken population using discriminate analysis

| Sex | District | | | | | Overall |
|-----------------------|-------------|-------------|-------------|-------------|-------------|--------------|
| | Madda | Delomena | Barbere | Ginnir | Sinana | |
| Cocks | 14 (87.50) | 0 (0.00) | 1 (6.25) | 1 (6.25) | 0 (0.00) | 16 (100) |
| | 2 (12.50) | 10 (62.50) | 1 (6.25) | 3 (18.75) | 0 (0.00) | 16 (100) |
| | 4 (25.00) | 1 (6.25) | 7 (43.75) | 2 (12.50) | 2 (12.50) | 16 (100) |
| | 1 (6.25) | 1 (6.25) | 1 (6.25) | 12 (75.00) | 1 (6.25) | 16 (100) |
| | 2 (12.50) | 0 (0.00) | 1 (6.25) | 2 (12.50) | 11 (68.75) | 16 (100) |
| Total | 11 (13.75) | 23 (28.75) | 12 (15.00) | 20 (25.00) | 14 (17.50) | 80 (100) |
| Error count estimates | | | | | | |
| Rate | 0.13 | 0.38 | 0.56 | 0.25 | 0.31 | 0.33 |
| Hens | 65 (42.76) | 17 (11.18) | 38 (25.00) | 18 (11.84) | 14 (9.21) | 152 (100.00) |
| | 31 (20.39) | 69 (45.39) | 19 (12.50) | 23 (15.13) | 10 (6.58) | 152 (100.00) |
| | 19 (12.50) | 11 (7.24) | 83 (54.61) | 24 (15.79) | 15 (9.87) | 152 (100.00) |
| | 17 (11.18) | 20 (13.16) | 18 (11.84) | 71 (46.71) | 26 (17.11) | 152 (100.00) |
| | 9 (5.92) | 22 (14.47) | 21 (13.82) | 25 (16.45) | 75 (49.34) | 152 (100.00) |
| Total | 141 (18.55) | 139 (18.29) | 179 (23.55) | 161 (21.18) | 140 (18.42) | 760 (100.00) |
| Error count estimates | | | | | | |
| Rate | 0.57 | 0.55 | 0.45 | 0.53 | 0.51 | 0.52 |

Canonical multipartite discriminant characterization

Mahalanobis distances between cocks, hens, and overall indigenous chicken populations across the districts are indicated in Tables 6, 7, and 8, respectively. The canonical multivariate variations between the traits of hens and overall chicken population among districts was highly significant ($P < 0.0001$) in all four types of canonical multivariate discriminate tests (Wilks' Lambda, Pillai's Trace, Hotelling-Lawley Trace and Roy's Greatest Root tests). This might be the chicken populations in the study districts were distinct and different from each other. The significant level of Mahalanobis distances of male chicken populations across districts

showed variations. Canonical discriminant characterization showed that the nearest ($P < 0.0001$) genetic distance of the overall population was observed between Madda Walabu and Berebere districts and the wider ($P < 0.0001$) genetic distance was between Delomena, Madda Walabu and Ginnir indigenous chicken populations. This wider genetic distance might be resulted from the very high morphometric differences and proper sampling frame used in the study. These differences might be used as an opportunity for selection, upgrading of indigenous chicken population and to conserve the genetic resources of the chicken population and to improve them through selection breeding strategy.

Table 6. Mahalanobis distance (P-value) of cock chicken populations and areas of their separation across districts

| Districts | Madda | Delomena | Barberbere | Ginnir | Sinana | Separation | | | |
|------------|-----------------|----------------|----------------|----------------|---------|------------|-------|-------|-------|
| | | | | | | Can1 | Can2 | Can3 | Can4 |
| Madda | 0 (1.0) | | | | | 1.30 | -0.24 | -0.02 | -0.63 |
| Delomena | 5.06 (0.002) | 0 (1.0) | | | | -0.09 | -1.70 | 0.34 | 0.31 |
| Berberbere | 2.70 (0.092) | 6.19 (0.000) | 0 (1.0) | | | 0.53 | 0.36 | -0.91 | 0.35 |
| Ginnir | 12.15 (<0.0001) | 8.55 (<0.0001) | 8.09 (<0.0001) | 0 (1.0) | | -2.13 | 0.25 | -0.12 | -0.27 |
| Sinana | 4.54 (0.004) | 9.50 (<0.0001) | 3.55 (0.0226) | 8.44 (<0.0001) | 0 (1.0) | 0.39 | 1.32 | 0.701 | 0.24 |

Table 7. Mahalanobis distance of hen chicken populations and areas of their separation across districts

| Districts | Madda | Delom | Barbe | Ginnir | Sinana | P-Value | Separation | | | |
|-----------|-------|-------|-------|--------|--------|---------|------------|-------|-------|-------|
| | | | | | | | Can 1 | Can2 | Can3 | Can4 |
| Madda | 0 | | | | | <0.0001 | 0.44 | -0.18 | 0.33 | 0.48 |
| Delome | 1.41 | 0 | | | | <0.0001 | 0.44 | 0.72 | -0.05 | -0.19 |
| Berber | 1.16 | 1.76 | 0 | | | <0.0001 | 0.34 | -0.59 | -0.16 | -0.39 |
| Ginnir | 1.71 | 1.79 | 1.61 | 0 | | <0.0001 | -0.47 | 0.01 | -0.57 | 0.26 |
| Sinana | 1.90 | 2.12 | 1.98 | 1.30 | 0 | <0.0001 | -0.75 | 0.04 | 0.45 | -0.17 |

Table 8. Mahalanobis distance of the overall chicken populations and areas of their separation across districts

| Districts | Madda | Delo | Barb | Ginnir | Sinana | P-Value | Separation | | | |
|-----------|-------|------|------|--------|--------|---------|------------|-------|-------|-------|
| | | | | | | | Can 1 | Can 2 | Can 3 | Can 4 |
| Madda | 0 | | | | | <0.0001 | 0.44 | 0.02 | 0.36 | 0.31 |
| Delo | 0.91 | 0 | | | | <0.0001 | 0.39 | 0.31 | 0.50 | 0.01 |
| Berb | 0.70 | 1.02 | 0 | | | <0.0001 | 0.34 | -0.45 | -0.08 | -0.32 |
| Ginnir | 1.73 | 1.75 | 1.38 | 0 | | <0.0001 | -0.69 | -0.36 | 0.19 | 0.18 |
| Sinana | 1.32 | 1.39 | 1.57 | 1.06 | 0 | <0.0001 | -0.48 | 0.48 | -0.24 | -0.19 |

Table 9. Multivariate discriminant function coefficients (total or Pooled-sample standardized canonical coefficient), canonical correlation and total variation explained by each function.

| Variable | Canonical variate /Structure matrix | | | |
|-----------------------|-------------------------------------|---------|--------|--------|
| | Can 1 | Can 2 | Can 3 | Can 4 |
| Variation % | 45.43 % | 26.07 % | 18.11% | 10.39% |
| Canonical Correlation | 0.43 | 0.34 | 0.29 | 0.22 |
| Body weight | 0.46 | 0.47 | -0.30 | 0.24 |
| Body length | 0.28 | 0.05 | -0.33 | 0.08 |
| Shank length | 0.60 | -0.18 | -0.01 | -0.24 |
| Shank circumference | -0.10 | 0.17 | -0.03 | -0.11 |
| Keel length | 0.48 | 0.10 | 0.17 | 0.28 |
| Chest circumference | 0.23 | 0.70 | -0.15 | -0.26 |
| Wing span | -0.04 | 0.18 | -0.02 | -0.26 |
| Comb height | 0.10 | 0.13 | 0.13 | 0.30 |
| Comb length | 0.10 | 0.14 | 0.04 | 0.28 |
| Beak length | 0.34 | 0.29 | 0.71 | -0.28 |
| Wattle length | 0.02 | 0.13 | 0.13 | 0.45 |

As indicated in Table 9, positively associated (r) predictor variables discriminate function one (Can1) was distinguished in shank length, sternum length, body weight, and beak length with the discriminate score value of $r=0.60$, 0.48 , 0.46 , and 0.34 , respectively. Whereas the predictor variable within the loading value of chest circumference, body weight, beak length, and wing span ($r = 0.70$, $r = 0.47$, $r = 0.29$, and $r = 0.18$), respectively were distinguished from discriminate function two (Can2) which were positively associated variables which elaborated for the presence of variations among the chicken population in the districts. Beak length ($r=0.71$), and sternum length ($r=0.17$) in Can3 whereas wattle length ($r=0.45$), comb height ($r=0.30$), sternum length ($r=0.28$), and comb length ($r=0.28$) in Can4 had positive power to

discriminate or differentiate indigenous chicken population in the study districts.

Negative values indicate the variation of the trait as compared to total variation explained by each function. Discriminate powers of such variables were varied from different discriminate function means that the greater score had the highest loading to discriminate the groups. However, any score falls in one side of the boundary (standard scoreless than zero, the case was predicted to be a member of one group) and if the score falls in the other side of the boundary (positive standard score) a member of the other group. The Can1 variable or fisher linear discriminate function variation explained 45.43% of the total variation whereas the remaining 26.07%, 18.11%, and 10.39% variations were explained by canonical

discriminate function two, three and four, respectively. Related finding was reported in the discriminating power of the two functions in Nigerian Muscovy duck (Ogah et al., 2011) with the proportion of 65% and 35% for can1 and can2, respectively.

Stepwise multivariate discriminant characterization

Stepwise discriminant characterization traits of indigenous chicken sample population were sorted out the traits in the order of their contribution to separation. Stepwise selection indicates that except body length and shank circumference, all the traits in the data set were found to have highly significant ($P < 0.0001$) discriminatory power (Table 10). This indicates, traits in the model were significant at level ($P <$

0.05) to discriminate the chicken populations in the study five districts. Beak length, wing span, shank length, body weight, and wattle length were the most important traits to cluster the sampled indigenous chicken populations. This agrees with stepwise discriminant characterization serves to identify traits that play significant role for clustering different group of chicken populations (Ogah et al., 2011). Most important traits for discriminating the chickens among the populations ordered were beak length, wing span, shank length, body weight and wattle length with the indicated partial discrete R2 values. In contrary to the current finding, body width and body height were reported as discriminating traits for chicken population (Al-Atiyat, 2009; Rosario et al., 2008).

Table 10. Summary of multivariate discriminant stepwise tests of the chicken population

| Traits | Partial R2 | Wilks' Lambda | F-statistics | P-Value |
|---------------------|------------|---------------|--------------|---------|
| Beak length | 0.0786 | 0.92136946 | 17.81 | <0.0001 |
| Body weight | 0.0731 | 0.85404603 | 16.44 | <0.0001 |
| Shank length | 0.0750 | 0.79001555 | 16.88 | <0.0001 |
| Wing span | 0.0780 | 0.72838756 | 17.60 | <0.0001 |
| Wattle length | 0.0536 | 0.68935778 | 11.76 | <0.0001 |
| Chest circumference | 0.0418 | 0.66056525 | 9.04 | <0.0001 |
| sternum length | 0.0293 | 0.64120522 | 6.26 | <0.0001 |
| Shank circumference | 0.0118 | 0.63364811 | 2.47 | 0.0434 |
| Body length | 0.0110 | 0.62666713 | 2.30 | 0.0569 |

Conclusion

There are morphometric traits variations in indigenous chicken population among the study districts. Most of traits showed significant variations across districts and between sexes. These variations suggest that opportunities for genetic improvement through selection and cross breeding of the indigenous chicken genetic resources. In the study districts there is introduction of exotics chicken whose sources is not well known. This situation leads to dilution of indigenous chicken. Therefore, formulation of breeding plan is important for conservation of indigenous chicken resources, management and genetic improvement of indigenous chicken population.

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Conflict of interest

The authors declared that there no any conflict of interests regarding authorship and in research grant of this study.

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