Phenotypic Characterization of Local Chicken Ecotypes in Selected Districts of North Wollo Zone, Ethiopia

Zelalem Tadesse Achenef[1], Tassew Mohammed Ali[1]*, and Nurlgn Mohammed[1]

[1]Department of Animal Science, College of Agriculture, Woldia University, Mersa, Ethiopia

Abstract: The study was conducted with the aim to characterize the indigenous chicken ecotypes managed under farmer's conditions in Habru and Gubalafto districts, North Wollo Zone. Multi-stage sampling technique based on chicken population was used for the study. Six *kebeles* from the two districts were purposely selected which contained randomly selected 186 households and 375 local chickens. Data was analysed using the Statistical Analysis System (SAS) version 9.4 and the least squares means were separated using the Tukey-Kramer test. The result of present findings showed that 96.27% of the local chickens in Habru and Gubalafto districts had feathered necks, 96.53% normal feather morphologies and only 3.73% chickens had naked neck. The dominant plumage color types were complete white (33.87%) followed by complete black (25.33%) and red (17.60%). The local chickens in the study areas were also predominately described by white (47.20%) and yellow (46.40%) shank colors, white skin color (97.87%), red earlobes (95.20%), and blocky (45.87) and triangular (46.13) body shapes. Single comb (50.13%) is the most common comp type, followed by rose (27.47%) and pea (15.73%) in the studied area. The body weight and shank length were significantly different between the districts. There were positive and strong correlations between body weight, body length, shank length, and egg weight. In both male and female chickens, the body weight was best predicted by including body length and shank length in the model. Discriminate analysis showed that a relatively large number of Habru chickens (46.11%) were misclassified as Gubalafto chickens. Similarly, 45.41 percent of the total Gubalafto local chickens were misclassified as Habru local chickens, showing the level of genetic exchange that has taken place between the two chicken ecotypes over time. The local chickens in Habru district are phenotypically similar and their body weight and other body measurement values fall under the Ethiopian chicken performance range. The findings of this study play a significant role in designing breeding and conservation policies through providing information on phenotypic characteristics of the chicken. They would also be used as important inputs or the basis for conducting further research.

Keywords: *Gubalafto, Habru, Local chicken, Morphological traits, Phenotypic characterization; Quantitative traits*

Introduction

The word poultry production is synonymous with chicken production under Ethiopian conditions (Moges *et al*., 2010; Kejela *et al.,* 2019). In Sub-Saharan Africa (SSA), 60% of rural chicken production has been carried out by keeping indigenous chickens (Kejela *et al.,* 2019). Ethiopia consisted of fifty-seven million chickens. Out of the total chicken population, the country has, 79%, 12%, and 9.11% indigenous, hybrid, and exotic, respectively (CSA, 2021).

The gradual growth of poultry production in Ethiopia has obtained good acceptance from small and medium-scale farmers living in rural areas (Milkias *et al*., 2019). A common attempt to increase production from local chickens has been cockerel exchange schemes (Solomon, 2007; Tassew, 2023), which involve mating them with improved cocks. Nowadays, commercial chicken hybrids namely Bovans Brown, ISA Brown, Lohmann, TETRA-SL, Sasso, Babcock, and Fayomi, have been widely introduced in Ethiopia through both governmental and non-governmental organizations. According to Nebiyu *et al.* (2013), chicken production has an important economic role and is experienced by about 80% of rural people. Local chicken shares almost 99% of the national egg and poultry meat production (CSA, 2021). Moreover, chickens are relevant sources of cheap and quality protein, thus putting its contribution in minimizing malnutrition among rural populations. They are also sources of incomes, natural fertilizer, and job creation (Nebiyu *et al*., 2013). Nevertheless, the economic return of the chicken sector is found to be lower as compared to the large chicken population. In Ethiopia, indigenous chickens are maintained under the traditional scavenging system with little input investment for good chicken husbandry practices such as housing, feeding, and health care. The annual egg production of local chickens under farmer's management conditions ranges from 53 to 60 eggs per hen (Lelisa, 2021; Mengesha *et al*., 2022; Shambel, 2022). The total egg production is very low, at about 162 million per year (Halima, 2007), due to constraints, which incorporate high disease occurrence (i.e., including parasites), predators, a lack of proper healthcare, shortage of feed sources, and poor marketing information. The impacts of these constraints start from early gestation to throughout lives of chicken and bring about productivity

*Corresponding Author. E-mail: tassewm010@gmail.com

Published by Haramaya University, 2023

ISSN: 2616-8804 (Print); 2959-0531 (Online)

declination of the chickens in most areas of the country. Among the above constraints, diseases are the main constraints, which had significantly negative impacts on the chicken population and compromised productivity (Natnael, 2015).

Characterization is the first step for strategic genetic improvement, as it offers the basis for any other livestock development interventions and provides information for designing appropriate breeding programs (FAO, 2011; Melesse and Negesse, 2011). Moreover, characterization of chicken resources is essential to know which breeds are at risk of extinction or that are preferred by farmers, and thereby characterization document can serve as supporting guide for policy developer to include endangered or desirable chicken into the nation's chicken plan (Halima *et al.,* 2007).

North Wollo Zone is known for its huge indigenous chicken population, which is 1,069,976 (CSA, 2021). The numbers of indigenous, hybrid, and exotic chickens out of the total numbers in the zone were 927,672, 104,284, and 104,284, respectively (CSA, 2021). The farmers' livelihoods are highly dependent on chicken production. The chicken sub-sector has good potential to support economic growth in developing countries through employment creation, income provision, and the nourishment of rural populations (Halima *et al.*, 2007; Nebiyu *et al.*, 2013). Despite its importance, no adequate previous studies have been made to characterize indigenous chicken ecotypes for qualitative and quantitative traits under an extensive production system in the North Wollo Zone. Thus, this calls for further investigation into the phenotypic characterization of indigenous chickens in the Zone. Characterization of the phenotypic traits of the indigenous chicken types under a traditional management system is crucial for smallholder farmers, government and non-governmental organizations, and policymakers. The major findings of the study enable the design of breeding and conservation policies that help to increase the production and reproduction performance of chickens and can be used as important inputs or the basis for conducting further research. Therefore, the study was initiated to phenotypically characterize the indigenous chicken ecotypes for qualitative and quantitative traits under farmer management conditions in selected districts of the North Wollo Zone, Ethiopia.

Materials and Methods

Description of the Study Areas

This study was conducted in Habru and Gubalafto districts of the North Wollo Zone of the Amhara National Regional State, Ethiopia. Habru is one of the thirty districts in the zone. It is situated at an altitude ranging from 1200 to 2350 meters above sea level (m.a.s.l.) at 39° 38' E longitudes and 11°35' N latitude in the semi-arid tropical belt of north-eastern Ethiopia (MoA, 1998) (Figure 1). Its mean annual maximum and minimum temperatures were 28.5 °C and 15 °C, respectively (HARDO, 2010), whereas the mean annual rainfall of the district varied from 750 to 1000 mm. It receives bimodal rainfall (SARC, 2010), namely the main and the short rainy seasons. The main rainy season extends from the beginning of August to mid-September, while the short rainy season starts by the end of January and ends in April. With respect to agro-ecology, Habru consists of highland (*dega*; 3.5%), mid-highland (*woinadega*; 40%), and lowland (*kolla*; 56.5%) out of the total area (HARDO, 2010). The total area of the district is 53013.7 ha, out of which the proportions of cultivated lands, grazing lands, shrub and bush lands, forest lands, and settlement were 64%, 6%, 21%, 3%, and 6%, respectively (HARDO, 2010).

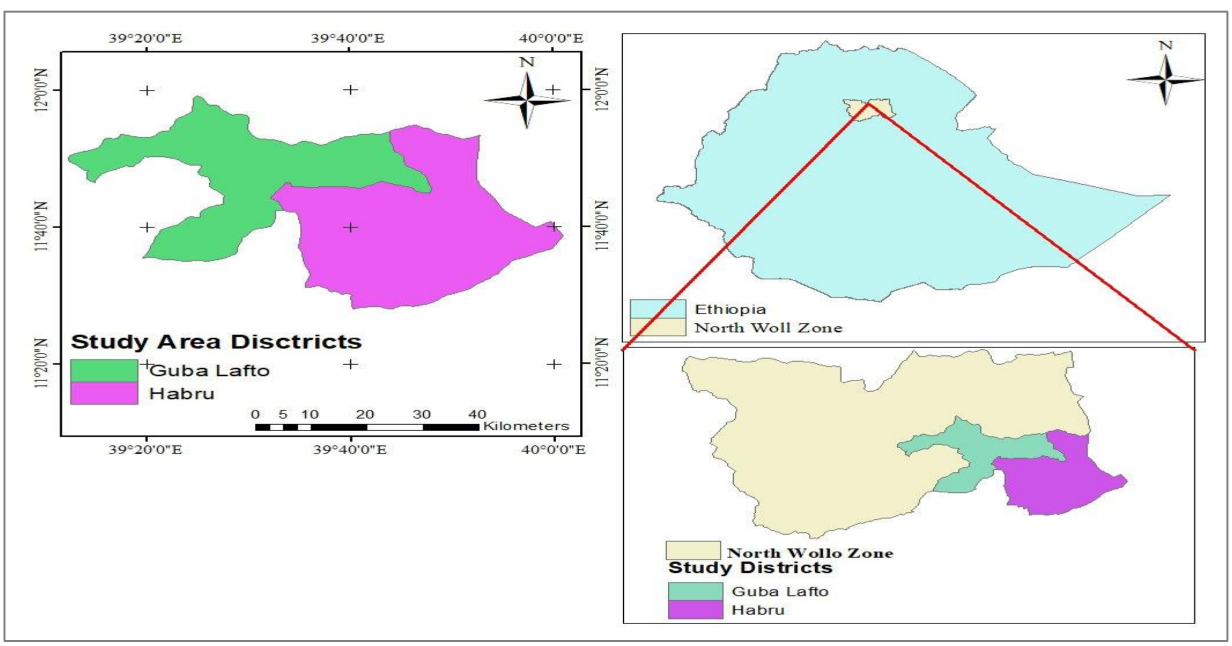

Figure 1. Map of Habru and Gubalafto districts in North Wollo Zone, Ethiopia.

Gubalafto is located in an altitude range of 1600 to 3300 m.a.s.l. (GWoARD, 2010) at 36.31° and 39.81°E longitude and 9.11° and 14.59°N latitude in the northwest highlands of Ethiopia (MoA, 1998) (Figure 1). The mean annual maximum and minimum temperatures recorded in Gubalafto district were 22.28 °C and 7.5 °C, respectively (GWoARD, 2010), while the mean annual rainfall of the study areas varied from 777 to 1050 mm. The district receives bimodal rainfall (SARC, 2010) in the main and short rainy seasons. The main rainy season extends from end of June to mid of September while the short rainy season starts at the end of January and lasts up to end of April. Mixed crop-livestock farming is the dominant production system in the district, where crop production is the primary agricultural activity and livestock production is an integral part of the land use system. In addition to mixed crop-livestock farming, barely-based sheep farming is also found in the parts (cool highlands) of the district where the rearing of sheep is the main farming activity for the livelihood of the farmers (a source of income, meat, manure, skin, and coarse wool). Gubalafto district has four agro-ecological zones, namely, lowland (*Koloa*) 1379-1500 m.a.s.l., mid-altitude (*woinadega*) 1500-2300 m.a.s.l, highland (*dega)* 2300-3200 m.a.s.l., and *wurch* >3200 m.a.s.l. Most of the rural population is settled on the highlands and plateaus (SARC, 2010).

Sampling Method

For this study, a multi-stage sampling technique was used. In the first stage of sampling, the two districts Habru and Gubalafto were selected purposefully based on poultry production potential and accessibility to transport (NWZOLFR, 2022). In the second stage, six and three *kebeles*, respectively from each district were also selected purposefully based on the presence of a high concentration of indigenous chickens and the accessibility of good infrastructure. Accessibility to infrastructure was taken as criterion to select districts and the corresponding *kebeles*, because infrastructures such as road and telecommunication are very essential to closely follow the study. In the third stage, a total of 186 respondents/households (90 from Habru and 96 from Gubalafto districts) were randomly taken out of the total of 2046 living in the selected *kebeles* (Table 1). The sample size determination was done using Yamane (1967) at 7% precision.

$$n = \frac{N}{1 + N(e)^2}$$

2046/ (1+2046*(0.07)²) =2046/11.0352 = 186

where, n = the sample size; N = the population size (total chicken owners), which is 2046; e= the level of precision, i.e., 7%.

Sampling Size for Body Measurement and Qualitative Traits' Descriptions

For liner body measurement (LBM) and qualitative trait descriptions, a total of 375 local chickens (180 chickens from Habru and 195 from Gubalafto districts) of both sexes, which were kept under farmer management conditions, were randomly taken from 186 households in six *kebeles* of two districts using the Cochran (1977) formula by considering 95% of the confidence level (z = 1.96), estimated proportion of an attribute in the population (p), and 7% level of precision (e). The formula is:

$$no = \frac{z^2 * p * q}{e^2}$$

where, no= is the total sample size; **z** is the selected critical value of the desired confidence level; p is the estimated proportion of an attribute that is present in the population; q=1-p; and e is the desired level of precision. Then, after determining the total sample size and probability of client and non-clients, take those samples from 14980 total households in the six *kebeles* (Table 2).

Table 1. Numbers of *kebeles* and households selected from Habru and Gubalafto districts in North Wollo Zone.

Districts	Agro-ecologies	*Kebeles*	Total households	Sample households
Habru	Low land	Abiwotfira	341	31
	Low land	Sirinka	319	29
	High land	Metro	330	30
Gubalafto	High land	Gedo	264	24
	Low land	Woyinye	385	35
	Low land	Gashober	407	37
Total		**6**	**2046**	**186**

Source: *(NWZOLFR, 2022).*

Data Collection

Appraisal survey procedure (ILCA, 1983), in which the participating households were visited only once. Data on qualitative and quantitative traits of chicken were recorded while doing the rapid single survey. Measurements were taken from individual chickens from randomly selected flocks until reaching the target sample size. The standard breed descriptor lists for chicken (FAO, 2011) were followed to study the qualitative and quantitative morphological characteristics. Information on the description of the chicken population under consideration was recorded by direct observation or counting of qualitative characters and measurements of quantitative characters from all members of the sample chicken flock. Quantitative traits, namely shank length and body length were measured by meter, whereas egg weight and body weight were measured by using a portable weighing scale.

Qualitative traits such as feather distribution and morphology, plumage, skin, earlobe and shank colors, comb type, head, and body shapes were assessed through observations.

Table 2. Numbers of chicken sampled for body measurements and qualitative traits' descriptions in the study areas.

Districts	*Kebeles*	Poultry holders	Male	Female	Total
Habru	Abiwotfire	2557	15	46	61
	Sirinka	2294	13	36	49
	Merto	3173	17	53	70
Gubalafto	Gedo	2496	22	45	67
	Woyinye	2937	23	56	79
	Gashober	1523	12	37	49
Total	**6**	**14980**	**102**	**273**	**375**

Source: (NWZOLFR, 2022).

Statistical Data Analysis

Both qualitative and quantitative data were analyzed using the Statistical Analysis System (SAS), version 9.40 (2013). Sex of chicken (male, female) and district (Habru, Gubalafto) were fitted as independent variables except for egg weight, whereas shank length, body length, and body weight were fitted as dependent variables. For egg weight, only district was the independent variable. Least squares means with their corresponding standard errors were calculated for each parameter over these independent variables. When analysis of variance declared a significant difference, least squares means were separated using the Turkey-Kramer test, and only significant interaction among fixed effects was discussed. The statistical model was:

$Y_{ijk} = \mu + D_i + S_j + e_{ijk}$, for shank length, body length, and body weight and

$Y_{ijk} = \mu + D_i + e_{ijk}$ for egg weight,

where, Y_{ijk}= the observed *k* (shank length, body length, and body weight) in the i^{th} districts and j^{th} sex and (egg weight) in the i^{th} districts; μ= overall mean; D_i= the effect of i^{th} districts (i= Habru & Gubalafto); S_j= the effect of j^{th} sex (*j*= male & female); e_{ijk}= random residual error.

The correlations among the quantitative traits considered in the study were computed using the Pearson correlation coefficient, whereas the stepwise regression procedure of SAS was used to regress body weight for males and females over other body measurements in the study. The best-fitting models were selected based on the coefficient of determination (R^2). The following models were used for the estimation of body weight from other body measurements:

For males:

$y = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + e_j$

where, *y* = the response variable (live body weight); β_0 = the intercept; $X_1 \ldots X2$ are the explanatory variables (body length, shank length); $\beta_1 \ldots$, β_2 are regression coefficients of the variables $X_1 \ldots, X_2$; e_j= random error.

For female:

$Y = \beta_0 + \beta 1X1 + \beta 2X2 + ej$

Where, *y* = the dependent variable body weight; β_0= the intercept; $X1 \ldots X2$ are independent variables (body length, shank length, and egg sizes); $\beta 1 \ldots \beta 2$ are regression coefficients of the variable $X1 \ldots, X3$; e_j = random error.

The quantitative variables from all sampled chicken populations were separately subjected to discriminate analysis (PROC DISCRIM of SAS version 9.40 (2013) and canonical discriminate of SAS version 9.40 (2013) program to ascertain the existence of population-level phenotypic differences in the study area. Individual animals as a unit of classification were taken to perform discriminate and canonical discriminate analyses. The step-wise discriminate analysis procedure (PROC STEP DISC SAS version 9.40, 2013) was run to rank the variables by their discriminating powers.

Results and Discussion

Phenotypic Characterization of Local Chickens

Qualitative traits' characteristics of local chickens: The proportions of each level of the nine qualitative traits of local chickens recorded for each district are given in Table 3. The local chickens in Habru district have mainly feathered necks (95%), and almost all local chickens in Gubalafto district possess feathered necks. Only a small proportion of local chickens in both districts had naked necks (3.73%). The naked-neck chickens are described by featherless skin on the neck and breast (Islam and Nishibori, 2009). In addition, these chickens are rich in heat tolerance genes that enable them to live and reproduce in tropical areas (Horst, 1989). The feather morphologies of local chickens in both districts are normal (96.53%), but few local chickens in both districts had silky feather morphologies. The current result in plumage color is not in line with Addisu and Aschalew (2014), who reported that white (19.5%), black (11.33%), and black with white stripes (10.17%) and *dira* (red wheaten) were the most predominant color types reported in North Gondar. This might be due to the type of nutrition.

The majority of the local chickens in both districts had snake-head-like or plain head shapes (62.40%), and the white earlobes (95.20%) were the most commonly observed in the local chickens in the study areas. The local chickens in the study areas were also dominantly described by white (47.20%) and yellow (46.40%) shank colors, white skin colors (97.87%), red earlobes (95.20%), and blocky (45.87) and triangular (46.13) body shapes. This result is comparable with the findings of

Mearg *et al.* (2016), who reported that yellow (41.17%), followed by white (19.83%) and black (15.5%) were the dominant shank colors in local chickens in central Tigray. Similarly, Melesse and Negesse (2011) reported that 53% of the chicken populations in southern Ethiopia had yellow shanks. The current results with respect to shank color are consistent with the reports of Faruque *et al.* (2010) and Guni and Katule (2013). It is proved that the shank color is primarily influenced by the level of nutrition and feed resources having carotene (Faruque *et al.,* 2010; Melesse and Negesse, 2011). Most scavenging chickens are dependent on naturally available feed resources, which are mainly composed of kitchen and household wastes with sporadic supplementation of low-quality grains. Single (50.13%), followed by rose (27.47%), and pea (15.73%) were observed to be the common comp types of local chickens in both districts. Similar to the present results, Melesse and Negesse (2011) showed that 55% of the chickens had single combs, followed by rose (28.5%) and pea (15.2%) combs in Southern Ethiopia. Chickens with single and rose combs were also observed to be the most noticeable types of local chicken in the Bure district of the Amhara region of Ethiopia (Moges *et al.,* 2010).

Table 3. Qualitative traits of local chicken in the Habru and Gubalafto districts.

Morphological character	Description	Habru		Gubalafto		Total	
		N = 180	%	N = 195	%	N = 375	%
Feather distribution	Normal/feathered neck	171*	95	190*	97.44	361*	96.27
	Naked neck	9	5	5	2.56	14	3.73
	χ^2	113.5		115		117	
	P-value	0.04		0.03		0.021	
Feather morphology	Normal	174*	97	188*	96.41	362*	96.53
	Silky	6	3	7	3.59	13	3.47
	χ^2	112.75		113		115	
Plumage colors	Complete white	60*	33.33	67*	34.36	127*	33.87
	Complete black	43	23.89	52	26.67	95	25.33
	Complete red	32	17.78	34	17.44	66	17.60
	Gebsima	21	11.67	22	11.28	43	11.47
	Teterima	17	9.44	15	7.69	32	8.53
	Brown	7	3.89	5	2.56	12	3.20
	χ^2	105.65		159.40		223.71	
Shank color	White	83	46.11	94*	48.21	177*	47.20
	Black	10	5.56	14	7.18	24	6.40
	Yellow	87*	48.33	87	44.62	174	46.40
	χ^2	218.58		249.99		345.50	
Skin color	White	174*	97	193*	98.97	367*	97.87
	Yellow	6	3	2	1.03	8	2.13
	χ^2	115.04		174.73		115.25	
Earlobe color	White	6	3.33	8	4.10	14	3.73
	Red	170*	94.44	187*	95.90	357*	95.20
	Yellow	4	2.22	0	0.00	4	1.07
	χ^2	215		221		241	
Comb type	Single combed	92*	51.11	96*	49.23	188*	50.13
	Rose combed	45	25.00	58	29.74	103	27.47
	Pea comb type	31	17.22	28	14.36	59	15.73
	Walnut combed	3	1.67	5	2.56	8	2.13
	Duplex comb type	9	5.00	8	4.10	17	4.53
	χ^2	100.5		145		163.5	
Head shape	Snake-like-head/plain	103*	57.22	131*	67.18	234*	62.40
	Is crest head	22	12.22	13	6.67	35	9.33
	Flat	55	30.56	51	26.15	106	28.27
	χ^2	79.41		71.45		85.04	
Body shape	Blocky shaped	81	45.00	91*	46.67	172	45.87
	Triangular	89*	49.44	84	43.08	173*	46.13
	Wedge-shaped	10	5.56	20	10.26	30	8.00
	χ^2	77.39		82.41		100.9	

*N = Sample size; * p<0.05.*

Effect of the district and sex on quantitative traits: Measuring and documentation of live body weight and other linear body measurements are among the activities to be carried out so as to identify chickens having desirable traits. The effects of district on body weight and shank length were found to be significant, but egg size and body length were not significantly affected by district (Table 4). The least square means of egg weight, body weight, body length, and shank length were 37.53±2.33 g, 0.78±0.10 kg, 18.17±4.12 m, and 6.77±1.75 m, respectively (Table 4). The local chicken reared in Habru districts had a higher body weight and shank length than the Gubalafto. The difference might be due to the breed-specific traits, nutritional status, genotype, and reflected adaptation fitness to their environment (Aberra and Tegene, 2011). However, the sex of the chicken had insignificant effects on all quantitative traits considered in the study. The current average live body weights of local chickens in both districts are comparable to the finding of Tarekegn *et al.* (2015) but lower than the findings of Eskinder (2013), who reported average body weights of 1.29±0.02, 1.69±0.03, and 1.41±0.04 in North Bench, Horro, and Jarso districts, respectively.

Table 4. The effects of sex and district on egg size (gram), body weight (kg), BYL (cm), and SKL (cm) in the local chicken in the study areas.

Effects and levels	EGS			BW	BYL	SKL
	N	LSM	N	LSM	LSM	LSM
Overall	213	37.53±2.33	375	0.78±0.10	18.17±4.12	6.77±1.75
CV	213	6.21	375	13	22.66	25.93
R^2	213	57	375	65	49	52
Sex:						
Male	-	-	102	0.79±0.01^{a}	18.16±0.40^{a}	6.75±0.17^{a}
Female	213	213	273	0.78±0.0^{1a}	18.19±0.25^{a}	6.78±0.11^{a}
District:						
Habru	105	37.82±0.23^{a}	180	0.80±0.01^{a}	18.54±0.3^{3a}	6.97±0.14^{a}
Gubalafto	108	37.24±0.22^{a}	195	0.77±0.01^{b}	17.82±0.31^{a}	6.57±0.13^{b}

Superscripts with different letters in the same column differ significantly at P<0.05; N= Number of chickens; EGS= Egg size; BW= Body weight, BYL= Body length, SKL= Shank length; LSM= Least square means.

Correlations among quantitative traits: The Pearson's correlation coefficient among quantitative variables for all age groups of male and female sample chicken population is presented in Table 5. The result showed that there was a strong positive correlation between body weight and egg size (r= 0.87**, P<0.01), and between body weight and body length (r = 0.93, p<0.01). Body weight was also positively and strongly correlated with shank length (r = 0.88**p<0.05). Emebet *et al.* (2014) reported that there were significant positive correlations among body weight, body length, and shank length. Egg size was positively and significantly (>0.05) correlated with body length (r = 0.79, p<0.01). Also, egg size was positively and significantly correlated with shank length (r = 0.73, P<0.01). In addition to these, body length was positively and strongly correlated and shank length (r =0.96; p<0.01). The positive and significant correlations between body weight, body length, and shank length indicate that selection for any of these linear body parameters will result in a direct improvement in body weight. Furthermore, the significant correlations observed in this study specify that in the absence of some measuring materials or device, measuring one of these easily measurable traits might enhance estimating values of traits that are difficult to measure under field conditions.

Table 5. Pearson's correlation coefficients of quantitative traits of local chicken in Habru and Gubalafto districts.

Measurements	BW	N	BYL	N	SKL	N	EGS	N
BW		375	0.93**	375	0.88**	375	0.87**	213
BYL	0.93**	375		375	0.96**	375	0.79**	213
SKL	0.88**	375	0.96**	375		375	0.73**	213
EGS	0.87**	375	0.79**	375	0.73**	375		213

*N= Number of chickens; *P<0.01; BW= Body weight, BYL= Body length, SKL= Shank length, EGS= Egg size.*

Multiple Linear Regression Analysis

The results of the study indicated that body weight in both male and female chickens was best predicted by including both body length and shank length in the model rather than including each trait separately in the model (Table 6). The prediction efficiency coefficients for the regression of body weight on body length and shank length in males, females and both sexes were 87.20%, 90%, and 86.20%, respectively. The prediction equations for body weight from body length and shank length for both males and females were 0.35±0.03β1+-0.01β2. Hence, improving the body weight of chickens could lead to an increase in meat and egg productivity and production. However, weighing the trait is usually difficult at the farmer level, which is linked to the absence of weighing scales. Thus, easily measurable linear body measurements are more important for chickens' body weight estimation at farmers 'level rather than guessing the body weights of chickens by physical touching. Moreover, the farmers might also try to mislead judgment chicken's body weights by feeding their chickens with supplementary feeds before taking them to the market aiming to increase the body weight tentatively. Hence, the role of prediction equation has great significance in avoiding or minimizing such type of misleadingness.

Table 6. Multiple linear regression analysis of live body weight on different body measurements (body and shank lengths) in local chicken.

Sex of chicken	N	Model	Intercept	β1	β2	R^2
Male	102	BYL+SKL	0.35±0.01	0.03+001	-0.01±0.004	0.872
Female	273	BYL+SKL	0.35+0.02	0.03+003	-0.01+0.01	0.90
Both sexes	375	BYL+SKL	0.35+0.01	0.03+002	-0.01+0.004	0.862

N= Number of chickens; BYL= Body length, SKL= Shank length; β1 and β2 are regression coefficient one and two; R^2*= Cofficient of determination.*

Discriminant Analysis

The performance of a discriminate function can be evaluated by estimating error rates (probabilities of misclassification). The stepwise discriminate function analysis procedure was applied to the data matrix of four quantitative variables and two sampling districts. The overall average error count estimate was 45.76% for all observations (Table 7) from both districts, which means that 54.24% of the samples were correctly classified. Discriminate analysis showed that a relatively large number of Habru chickens (46.11%) were misclassified as Gubalafto chickens. Similarly, considerable number of local chickens (45.41%) in Gubalafto districts were misclassified as Habru local chickens, showing the level of genetic exchange that has taken place between the two chicken ecotypes over time. This might also be explained by the migration of chickens from Gubalafto district to Habru due to market share because Habru is neighboring to Gubalafto district. However, as compared to the current result, a higher correct classification was reported by Fasil *et al.* (2016) for female chicken populations in the Metekel Zone, northwestern Ethiopia, whose overall average error count estimate was 1.59% for all observations.

Table 7. Percent classified into each district (hit rate) for sample population using discriminant analysis.

	Habru	**Gubalafto**	**Total**
From district:			
1	97 (53.89%)	83 (46.11%)	180 (100%)
2	89 (45.41%)	106 (54.36)	195 (100%)
Both	186 (49.47%)	189 (50.4%)	375 (100%)
Rate	0.4611	0.4541	0.4576
Prior	0.5000	0.5000	

1= Habru; 2= Gubalafto.

Conclusion

The analysis of morphological traits showed that local chickens from both Habru and Gubalafto had similar morphological characteristics. The majority of the chickens in both districts are characterized by normal feather distribution and morphologies, complete white and complete black plumage color, white and yellow shank color, white skin color, red earlobes, and blocky and triangular body shapes. There are also a few naked-neck local chickens in both districts. Correlations among body weight, body length, shank length, and egg weight were also positive and significant. The positive and significant correlations between body weight, body length, and shank length indicate that selection for any of these linear body parameters will cause a direct relation in body weight. The results of the study indicated that the body weights of both male and female chicken populations were best predicted by including both body length and shank length in the model. Significant non-genetic factors should be considered as part of poultry husbandry management. Further research focusing on genetic and performance evaluations of the local chickens should be considered.

Acknowledgments

The authors are grateful to express their appreciation to the Department of Animal Sciences and School of Graduate Studies of Woldia University for facilitating the work. We also appreciate Habru and Gubalafto *Woreda* Administration Office and Livestock Development, Health, and Marketing Agency staff members for providing the necessary baseline data and transportation service during data collection. Moreover, we appreciate and acknowledge the farmers and development agents who participated in the survey.

Conflict of Interests

The authors declare that they have no competing interests.

References

Addisu, G. & Aschalew, T. (2014). A phenotypic and genetic characterized indigenous chicken ecotypes in Ethiopia. *International Journal of Genetics*, 4 (1): 04-10.

Cochran, W. G. (1977). Sampling techniques, 2nd ed., John Wiley and Sons, Inc., New York.

CSA (Central Statistical Agency) (2021). Federal Democratic Republic of Ethiopia. Agricultural Sample Survey. Volume II: Report on Livestock and Livestock Characteristics. Private Peasant Holdings. *Statistical Bulletin* 589, Addis Ababa, Ethiopia.

Emebet, M., Singh, H., Sisaye, T. & Johansson, A. M. (2014). Phenotypic characterization of indigenous chicken population in southwest and south part of Ethiopia. *British Journal of Poultry Science*, 3 (1):15-19.

Eskinder, A. (2013). On-farm phenotypic characterization of the indigenous chicken and chicken production systems in Horro and Jarso districts, Oromia Regional State, MSc Thesis, Department of Animal and Range Science, Haramaya University, Ethiopia.

FAO (Food and Agricultural Organization) (2011). Draft guidelines on the phenotypic characterization of animal genetic resources. Commission on Genetic Resources for Food and Agriculture Organization thirteenth regular session, Rome, Italy. p: 59.

Faruque, S., Siddiquee, N. U., Afroz, M. A. & Islam, M. S. C. (2010). Phenotypic characterization of native chicken reared under an intensive management system. *Journal Bangladesh Agriculture University,* 8 (1): 79-82.

Fasil, G., Solomon, A., Abraham, A., Manaye, M. & Yibrehu, E. Abebe, H., *et al.* (2016). Multivariate analyses of morphological traits in indigenous chicken populations of the Metekel Zone, northwestern Ethiopia. *Animal Genetic Resources*, 59: 15-25.

GARDO (Gubalafto District Agriculture and Rural Development Office) (2010). Socio-economic survey report of Gubalafto. Gubalafto, Ethiopia. (Unpublished government report).

Guni, F. S. & Katule, A. M. (2013). Characterization of local chickens in selected districts of the southern highlands of Tanzania: I. Qualitative characters. *Livestock Research Rural Development*, 25. *Retrieved from*: http://www.lrrd.org/lrrd25/9/guni25153.htm.

Halima, H. (2007). Phenotypic and genetic characterization of indigenous chicken populations in northwest Ethiopia, PhD Thesis, University of the Free State, Bloemfontein, South Africa.

Halima, H., Neser, F. W. C., van Marle-Koster, E. & De Kock, A. (2007). Phenotypic variation of native chicken populations in northwest Ethiopia. *Tropical Animal Health and Production*, 39 (7): 507-513.

HARDO (Habru District Agriculture and Rural Development Office) (2010). Socio-economic survey report of Habru. Habru, Ethiopia. (Unpublished government report).

Horst, P. (1989). Native fowl as a reservoir for genomes and major genes with direct and indirect effects on the adaptability and their potential for tropically orientated breeding plans. *Archive for Development*, 53 (3): 93-101.

ILCA (International Livestock Centre for Africa) (1983). ILCA's strategy and long-term plan, ILCA, Addis Ababa, Ethiopia. p: 99.

Islam, M. A. & Nishibori, M. (2009). Indigenous naked neck chicken: A valuable genetic resource for Bangladesh. *World's Poultry Science Journal*, 65: 125-138.

Kejela, Y., Banerjee, S. & Taye, M. (2019). Some internal and external egg quality characteristics of local and exotic chickens reared in Yirgalem and Hawassa towns, Ethiopia. *International Journal of Livestock Production*, 10 (5):135-142.

Lelisa, D. (2021). Impacts of introducing exotic chicken breeds and their crosses on local chickens in Ethiopia. *Poultry, Fisheries and Wildlife Sciences,* 9: p011.

Mearg, F. (2016). Phenotypic characterization of local chicken ecotypes in the Central Zone of Tigray in northern Ethiopia, MSc Thesis, Jimma University, Ethiopia.

Melesse, A. & Negesse, T. (2011). Phenotypic and morphological characterization of indigenous chicken populations in the southern region of Ethiopia. *Animal Genetic Resources*, 49:19-31.

Mengesha, Y., Kebede, E. & Getachew, A. (2022). Review of chicken productive and reproductive performance and its challenges in Ethiopia. *All Life* 15 (1): 118–125. https://doi.org/10.1080/26895293.2021.2024894.

Milkias, M., Molla, M. & Tilahun, S. (2019). Productive and reproductive performance of indigenous chickens in Gena Bossa district of Dawro Zone, Ethiopia. *International Journal of Livestock Production*, 10 (1): 24-32.

MoA (Ministry of Agriculture) (1998). Agro-ecological zones of Ethiopia. Addis Ababa, Ethiopia.

Moges, F., Abera, M. & Tadelle, D. (2010). Assessment of the village chicken production system and evaluation of the productive and reproductive performance of the local chicken ecotype in Bure district, northwest Ethiopia. *African Journal of Agricultural Research*, 5 (13): 1739-1748.

Natnael, T. (2015). Pathological and seroprevalence studies on infectious bursal disease in chickens in and around Bahir Dar, northwest Ethiopia, MSc Thesis, Addis Ababa University, Ethiopia.

Nebiyu, Y., Berhan, T. & Kelay, B. (2013). Characterization of village chicken production performance under a scavenging system in the Halaba district of southern Ethiopia. *Ethiopian Veterinary Journal*, 17 (1): 69-80.

NWZOLFR (North Wollo Zone Office of Livestock and Fishery Resources) (2022). Annual report. Woldia, Ethiopia. (Unpublished government report).

SARC (Sirinka Agricultural Research Centre) (2010). Socio-economic survey report of North Wollo. Sirinka, Ethiopia. (Unpublished government report).

SAS (Statistical Analysis Systems) (2013). Statistical analysis systems user's guide (9.40 Version), SAS Institute Inc. Cary, North Carolina, USA.

Shambel, T. F. (2022). Review on potential and impact of chicken crossbreeding in developing countries. *World Scientific News,* 166: 28–42.

Solomon, D. (2007). Suitability of hay-box brooding technology to rural household poultry production systems. Jimma University College of Agriculture and Veterinary Medicine, Jimma, Ethiopia. *Livestock Research for Rural Development*, 19. *Retrieved from*: http://www.lrrd.org/lrrd19/1/deme19003.htm.

Tarekegn, G., Ewonetu, K., Negassi, A. & Aemro, T. (2015). Village chicken husbandry practice, marketing, and constraints in eastern Ethiopia. *Journal of World's Poultry Resource*, 5: 104-108.

Tassew Mohammed (2023). A conceptual review of cock exchange and culling programs: implications for the genetic improvement of the local chicken gene pool. *World's Poultry Science Journal*, 79 (4): 835–849. https://doi.org/10.1080/00439339.2023.2234346.

Yamane, M. (1967). Elementary sampling theory, Printice-Hall Inc, Englewood Cliffs, New Jersey, USA.