Phenotypic Characterization and Production Systems of Chicken Ecotypes in Central Ethiopia

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Abstract: The Ethiopian indigenous chicken population size is declining in alarming conditions. Therefore, reversing conservation action through the identification of chicken type and production practices is crucial to mitigating the problem. The study was conducted to characterize the phenotypic features and production systems of chickens managed under rural smallholder production systems. A total of 426 chickens were included for quantitative measurements and qualitative observation. For the farming practice, 152 farmers were included in the study. The morphological data were analyzed using district as the main effect. The morphometric data were entered into SAS version 9.4 for conducting UNIVARIATE and GLM procedures. GLM was conducted by fitting sex and district as factors. The significance level was set at 5% for both morphological and morphometric data. Diksis and Gimbichu chickens were significantly ($P<0.05$) superior in terms of body weight, body length, shank circumference, and shank length than those from the Wulbareg district. However, the canonical discriminant analysis result indicates the similarity of chickens among the study areas with some variation within the population. Plain plumage pattern (53.85%), triangular body shape (60.14%), flat head shape (69.23%), single comb type (56.64%), red earlobe color (58.04%), white skin color (65.03%), and absence of spur (76.22%) were the most observed qualitative characteristics of chickens in the study areas. Generally, the qualitative and quantitative characteristics of chickens show similarity among the Wulbareg, Gimbichu, and Diksis populations. On-farm evaluation and molecular characterization may be needed for detailed characterization. Urgent alternative conservation and improvement programs should be implemented to overcome the alarming decrease in the chicken population.

Keywords: *Chicken ecotype, Phenotypic characterization, Production system*

Introduction

The classification of today's chicken (*Gallus gallus domesticus*) recognizes its primary origin, the Red Junglefowl, and domestication probably occurred 7,000-10,000 years ago in Southeast Asia and Oceania. Distribution of chickens occurred rapidly and was widespread because of their ability to provide meat and eggs without being competitive for human food sources (Masaki, 2021). While the exact time of their introduction in Ethiopia is not precisely documented, chickens contribute to meat and egg production, generating employment opportunities, improving family nutrition, and empowering women in all agroecologies (Urgesa and Lensa, 2023). In number, Ethiopia has more than 70 million heads of chicken (CSA, 2023). In ecotype, the country has more than 17 ecotypes, which are distributed along different locations (DAD-IS, 2025). Despite the lengthy history of chicken farming in Ethiopia and many recent developments, there are still significant limits to productivity. These include the genetic resources available, the availability and quality of feed, limitations within the supply chain, including marketing opportunities, and the high prevalence of disease and predation (Habte *et al.,* 2017).

Ethiopia has a diversified chicken genetic resource with numerous functions and distributions along different agro-ecologies. However, compiled information on Ethiopian chicken ecotypes has not yet been collected. Moreover, an intensive characterization of the chicken was not conducted. Particularly, the inclusion of different sections in one sampling procedure has not been considered in previous studies. A study on Ethiopian indigenous chicken breeds was first attempted by Forssido (1986), who reported the existence of five breeds, such as Tikur, Melata, Kei, Gebsima, and Netch, referring to black, naked neck, red, gray, and white, respectively. The study classified these breeds solely based on their plumage color. While this study laid a foundation for further understanding of the indigenous chicken ecotype, it did not explore the phenotypic characteristics or genetic relationships of these breeds.

In 2003, better chicken ecotype characterization was carried out by collecting and hatching eggs at the International Livestock Research Institute (ILRI) center and assigning the ecotype designation to the places where the eggs were initially gathered (Tadelle *et al.,* 2003). Furthermore, several subsequent studies have been conducted for classifying the indigenous chicken ecotype of the country, including Tilili, Horro, Jarso, and Tepi chicken breeds (Tadelle, 2003); Farta breed (Halima *et al.*, 2007), and Konso and Mandura breeds (Dana *et al.*, 2010). To update this information, a recent review was conducted by researchers from the Ethiopian Biodiversity Institute (EBI), the country's steering committee for indigenous animal genetic resources, and

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other stakeholders, which has added ten new indigenous chicken ecotypes to the national chicken diversity list. These ecotypes include Adwa, Bale, Gambella, Gasgie, Gelilia, Hemete, Kuakuate, Welkaite, Chefe and Yebereha Tsehaye. The inclusion of these ecotypes was based on their distinct phenotypic characteristics and geographic separation. However, during reviewing still further confirmation study among the Silite, Arsi and Eastern Shewa zones was given to EBI for summarizing to confirm similarity/difference among them. Accordingly, the objective of the study was to evaluate population differences within Chefe chicken (one ecotype of Ethiopian chicken) and other chicken breeds located in the central highland of Ethiopia. Moreover, the study aimed to generate baseline information for conducting further conservation and improvement programs for the chicken ecotype located in the study areas.

Materials and Methods

Study Areas

The study site was selected based on prior research conducted (Arsi and Silite zones) with Gimbichu chicken as a benchmark. Based on this, Wulbareg, Diksis and Gimbichu districts (Figure 1) were selected purposively. Moreover, the site selection was conducted by area representation, population size of indigenous chicken, road access, previous research site, and security.

Sampling Strategy and Sample Size Determination

The sampling procedure was conducted by considering the FAO guideline for characterization of chicken (FAO, 2012). Both male and female chickens of adult age were included in the measurement. Adult age for females represents the start to lay eggs, while the mating ability is considered for males. All morphometric measurements were made using measuring tape and a sensitive digital balance (10 kg * 1 g) during the morning to avoid the effect of feed on body measurements. The sample size was determined using the FAO (2012) guideline, which was adopted in the Ethiopian context (EBI, 2016);100–300 heads of chicken should be taken as a sample per population or breed. Moreover, the guideline also recommended that 90% of the sample size could be female and the remaining male. Based on this, a total of 426 chickens were included in the measurements (157from Wulbareg, 132 from Diksis, and 137 from Gimbichu). Moreover, the sample size of individual participants was also determined by considering the FAO guideline (FAO, 2012). Thus, 152 farmers (41 from Diksis, 63 from Wulbareg, and 48 from Gimbichu districts) were included to assess chicken farming practices. The farmers who participated in the study were selected purposively and asked based on a pre-tested questionnaire, which was translated into the local languages.

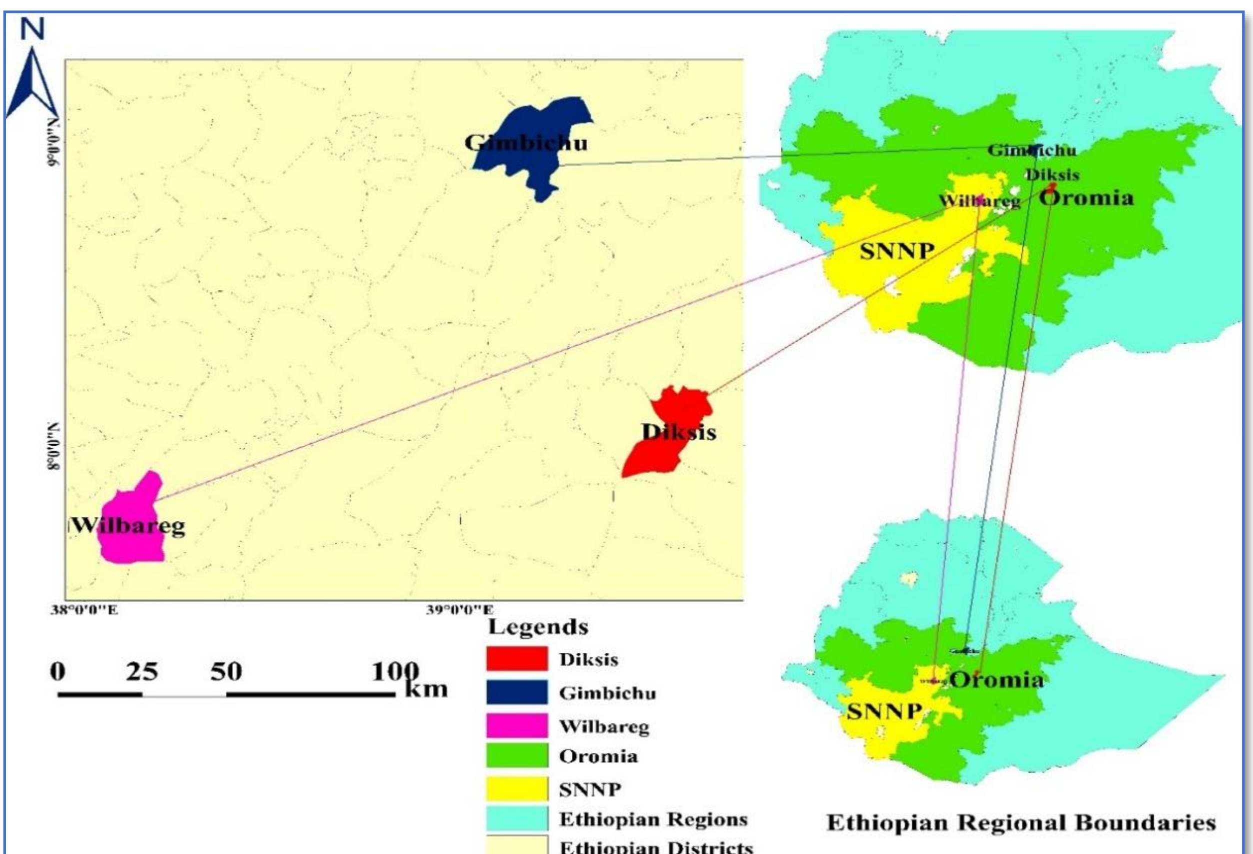

Figure 1. Map of the study areas.

Data Collection

Based on districts and chickens' sex, data were collected for both qualitative and quantitative traits. Quantitative data like wingspan, body weight, body length, chest circumference, shank length, shank circumference, and spur length were collected from each chicken. All morphometric traits were measured using a measuring tape in centimeter while body weight was measured using a digital balance with a 5kg capacity and 1g of accuracy. For qualitative data, feather morphology, feather distribution, plumage pattern, plumage color, body shape, head shape, comb type, comb size, earlobe color, skin color, shank color, and spur presence/absence were collected in parallel with quantitative data of each chicken. The production practice like purpose of chicken selection, socioeconomic character, chicken breeding objectives, and trait selection criteria, were among the collected data.

Data Management and Analysis

The farming practice data was entered and analyzed using Excel, mainly for ranked data. Both morphological and morphometric data were entered into Excel. The farming data and morphological data were entered into SAS version 9.4 for conducting the chi-square test. The morphological data were analyzed using district as the main effect. The morphometric data were cleaned in Excel through filtering. Next to that, the data were entered into SAS version 9.4, and the UNIVARIATE procedure of SAS was conducted prior to actual work to detect outliers and test data normality. After conducting data cleaning, SAS GLM procedures were conducted by fitting sex and districts as the factors. Sex and district interaction effect not observed and therefore excluded from the model. The significance level was set at 5% for both morphological and morphometric data. The following model was used to analyze morphometric data:

$Y_{ijk} = \mu + \text{district } (D_i) + \text{sex } (S_k) + e_{ijK}$.

where, Y_{ijk}= the observed n (morphometric measurements) in the i[th] districts j[th] sex; μ = overall mean, D = effect of district (i = Wulbareg, Diksis and Gimbichu); Sk = the effect of sex (male and female); and e_{ijK}=residual error.

Indices were calculated using: Index = [3 for rank 1 + 2 for rank 2 + 1 for rank 3] given for particular variables, divided by [3 for rank 1 + 2 for rank 2 + 1 for rank 3] using Microsoft Excel.

Multivariate analysis was conducted using Quantitative measurements. Based on these, the STEPDISC procedure, DISCRIM procedure, and CANDISC procedure were applied in order to discriminate chicken populations.

Results and Discussion

Socioeconomic Characteristics of Farmers

Table 1 presents the sex, position, and level of education of the respondents. The majority of respondents were male (68.4%). In the majority of the households (64.5%), the male was the head of the family. The overall proportion of illiterates was 32.2%. These findings are in line with previous reports from the Gurage zone of central Ethiopia (Alemu, 2020). Variation may be due to social, cultural, and economic factors, but this gives rise to gender inequality and needs to be corrected through continuous awareness creation (Obosha, 2020). Knowing household socioeconomic information is vital to the nature and effectiveness of any research or development activity, including policy design, technology adoption, extension services, policy analysis, evaluation, training, and other purposes (Vinicio *et al.*, 2015; NISR, 2018).

Table 1. Socioeconomic characteristics of respondents.

Characteristics	Districts			
	Wulbareg	Diksis	Gimbichu	Total
Sex of respondents				
Male	47(71)	28(68.3)	32(65.3)	104(68.4)
Female	18(29)	13(31.7)	17(34.7)	48(31.6)
Position of respondents				
Male household head	43(69.4)	23(56.1)	32(65.3)	98(64.5)
Female household head	18(29)	11(26.8)	17(34.7)	46(30.3)
Son	1(1.6)	5(12.)	0(0)	6(3.9)
Daughter	0(0)	2(4.)	0(0)	2(1.3)
Level of education of respondents				
Illiterate	33(53.2)	2(4.9)	14(26.6)	48(32.2)
Read and write	12(19.4)	4(9.8)	17(34.7)	33(21.7)
1-4 grade educated	11(17.7)	14(34.1)	8(16.3)	33(21.7)
5-8 grade educated	4(6.5)	8(19.5)	6(12.2)	18(11.8)
9-12 grade educated	2(3.2)	13(31.7)	4(8.2)	19(12.5)

Management Practice of Chicken

The housing, source of feed and method of incubation are presented in Table 2. According to this, a room inside the house was the main (87.5%) keeping method at night across all districts. Similarly, a previous study from Eastern Ethiopia indicated that chickens stayed at night on wooden perches fixed on the wall of the households' living room (Getachew *et al.,* 2015). Moreover, the finding is in line with a report from central Ethiopia, where chicken production has no separate chicken house (perch inside the house). The reason may relate to a lack of awareness of participants about the significance of separate housing in chicken production improvement. Lack of proper housing can lead to mortality and expose them to predators (Alemu, 2020). The main source of feed in Diksis district was own scavenging (70.7%), while in Gimbichu and Wulbareg districts, provision of supplementary feed like grains and food leftover were the main feeding practice. The feeding practice of Diksis is similar to that reported in Western Ethiopia, in which scavenging of feed is the main source of feed (Mohammed, 2018; Abera *et al.,* 2024). The feed and feeding practice of Gimbichu and Wulbareg is similar to reports from Konso Zone and Derashe special district, in which it was a common practice to give supplementary feed, such as food left over, grain, and other supplementary feed (Gage and Mekete*,* 2023). Farmers use a brooding hen for incubation of egg there with different materials. Based on this, most of the farmers in Wulbareg used wooden containers and on the ground with crop residue, while in Diksis (61.2%) and Gimbichu (40.8%), mud container was the main material used for egg incubation. The finding is similar to those reported from Eastern Ethiopia, in which grass and straw were used for bedding materials, while pots made of clay and cow dung were the main material used for incubating eggs (Lemma *et al.,* 2019).

Table 2. Chicken management practice of farmers in the study areas (frequency and percentage).

Variables	Districts				Chi-square	P-value
	Wulbareg	Diksis	Gimbichu	Total		
Housing:						
A room inside the house	56(90.3)	35(85.4)	42(85.7)	133(87.5)	0.76	0.68
In the kitchen	6(9.7)	6(14.6)	7(14.3)	19(12.5)		
Main source of feed:						
Scavenging	28(45.2)	29(70.7)	0(0)	57(37.5)	50.50	0.001
Supplementary feed	34(54.8)	12(29.3)	49(100)	95(62.5)		
Materials used for the incubation of eggs:						
Mud containers	3(4.8)	29(70.7)	30(61.2)	62(40.8)	84.05	0.002
Clay	12(19.4)	3(7.3)	5(10.2)	20(13.2)		
Wooden containers	23(37.1)	2(4.9)	2(4.1)	27(17.8)		
On the ground with crop residue	24(38.7)	7(17.1)	12(24.5)	36(23.7)		

The Purpose of Keeping Chickens

The purpose of keeping both male and female is presented in Table 3. Based on this, female chicken keeps by farmers for egg laying (for selling and home consumption), breeding (mating of hens for their own farm), income generation (selling of live animals and their products), and meat consumption (own home consumption) in respective order of index 0.44, 0.24, 0.18 and 0.14. male chicken keeps for income generation, breeding and meat consumption in the respective order of index 0.38, 0.35 and 0.27. Generally, egg laying for females and income generation and breeding function for males were the main purposes of keeping chickens, which is in line with farmer production practice in northwest Ethiopia, where male chickens were kept for income generation and breeding, while hens were kept for egg laying and breeding practice (Muluneh *et al.,* 2024). Variation in chicken functions among different districts may be attributed to farmers' socio-economic, socio-cultural, and perception differences (Zemelak *et al.,* 2018; Oljira, 2019; Muluneh *et al.,* 2024).

Table 3. Purpose of farmer chicken keeping in the study areas (index).

Parameters	**Index value in district:**			
	Wulbareg	Diksis	Gimbichu	Total
The purpose of the female chicken				
Breeding	0.28	0.15	0.29	0.24
Egg laying	0.39	0.50	0.47	0.44
Income generation	0.27	0.13	0.14	0.18
Meat consumption	0.08	0.21	0.10	0.14
Purpose of male chicken keeping				
Breeding	0.39	0.35	0.35	0.35
Income generation	0.27	0.40	0.33	0.38
Meat consumption	0.34	0.25	0.32	0.27

Chicken Selection Criteria of Farmers

Farmers' chicken selection criteria for both sex is presented in Table 4. Accordingly, plumage color, productivity (selection based on pedigree information), and disease resistance (better adaptation of previously outcrossed disease history progeny) were the main cock selection criteria in that order. Moreover, productivity, health, and age were the main selection criteria of the hen in the study areas in that order. However, some trait selection criteria variations were observed among the study areas. For example, in Wulbareg and Diksis districts, productivity and health condition were the basic selection criterion while in Gimbichu, age and productivity were the main selection criteria. Therefore, a confirmatory approach of trait preference identification should be conducted before the establishment of actual breeding programs. Generally, the selection criteria of both hen and cock are similar in northwest Ethiopia (Muluneh *et al.,* 2024). Moreover, the finding is in line with farmer preference in west Hararghe zone of Ethiopia (Musa *et al.,* 2024). However, the farmer selection criteria in the study area are unlike those of farmers in Uganda, where body size for both cocks and hens was the most important trait used in the selection criteria (Kugonza, 2025). Moreover, the selection of farmers was also unlined to farmers in West Hararghe Zone, Ethiopia (Musa *et al.,* 2024).

Table 4. Farmers' chicken replacement selection criteria in the study areas (index).

Selection criteria	Index value in district:			
	Wulbareg	Diksis	Gimbichu	Total
Method of cock selection				
Plumage color	0.24	0.30	0.18	0.24
Disease resistance	0.12	0.24	0.01	0.12
Pedigree information	0.10	0.05	0.01	0.06
Productivity	0.15	0.19	0.24	0.16
Method of hen selection				
Age	0.19	0.14	0.38	0.24
Brooding	0.09	0.1	0.05	0.08
Health	0.34	0.42	0.26	0.34
Productivity	0.38	0.34	0.31	0.35

Morphometric Characteristics of Chicken

The morphometric values showed a variation ($P<0.05$) between districts and the sex of chickens (Table 5). Thus, Diksis and Gimbichu chickens have significantly better ($P<0.05$) body weight, body length, shank circumference, and shank length than those in the Wulbareg district. The chest circumference of chicken also has variation, and Gimbichu has the highest (27.48 cm) value, while Wulbareg has the lowest (25.19 cm). Wingspan has no variation ($P>0.05$) in the study areas. The sex of chickens also shows variation in all morphometric traits except the chest circumference. Based on this, cocks have significantly ($P<0.05$) better morphometric values than hens.

In general, characterization of quantitative features helps to differentiate and identify indigenous chicken breeds. Furthermore, quantitative characterization is one of the initial steps toward genetic improvement (Hlokoe and Tyasi, 2022). However, quantitative traits have a wide variety of phenotypes and are governed by several genes. In genetics, quantitative features tend to be more complex or particular than their qualitative equivalents (Devin, 2023). Based on this, the better value showing in Diksis and Gimbichu may be related to better management practices in the two districts compared with the Wulbareg district. The result is in line with (Kaleri *et al.,* 2023), in which enhancing quantitative traits can be achieved through improved management practices, feed and feeding practices, proper vaccination, and treatment supplies. On the other hand, the variation may indicate the presence of variation among the population (Wolde *et al.,* 2019). Therefore, on-farm selection and evaluation may be needed to confirm variation. Generally, the body length and shank circumference of Diksis and Gimbichu district chickens have similar metric values to those in southwest Ethiopia. Moreover, the shank length of Wulbareg and the chest circumference of Gimbichu chicken have similar values to those of southwest Ethiopia; however, the body weight of all districts of chicken is lower than that of southwest Ethiopian chicken (Balcha *et al.,* 2022). Moreover, the wingspan of the chicken is in line with the chicken population in the South Omo areas. Furthermore, body weight, body length, chest circumference, shank length, and shank circumference have similarities with the chicken population in the Hamer district of the Omo zone (Mustefa *et al.,* 2021).

The observed sex effect may be due to anatomical and physiological differences. Physiologically, sex differences may be due to the sex-specific hormonal effect on growth (Semakula *et al.,* 2011). As a result, female chickens had lower body measurement values than male chickens in this study, indicating that sexual dimorphism in chickens occurs in a different trait and across most breeds. This could be due to sex hormones, which may encourage greater muscular development in males than in females (Fitsum, 2015). The body weight, body length, and shank length of both males and females in the study areas are comparable with the chicken population in the Jawi district, whereas shank circumference and wingspan are better than the Jawi chicken population (Begna *et al.,* 2025). Moreover, the body weight and shank circumference of the chicken are in line with the chicken population in southeastern Oromia, while the shank length of the study area's chicken is better than that of southeastern Oromia (Negassa *et al.,* 2014). The body weight, body length, and shank length are similar to those of the chicken population in eastern Ethiopia. However, lower chest circumference and better wingspan were observed compared with the eastern Ethiopian chicken population (Musa, 2022).

Table 5. Morphometric(cm) and body weight(g) values of chicken ecotype in the study areas (Least square mean ± SE).

Traits	Districts			P-value	Sex		P-value	CV
	Wulbareg	Diksis	Gimbichu		Female	Male		
Wing span	40.94±0.26	41.74± 0.30	41.39± 0.29	0.92	39.68± 0.18	43.02±0.31	<0.001	7.9
Body weight	1089.85±23.89^{b}	1334.64± 27.18^{a}	1370.00±26.77^{a}	<0.001	1205.24±16.36	1324.41±28.50	0.003	23.8
Body length	36.83±0.22^{b}	37.88± 0.25^{a}	38.52± 0.25^{a}	<0.001	36.79 ±0.15	38.700 ±0.26	<0.001	7.2
Chest Circ.	25.19±0.21^{c}	25.98 ±0.24^{b}	27.48± 0.23^{a}	<0.001	26.17± 0.14	26.26± 0.25	0.77	9.7
Shank length	7.99±0.07^{b}	8.22±0.08^{a}	8.57±0.08^{a}	<0.001	7.72± 0.05	8.81± 0.09	<0.001	11.2
Shank Circ.	3.59±0.05^{b}	4.06 ±0.05^{a}	4.10±0.05^{a}	<0.001	3.75± 0.03	4.08± 0.05	<0.001	14.5
Spur length	0.25±0.04^{c}	0.70±0.05^{a}	0.41±0.05^{b}	<0.001	0.11± 0.03	0.80± 0.05	0.001	-

Superscript with a different letter in the row indicate significance difference (P<0.05); SE= Standard error; Circ. = Circumference.

Stepwise Discriminant Analysis

Stepwise discriminant analysis was performed to find out the traits that can be used to identify chicken populations. Bodyweight, chest circumference, wingspan, spur length, shank circumference, shank length, and body length traits were used for identification. At a 5% α level of significance, traits that potentially distinguish chicken populations were chosen chronologically, as shown in Table 6.

Canonical Discriminant Analysis

The canonical discriminant analysis was carried out to obtain Mahalanobis distances between chicken populations and to observe the spatial distribution of chicken populations on canonical variables as presented in Figure 2. All traits have a contribution to show variation as presented in Table 2 of the STEPDISC procedure. Therefore, all traits used for conducting canonical discriminant analysis and the canonical analysis yielded two canonical methods: CAN1 and CAN2. The two canonical methods, CAN1 and CAN2, explained 100% of the chicken population. CAN1 can separate the chicken population better than CAN2. However, the separation potential is not strong; it indicates the similarity of chickens among the study areas with some variation within the population. The shortest distance was observed between the Diksis and Gimbichu districts, while the longest distance was observed between Diksis and Wulbareg, as presented in Table 7. Moreover, the CAN-DISC in Figure 2 indicates the similarity of the chicken population.

The percentage of classification in its sampling areas is presented in Table 8. Accordingly, 80.77%, 52.27%, and 56.52% of the chicken population were classified in the Wulbareg, Diksis, and Gimbichu district study areas, respectively. The performance of the discriminant function in the classification of new observations can be evaluated by estimating the probabilities of misclassification or error rates. The highest error rate (0.47 and 0.43) of classification was observed in the Diksis and Gimbichu chicken populations. This could be more related to the sharing of common genetic material than to the other populations. This result is in agreement with Selolo *et al.* (2015), who indicated misclassification may suggest the level of genetic exchange that has taken place over time between the chickens in different ecological regions or descends from a common ancestor.

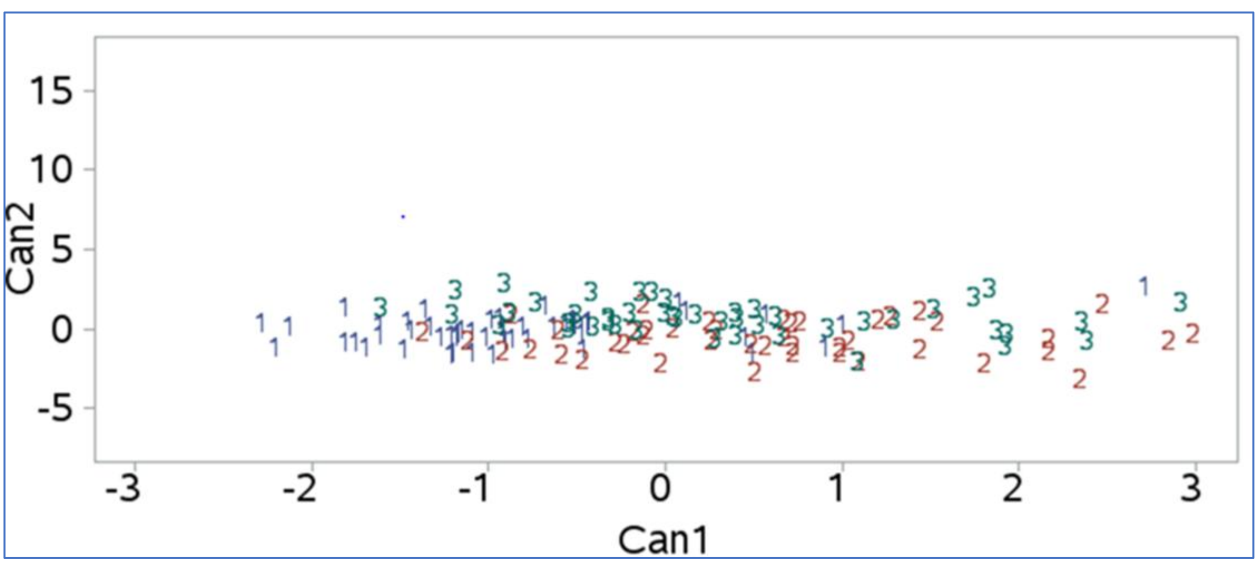

Figure 2. The canonical representation of the chicken population, where 1= Wulbareg; 2= Diksis; and 3= Gimbichu.

Table 6. Summary of the stepwise discriminant for the selection of traits that identify the chicken population.

Step	Traits	Partial R-Square	F Value	Pr> F	Wilks' Lambda
1	Body weight	0.1402	34.49	<.0001	0.86231490
2	Chest Circ.	0.1226	29.47	<.0001	0.85979108
3	Wing span	0.1140	27.09	<.0001	0.75441447
4	Spur length	0.0737	16.70	<.0001	0.66838541
5	Shank Circ.	0.0585	15.17	<.0001	0.54356875
6	Shank length	0.0195	12.99	0.0166	0.53299115
7	Body length	0.0178	4.14	0.0238	0.52350160

Circ. = Circumference.

Table 7. Eigenvalue, canonical correlation, proportion and Mahalanobis distance of districts.

Attributes	Canonical correlation	Eigenvalue	Proportion	Pr> F
Can1	0.538583	0.4086	0.5771	<.0001
Can2	0.480054	0.2995	0.4229	<.0001
Mahalanobis distance of districts				
From districts	Wulbareg	Diksis	Gimbichu	
Wulbareg	0	2.32381	2.09984	
Diksis	2.32381	0	1.89576	
GimbichuDonsa	2.09984	1.89576	0	

The Qualitative Characteristics of Chicken

The qualitative character of chicken is presented in Table 9. According to this, plain plumage pattern (53.85%), triangular body shape (60.14%), flat head shape (69.23%), single comb type (56.64%), red earlobe color (58.04%), white skin color (65.03%), yellow shank color (51.05%), and absence of spur (76.22%), were the most observed features across the study areas. Moreover, normal feather morphology and distribution showed no variation (*P>0.05*) among the districts. Generally, qualitative traits are important for breed identification, assisting breeders in improving certain desirable traits, valuable for maintaining genetic diversity and adapting to different environments, influencing consumer preferences and market demand for specific chicken types, indicators of potential health or welfare issues, and indirectly influencing productivity by affecting factors such as disease resistance or adaptability to specific environments (Indi *et al.,* 2024). The feather distribution, earlobe color, spur, shank color, comb color, comb shape, and head shape characteristics are in line with earlier report fom Tigray region of Ethiopia (Fitsum, 2015). Comb type, earlobe color, skin color, and shank color characteristics are in line with the chicken population in Cambodia (FAO, 2009). Moreover, the comb type, head shape, shank color, earlobe color, and skin color of the chicken are in agreement with the chicken population in southern Ethiopia (Negassa *et al.,* 2014).

Table 8. Number of observations and percent classified into districts.

From districts	1	2	3	Total
1	126(80.77)	12(7.69)	18(11.54)	156(100)
2	30(22.73)	69(52.27)	33(25)	132(100)
3	30(21.74)	30(21.74)	78(56.52)	138(100)
Total	186(43.66)	111(26.06)	129(30.28)	426(100)
Priors	0.33	0.33	0.33	
Error rate	0.1923	0.4773	0.4348	0.3681

Plumage Color of Chicken

The plumage color of the chicken is presented in Figure 3. Based on this, in the Wulbareg district, red, black, and brown-penciled colors were the most observed colors in that order. In the Diksis and Gimbichu areas, brown-penciled, red, and Wosera (red-white) colors are observed in that order. Moreover, brown-penciled, black, and white colors were observed in Gimbichu in that order. Overall, brown-penciled, red, and black plumage colors were the most observed plumage colors. On the other hand, unique plumage colors like Gebisma (black-white) and Kokima (grayish) were observed in a few individuals in the study areas.

Sources of variation in plumage coloration (black, red, brown, and grey) are related to genetics, diet and condition, and environmental influences. The carotenoid-based pigmentation influences the degree of color expression, not the location, pattern, or specific colors expressed. The most common avian plumage pigment is melanin, a pigment responsible for many of the blacks, grays, browns, and other colors (Figure 4). In particular, melanin is responsible for all the spotting, striping, and high-contrast patterning typically observed in a wide variety of birds (Delhey *et al.,* 2006). Moreover, the diet and condition of birds can influence the expression of color. This is particularly true for carotenoids, which are entirely acquired from the diet (Hill, 1994). The environment can also influence plumage coloration after feathers are grown and are generally inert. The color of feathers can change over time due to physical abrasion of the keratin structure and UV bleaching of pigments (Delhey *et al.,* 2006). The observed red, black, and brown penciled in the population is in line with a report from Nigeria (Akumbugu *et al.,* 2023), and is considered a survival and adaptation strategy to overcome heat stress. The plumage color of Diksis and Gimbichu chickens has similar characteristics to the chicken population in Sudanese native chickens (Wani *et al.,* 2014). Moreover, the Wulbareg chicken population has similar plumage color to the chicken population in the North Gondar Zone, in which red is the most observed color (Getu *et al.,* 2014).

Table 9. Qualitative description of chicken ecotype in the study areas (frequency and percentage).

Attributes	Traits	Districts				Chi-square	P-value
		Diksis	Gimbichu	Wulbareg	Total		
Feather morphology	Normal	114(84.44)	108(78.26)	135(86.54)	357(83.22)	3.8049	0.1492
	Silky	21(15.56)	30(21.74)	21(13.46)	72(16.78)		
Feather distribution	Normal	135(100)	138(100)	156(100)	429(100)		
Plumage pattern	Barred	0(0)	12(8.7)	36(23.08)	48(11.19)	52.9624	<0.0001
	Patchy	24(17.78)	33(23.91)	24(15.38)	81(18.88)		
	Plain	75(55.56)	75(54.35)	81(51.92)	231(53.85)		
	Spotty	36(26.67)	18(13.04)	15(9.62)	69(16.08)		
Body shape	Blocky	9(6.67)	75(54.35)	15(9.62)	99(23.08)	113.5589	<0.0001
	Rectangular	30(22.22)	15(10.87)	27(17.31)	72(16.78)		
	Triangular	96(71.11)	48(34.78)	114(73.08)	258(60.14)		
Head shape	Flat	102(75.56)	75(54.35)	120(76.92)	297(69.23)	21.2182	<0.0001
	Snake	33(24.44)	63(45.65)	36(23.08)	132(30.77)		
Comb type	Pea	27(20.0)	18(13.04)	18(11.54)	63(14.69)	51.3515	<0.0001
	Rose	36(26.67)	66(47.83)	21(13.46)	123(28.67)		
	Single	73(53.33)	54(39.13)	117(75.0)	243(56.64)		
Comb size	Large	27(20.00)	36(26.09)	27(17.31)	90(20.98)	19.5607	0.006
	Medium	60(44.44)	45(32.61)	39(25.00)	144(33.57)		
	Small	48(35.56)	57(41.30)	90(57.69)	195(45.45)		
Earlobe color	Black	0(0)	0(0)	18(11.54)	18(4.20)	92.5174	<0.0001
	Brawn	3(2.22)	0(0)	3(1.92)	6(1.40)		
	Red	87(64.44)	102(73.91)	60(38.46)	249(58.04)		
	Red-white	21(15.56)	27(19.57)	15(9.62)	63(14.69)		
	White	24(17.78)	9(6.52)	60(38.46)	93(21.68)		
Skin color	White	96(71.11)	108(78.26)	75(21.74)	279(65.03)	32.5361	<0.0001
	Yellow	39(28.89)	30(21.74)	81(51.92)	150(34.97)		
Shank color	Black	12(8.89)	0(0)	21(13.46)	33(7.69)	67.4609	<0.0001
	Brawn	12(8.89)	18(13.04)	15(9.62)	45(10.49)		
	White	57(42.22)	60(43.48)	15(9.62)	132(30.77)		
	Yellow	54(40.00)	60(43.48)	105(67.31)	219(51.05)		
Spur	Absence	81(60.00)	117(84.78)	129(82.69)	327(76.22)	28.7863	<0.0001
	Presence	54(40.00)	21(15.22)	27(17.31)	102(23.78)		

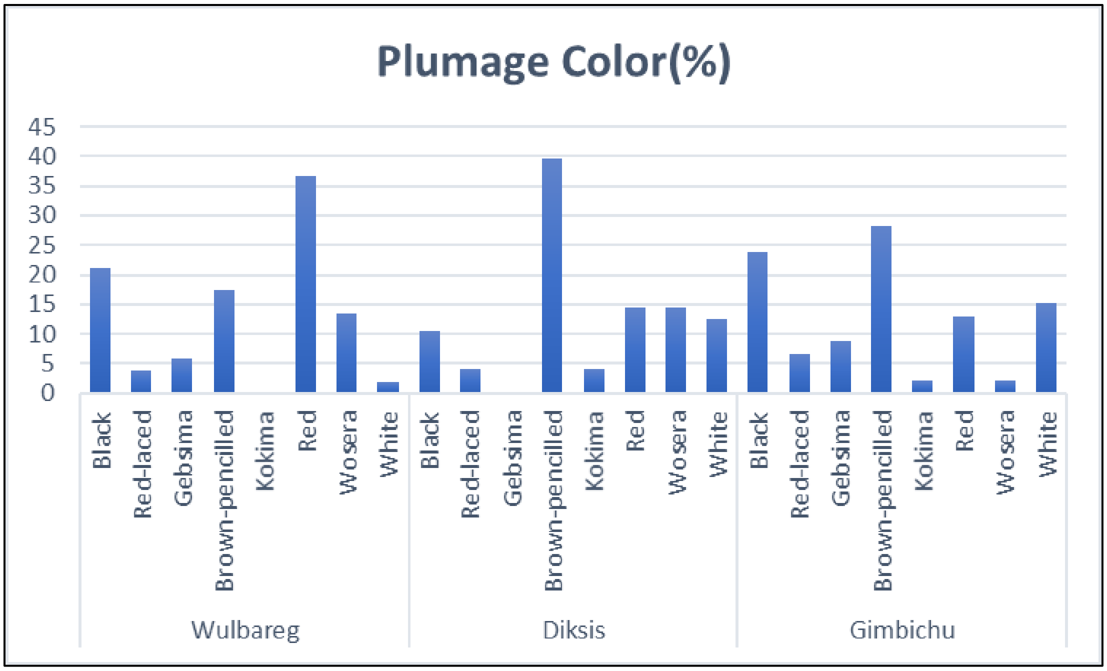

Figure 3. Plumage color of chickens in the study areas.


Figure 4. From left to right: female chickens in the Chefe area, a male chicken in the Diksis area, and a male chicken in the Wulbareg area.

Conclusion

In the study areas, farmers keep hens mainly for their eggs, which may be used for household consumption or as a means of income generation, to fulfill household consumption commodities. Rooster is used for breeding, income generation, and household meat consumption mainly during holidays. Farmers have their own selection criteria for selecting replacement cockerels in the study areas. The overall selection criteria of farmers in respective orders are plumage color, productivity, and disease resistance, while for hen productivity, health, and age are the main selection criteria. The canonical discriminant analysis revealed an overlap of chicken population one another, with chicken population in Gimbichu districts previously reported as Chefe chicken, and chicken population in Diksis in areas that overlap each other. On the other hand, the chicken population from the Wulbareg area shows some variation. However, in total, the population does not distinguish clearly, which also indicates similarity and can be considered as management variation among the study areas. The plumage color of the chicken also indicates that the chicken population in Gimbichu and Diksis have similar color. However, the chicken population in the Wulbareg district shows some variation, but it is not a major variation. It can be concluded that the chicken population are similar ecotype and distributed in the highlands of central Ethiopia. Merging this population and naming it as "central chicken ecotype" may give inclusive ecotype naming. Alternative naming includes "Chefe chicken" and includes other central highland chickens as a sub-population. On-farm evaluation and molecular characterization may be needed for detailed characterization. Urgent alternative conservation and improvement programs should be implemented, as the population of chickens is decreasing alarmingly. Generally, this research engenders baseline information for conducting further research, conservation, and development programs.

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Conflict of Interests

The authors declare that they have no competing interests.

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