Ecology and Evolutionary Biology
2024, Vol. 9, No. 2, pp. 37-60
https://doi.org/10.11648/j.eeb.20240902.12

Research Article

On-Farm Phenotypic Characterization of Indigenous Chicken Ecotypes in the Western Tigray Region of Northern Ethiopia

Shishay Markos[1, *], Berhanu Belay[2], Tadelle Dessie[3]

[1]Humera Begait Research Center of Tigray Agricultural Research Institute, Mekelle, Ethiopia
[2]College of Agriculture and Veterinary Medicine, Jimma University, Jimma, Ethiopia
[3]International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia

Abstract

The study was conducted to characterize morphometric traits of indigenous chickens and determine the relationships among the traits in three agro-climatic regions of western zone of Tigray regional state of Ethiopia. Twenty- one morphometric traits from 770 local chickens (412 hens, 358 cocks) were measured and analyzed using the PROC GLM of SAS 2008. Tukey mean comparison was used to analyze significantly different traits. Correlation analysis was used to determine the relationships among the traits. Significant variations were found in most traits among ecotypes, with males showing higher values in many traits. *Kolla* chickens generally exhibited higher values, except for neck length, skull length, and wattle, earlobe, comb, and beak indices. Interactions between sex and ecotypes significantly affected the morphometric traits. The strength and direction of significant correlations among the quantitative traits varied across the chicken ecotypes and sexes. The variation in morphometric measurements among the chicken ecotypes is an indicator of genetic diversity in the study area, calling for a community-centered holistic genetic enhancement program.

Keywords

Quantitative Trait, Chicken Ecotypes, *Kolla*, *Weynadega*, *Dega*

1. Introduction

The domestic chicken is the most populous livestock species globally, estimated at 19 billion, averaging three per person [1]. Poultry accounts for approximately 34.6% of the world's livestock meat, while chickens accounts for 88% of poultry meat and 30.1% of all animal meat [2]. Backyard chickens play an important role in reducing poverty and increasing household food security in many developing countries [3]. Approximately 1.5 billion chickens are raised in Africa, 80% of which are local chickens (in rural and urban areas), managed using traditional low-income systems [4, 5].

Indigenou chickens play important roles in the food security and economic sustainability for rural households [6-8]. They act as valuable resources and help fight poverty

*Corresponding author: shishaymarkos@gmail.com (Shishay Markos)

Received: 21 March 2024; **Accepted:** 16 April 2024; **Published:** 23 July 2024

Copyright: © The Author(s), 2024. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

and promote gender equality, especially among disadvantaged groups. The village chickens have significant impact on developing countries' economy and small-scale farmers due to its low production costs [9]. They also act as a transitional bridge to larger livestock production [10] and can serve as a means of protecting and securing households [11].

Indigenous chickens exhibit scavenging and nesting behaviors, along with excellent mothering abilities. Their resilience to diseases and parasites under scavenging conditions makes them preferred over exotic breeds by farmers [12]. Despite their qualities, indigenous chicken breeds face threats from changing production systems and indiscriminate crossbreeding practices [11].

The poultry population in Ethiopia was recently estimated at 57million, comprising 78.85% indigenous chicken, 12.02% hybrid chicken, and 9.11% exotic breeds [13]. Approximately 97.3% of indigenous chickens are distributed across various agro-ecological zones, showcasing their adaptability and disease tolerance [11, 14]. The national chicken egg production is about 368.8 million, comprising 33.52% from local, 57.1% from hybrid and 9.38% from exotic chickens [13]. However, their productivity does not align with their numbers, hindering their potential contribution to livelihood and national development due to breeding constraints.

Since the early 1990s, efforts have been made to improve the performance of indigenous chickens in Ethiopia through the introduction of exotic breeds [15]. However, the indiscriminate introduction of exotic genetic resources without proper characterization has led to the loss of indigenous chicken genetic diversity [11].

Characterization of indigenous chickens is crucial for designing breeding programs and exploring variability. This process provides the foundation for genetic improvement, livestock development interventions, and breeding strategies to enhance productivity [16]. Phenotypic characterization based on a large sample size provides a reliable representation of genetic performance [17].

Breeding and selection trait preferences studies have been conducted with Ethiopian local chickens to design breeding schemes [18, 19]. Morphological and morphometric characterizations of local chicken populations have also been carried out in Ethiopia [20, 21]. Studies on molecular and phenotypic parameters regarding body weight and egg production in Horro chickens have been conducted as well [22]. However, there is a need for phenotypic characterization of local chicken ecotypes based on morphometric traits in the western region of Tigray. This study aims to fill the gaps in the characterization of local chicken ecotypes in the region.

2. Materials and Methods

2.1. Description of Study Area

This research was carried out in three agro-climatic zones – *Kolla*, *Weynadega*, and *Dega* – across Kafta Humera, Welkait, and Tsegede districts in the Western Tigray of Northern Ethiopia (Figure 1) These areas represent three local chicken types: *Kolla*, *Weynadega*, and *Dega* ecotypes. *Kolla* chickens are raised in areas below 1500 meters above sea level, *Weynadega* chickens between 1500-2500 meters, and *Dega* chickens above 2500 meters. The study site is located 580-750 kilometers from Mekelle, the capital of Tigray, with coordinates ranging from 13°42′ to 14°28′ north latitude and 36°23′ to 37°31′ east longitude [23]. The zone receives annual rainfall between 600mm to 1800mm and temperatures from 10 ℃ to 45 ℃. It spans 1.5 million hectares with altitudes ranging from 500-3008 masl.

2.2. Sampling Methods

A stratified sampling approach was utilized to classify *kebeles* (smallest administrative unit in Ethiopia) in three rural districts as *Kolla* (500-1500masl), *Weynadega* (1500-2500masl), and *Dega* (>2500masl) [24]. A multi-stage sampling method was then employed to select sample *kebeles* and chicken producers (farmers). Nine *kebeles* were purposefully chosen based on factors like poultry population, production potential, and accessibility, with four from *Kolla*, three from *Weynadega*, and two from *Dega* areas. Prior to the main survey, a cross-sectional study confirmed the distribution and population of local chicken ecotypes. A total of 770 chickens aged six months or older were selected using purposive random sampling – 310 from *Kolla*, 260 from *Weynadega*, and 200 from *Dega* areas, proportionate to their respective populations.

Sample size determination: The total number of households needed for the study was calculated using the formula outlined by Cochran [25].

$$N_o = [Z^2 pq] / e^2$$

Where $N_{o=}$ required sample size

Z^2 =is the abscissa of the normal curve that cuts off an area at the tails (1-α)

(95%=1.96)

e = is the margin of error (eg. ±0.05% margin of error for confidence level of 95%)

p = is the degree of variability in the attributes being measured refers to the distribution of attributes in the population

q= 1-p.

N_o= [(1.96)^2 x (0.5x0.5)] / (0.05x0.05) =0.9604/0.0025= 385 farmers were included in the study.

Proportionate Sampling Technique:

$$W= [A/B] \times N_o$$

Where:

W, Number of chicken required per single agro climate

A, Total number of chickens of a single selected agro climate

B, Total sum of chickens in all selected sample agro climates and

N_o, The total required calculated sample size

2.3. Data Collection

Measurement of Quantitative Morphological Traits:

A total of 770 indigenous chickens (412 females and 358 males) of both sexes: 310 chickens (146 male and 164 female) from *Kolla*, 260 chickens (120 male and 140female) from *Weynadega* and 200 chickens (92 male and 108 female) from *Dega* chicken ecotypes, managed under traditional scavenging system, were selected by purposive random for this study. The chicken used were approximately six months or older in age as per information provided by the owners, and also verified by the researchers using wing plumage. Twenty- one traits (body weight, body length, Skull length and width, comb length and width, beak length and width, earlobes length and width, wattles length and width, neck length, wingspan, skull index, comb index, earlobes index & wattle index) were measured based on the methodology developed by FAO [16] & Francesch *et al*. [26].

A measuring tape (±1 mm) was used to measure wingspan, neck length, body length and shank length, and a balance with an electronic weighing scale (precision =1 gram) was used to measure the live body weight of the chickens. Comb length, comb width, earlobe length, earlobe width, wattle length, wattle width, skull length, skull width, beak length, beak width and spur length of the chickens were measured using a caliper (±0.01 mm). All measurements were made by the one person early in the morning before the chickens were fed. Five body indices were determined according to the method developed by Francesch *et al*. [26] (Figure 2). They show the relationship between the length and the width of the character/ trait.

$$\text{Skull index} = \frac{\text{Skull length}}{\text{Skull width}} \quad \text{Comb index} = \frac{\text{Comb length}}{\text{Comb width}} -$$

$$\text{Earlobe index} = \frac{\text{Earlobe length}}{\text{Earlobe width}} \quad \text{Wattle index} = \frac{\text{Wattle length}}{\text{Wattle width}}$$

$$\text{Beak index} = \frac{\text{Beak length}}{\text{Beak width}}$$

2.4. Statistical Model and Data Analyses

SAS software version 9.2 [27] was used for all statistical analysis of quantitative traits of the chickens.

Data analysis: Quantitative traits were subjected to analysis of variance using the general linear model procedure (PROC GLM) to determine the effects of chicken sex and agro-climate (chicken ecotypes). Significant means were separated using Tukey test.

$$Y_{ijkl} = \mu + A_i + B_j + AB_k + E_{ijkl}$$

Where Y_{ijkl}: The corresponding quantitative trait of local chicken in i^{th} agro-climate (i=3, *Kolla*, *Weynadega* & *dega*) and

μ: Overall population mean for corresponding quantitative trait

A_i: Fixed effect of i^{th} agro-climate /chicken ecotype/

B_j: Fixed effect of j^{th} chicken sex (j=2, male and female) and

AB_k: Chicken ecotype by chicken sex interaction effect and

E_{ijkl}: residual error

3. Results and Discussion

3.1. Quantitative Traits of Local Chicken Ecotypes

The average least square means ± se for local chicken ecotypes' quantitative traits across different agro-climates are shown in Table 1.

Effect of agro-climate/chicken ecotypes/ on quantitative traits: Significant differences (P<0.05) were observed among the three chicken ecotypes in all quantitative traits examined except skull width (Table 1). The highest values for body length, body weight, shank length, comb length, beak length, and wing span were recorded in *Kolla* chicken ecotypes, followed by *Weynadega*, while the lowest values were found in *Dega* chickens. Similarly, the maximum values of comb width, earlobe length, wattle length, wattle width, beak width, and spur length were found in *Kolla* chicken ecotypes, followed by *Dega* chicken ecotypes, while the lowest values were recorded in *Weynadega* chicken ecotypes. In addition, the highest values of comb and earlobe indices were found in the *Weynadega* chicken ecotypes, followed by the *Kolla* chicken ecotypes, while the lowest values were found in the *Dega* chicken ecotypes. The average values of wattle index and neck length of *Weynadega* chicken ecotypes were significantly higher than those in *Kolla* and *dega*, which were not significantly different. The mean earlobe width value of *Kolla* and *Dega* ecotypes was not significantly different but was higher than that of *Weynadega* chickens. The mean values of skull index and skull length of *Weynadega* and *Dega* chicken ecotypes were not significantly different, but were higher than those of *Kolla* chicken ecotypes.

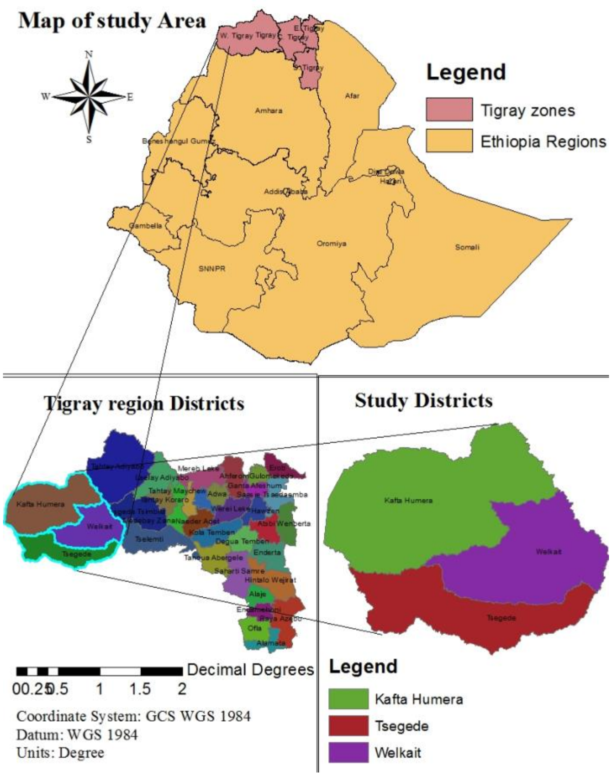

***Figure 1**. Geographical Map of the Study Areas.*

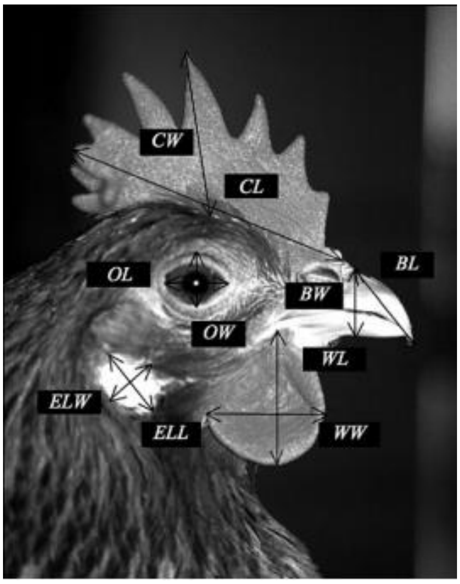

***Figure 2**. Measurement of head characteristics [26].*

Remark: CL=Comb length and CW=Comb width
WL=Wattle length and WW=Wattle width
ELL=Earlobe length and ELW= Earlobe width
BL=Beak length and BW=Beak Width

***Table 1**. Effect of Agro-climate on quantitative traits of local chicken ecotypes under scavenging production system of western zone of Tigray (Lsmeans ±SEM).*

Traits	**Agro-climatic zones**			
	Kolla **(N = 310)**	***Weynadega*** **(N = 260)**	***Dega*** **(N = 200)**	**CV**
Body length (cm)	31.88 ±0.06^{a}	30.50 ±0.07 ^{b}	28.16 ± 0.08 ^{c}	3.72
Body weight (kg)	1.474 ±0.004^{a}	1.425 ± 0.005^{b}	1.346 ±0.005^{c}	5.34
Shank length (cm)	10.37 ±0.03^{a}	9.55 ± 0.04^{b}	9.07 ±0.04^{c}	6.24
Comb length (cm)	5.11 ± 0.026^{a}	4.46 ± 0.029^{b}	4.13 ± 0.033^{c}	10.1
Comb width (cm)	2.64 ± 0.01^{a}	2.13 ± 0.01^{c}	2.28 ± 0.02^{b}	9.47
Comb index	1.93 ± 0.01^{b}	2.07 ±0.02^{a}	1.84 ± 0.02^{c}	13.22
Earlobe length (cm)	2.59 ±0.01^{a}	1.90 ±0.01^{c}	2.47 ± 0.01^{b}	7.85
Earlobe width (cm)	1.55 ± 0.01 ^{a}	1.01 ± 0.01 ^{b}	1.55 ±0.01 ^{a}	13.92
Earlobe index	1.74 ± 0.02 ^{b}	1.90 ±0.02^{a}	1.61 ±0.02^{c}	15.65
Wattle length (cm)	4.16 ± 0.03 ^{a}	3.24 ±0.04 ^{c}	3.69 ± 0.04^{b}	16.83
Wattle width (cm)	2.66 ±0.03 ^{a}	1.92 ±0.03 ^{c}	2.38 ± 0.03^{b}	21.69
Wattle index	1.61 ±0.02^{b}	1.86 ± 0.02^{a}	1.59 ± 0.02^{b}	20.82
Skull length (cm)	6.20 ±0.05^{b}	6.66 ± 0.05 ^{a}	6.51 ± 0.06 ^{a}	12.91
Skull width (cm)	3.79 ± 0.04^{a}	3.85 ± 0.04^{a}	3.73 ±0.04^{a}	16.57
Skull index	1.70 ± 0.01^{b}	1.77 ± 0.02 ^{a}	1.77 ± 0.02 ^{a}	14.54

Traits	Agro-climatic zones			
	Kolla **(N = 310)**	***Weynadega*** **(N = 260)**	***Dega*****(N = 200)**	**CV**
Neck length (cm)	14.71 ± 0.05^{b}	16.27 ± 0.06^{a}	12.93 ± 0.06^{b}	6.30
Beak length (cm)	2.13 ± 0.01^{a}	2.07 ± 0.01^{b}	2.02 ± 0.01^{c}	9.29
Beak width (cm)	1.16 ± 0.01^{a}	0.95 ± 0.01^{c}	1.04 ± 0.01^{b}	16.98
Beak index	1.88 ± 0.02^{c}	2.26 ± 0.02^{a}	1.97 ± 0.03^{b}	17.81
Spur length (cm)	1.43 ± 0.01^{a}	0.93 ± 0.01^{c}	1.14 ± 0.01^{b}	13.48
Wing span (cm)	41.79 ±0.10a	37.20 ± 0.10b	34.81 ±0.12c	4.31

LS-means with the different letter in the same row are significantly different ($p<0.05$).
N = number of sampled matured local chickens per agro-climate

The body weight estimates from the current study was corroborated the live body weights of indigenous chickens ranging 6 -10 months age in Lake Victoria basin of Uganda [28] but lower than the values reported from local chickens of three districts of southern highlands of Tanzania [29]. The average body length obtained in this study was higher than the body lengths of indigenous chickens ranging 6 -10 months age in Lake Victoria basin of Uganda [28] and lower than values reported for local chickens of three districts of southern highlands of Tanzania [29]. Similarly, the average shank length obtained in the current study was higher than values reported for indigenous chickens ranging 6 -10 months age in Lake Victoria basin of Uganda [28] and local chickens of three districts of southern highlands of Tanzania [29]. The average values of wing span obtained in this study was lower than the values reported for local chickens of three districts of southern highlands of Tanzania [29], Northwest Algeria [30] Spain chicken breeds (Penedesenca and Empordanesa) [26]. The significant variations in the quantitative traits among the three local chickens (*Kolla*, *Weynadega* & *Dega*) is a strong indication that there is a high degree of genetic variation among the three local chicken ecotypes that contributes significantly to genetic improvements of the indigenous chicken ecotypes through appropriate genetic improvement methods. The phenotypic differences in the examined traits are indicative of genetic differences existed in these traits amongst the three chickens. This is due to differences in agro ecological variables/elements/ (altitude, rainfall, temperature, humidity, production systems, etc.) that create different production environments in agro-ecological units. This will allow development of new breeds/strains with different performance levels from different or related populations of the same species through natural selection over time. This is because the sub populations of the species separated from each other by physical barriers (river, mountain, lake, sea, etc.) and allowing each species to adapt to a different environment with different selection pressures and to reveal their differences Their differences will gradually increase and becomes more diverse over time so that subpopulations do not mix again (so they remain isolated over time). They eventually become different breeds/strains of the species. The variability observed in this cross-sectional study can be used in designing community-centered genetic improvement in case of livestock record shortage in the backyard poultry production system.

Effect of sex on quantitative traits: Significant variations were observed between male and female chickens in body weight and all studied quantitative traits except earlobe index (table 2). Significantly higher mean values of body weight and all considered body measurements and one corporal index (comb index) in male than female chickens while the average values of the remaining three corporal indices (wattle, skull and Beak) were significantly higher in female than male chickens. The significant sex differences in body weight and body measurements are in consistent with reports from Northwest Algeria [30] and Nigeria [31] and Lake Victoria basin of Uganda [28]. That can be explained due to Sexual dimorphism [28] which are attributable to differential effects of growth hormones (Androgen & estrogen) [32] in addition to other factors.

Sex by agro-climate interaction effect on quantitative traits: Sex by chicken ecotype (agro-climate) interaction had significant effect on all considered morphometric traits (Table 2). Significantly higher mean values of body weight, body length, shank length, comb length, beak length, wing span, comb width, earlobe length, earlobe width, spur length, wattle length, wattle width and beak width were obtained from *Kolla* male chickens than the rest two male chicken ecotype whereas the mean values of neck length, skull length, comb index, earlobe index and beak index of *Weynadega* male chickens were significantly higher than *Kolla* and *Dega* male chicken ecotypes. The average values of skull width of both *Kolla* and *Weynadega* male chicken ecotypes were significantly higher than *Dega* male chicken ecotypes, which were not significantly different. No significance variations were observed among the three male local chicken ecotypes in wattle and skull indices.

The current results on body length of male chickens were Comparable with those reported from Nigerian male chickens [33] and indigenous male chickens of Bale zone Oromia regional state of Ethiopia [21] but higher than reports from male chickens of six agro-ecological zones of Oman [34], Nigerian male indigenous chickens [32] and Northwest Algeria [30]; and lower than reports of Tanzanian indigenous male Chickens [35]. The mean body weight of male chickens in the present study was in agreement with the values reported from local cock in three districts (Quara, Alefa & Tache Armacheho) of North Gondar [36] and Centeral highlands of Ethiopia [37] but higher than values reported from Nigerian local male chickens [32, 33] and six agro-ecological zones of Oman [34]; and lower than the body weights of male chickens reported from Tanzanian indigenous male Chickens [35] and North West Algeria [30].

The shank length of male chickens in the current study were corroborated those reported from indigenous cocks of Bale zone of Oromia regional state of Ethiopia [21] and guinea fowl cocks of northern Ghana [38] but higher than values reported from three districts of North Gondar [35], Nigerian local male chickens [32, 33], six agro-ecological zones of Oman [34], Tanzanian indigenous male chickens [35] and intensively managed Nigerian indigenous and exotic male chickens [39]. The average wing span of local cocks in the present study corroborated those reported from Northwest Algeria [30] and three districts of North Gonder [36] but were lower than those reported from local cocks of Bale zone of Oromia region of Tigray [21], Tanzanian Indigenous male Chickens by Guni and Katule [35], Penedesenca and Empordanesa chicken breeds of Spain by Francesch *et al*. [26], indigenous and guinea fowl males of Tamale zone of Ghana [38] and intensively managed Nigerian indigenous and exotic cocks [39]. The spur length of local cocks in this study greater than values reported from local male chickens of North Gonder [36].

Significant variations were observed among the three local male chicken ecotypes in all considered head morphometric traits (Table 2). The comb length, Skull length, beak length, comb width, Skull width and beak width of the present local cocks were similar to those reported for Penedesenca and Empordanesa chicken breeds of Spain [26]. Addis *et al*. [36] also reported similar beak lengths but lower comb lengths, comb width, wattle length and wattle widths of local cocks in three districts (Quara, Alefa & Tache Armacheho) of North Gonder. Similar beak lengths but lower neck and comb lengths were reported for Nigerian indigenous male chickens [32, 33]. Though both comb and beak lengths of local cocks in this study were comparable to those of local cocks in the Bale zone of Oromia, the present local cocks had higher wattle length than those Ethiopian chickens [21]. The current local cocks had also longer wattle length but shorter beak length than local cocks from Northwest Algeria [30].

Significant variations were observed among the three female chicken ecotypes in all studied morphometric traits of body except spur length. Female lowland chickens had significantly (P<0.05) longer body length; shank length and wing span than the rest two female chicken ecotypes. The average values of comb length, comb index, wattle width and beak width of both female lowland and highland chicken ecotypes were significantly higher than the values of female midland chickens, which were not significantly different. Mean values of body weight and earlobe index of both female lowland and midland chickens were not significantly different but were significantly higher than the values of female highland chicken ecotypes. Both female lowland and highland chickens had similar values of both wattle and beak indices but were significantly lower than the values of female midland chicken ecotypes. Skull length values of both female midland and highland chickens were similar but significantly higher than values of female lowland chickens. However, mean values of comb width, wattle length, skull width, skull index, neck length, beak length and spur length were similar among the three female chicken ecotypes.

The overall body lengths of the local hens in the present study were slightly similar to those reported from local hens of Nigeria [32] and Northwest Algeria [30] but were much lower than those reported from local hens of three districts of north Gonder [36], Bale zone of Oromia [21], Southern highlands of Tanzania [35], Denkia local government areas of Kogistate of Nigeria [33] and local and guinea fowl hens of Tamale zone of Ghana [38]; and higher than those reported from local hens of six agro-ecological zones of Oman [34]. The overall shank lengths of the current local hens were almost similar with values reported from local hens of Bale zone of Oromia [21] and guinea fowl hens of Tamale zone of northern Ghana [38] but were higher than values of previous studies [32-36, 40], and lower than those reported from local hens of Tamale zone of northern Ghana [38]. The current local hens had similar body weights with the guinea fowl hens of Tamale zone of northern Ghana [38] but heavier than local hens of Bale zone of Oromia [21], Nigeria [32, 33, 41]; six agro-ecological zones of Oman [34] and Tamale zone of northern Ghana [38]; and lighter than local hens of Tanzania [35], North Gonder [36] and Northwest Algeria [30]. The overall wing span of local hens in the present study were slightly similar to those reported from local hens of North Gonder [36] but shorter than those reported from local hens of southern highlands of Tanzania [35], Bale zone of Oromia [21], Northwest Algeria [30] and local and guinea fowl hens of Tamale zone of Ghana [38]. The average spur lengths of the local hens (0.40±0.01cm) in the current study were longer than the values of North Gonder local hens (0.18cm) [36].

Significant differences were observed among the three female chicken ecotypes in all considered quantitative traits of head except comb width, wattle length, skull width, skull index, neck length and beak length. The current results on Comb lengths of local hens were similar to those reported from local hens of North Gonder [36] and Bale zone of Oromia [21] but longer than those reported from local hens of

Nigeria [33] and Northwest Algeria [30]. The present local hens had slightly similar wattle lengths to those of Northwest Algeria local hens [30] but higher than those reported from local hens of Bale zone of Oromia regional state of Ethiopia [21] and North Gonder of Ethiopia [36]. Wattle widths of the current local hens had higher than those values reported from local hens of North Gonder [36]. The beak lengths of the local hens in the current study were similar to those reported from local hens of bale zone of Oromia [21] but longer than values reported from local hens of Nigeria [32, 33]; and shorter than those reported from local hens of Northwest Algeria [30]. The current local hens had longer necks than the local hens of Nigeria [32]. The variability of measurements of the present chicken from their counter parts in other localities might be attributed to a wider variation in the genetic resources of the chicken as well as differential response to different environmental conditions.

3.2. Phenotypic Correlations Between Quantitative Traits of Three Male Local Chicken Ecotypes

Body weight was positively and significantly ($P< 0.05$) correlated with body length in *Kolla* and *Weynadega* male chickens but not in *Dega* male chicken ecotypes. Body weight was also strongly and positively correlated with shank length, comb length, comb width, earlobe length, earlobe width, wattle length, wattle width, skull length, skull width, beak index, spur length and wing span but weakly and positively correlated with beak length; and weakly and negatively correlated with neck length and beak width in *Kolla* male chicken (Table 3). The correlations between body weight with the comb, earlobe, wattle and skull indices were not significant in *Kolla* male chicken. In *Weynadega* male chicken ecotype, body weight was positively correlated with shank length, earlobe length, wattle length, skull length, skull width, spur length and wingspan but not significantly correlated with the rest studied quantitative traits (Table 3). Similarly, body length was positively correlated with comb length, comb width, earlobe width, wattle length and wattle width but not significantly correlated with the remaining studied quantitative traits in *Dega* male chicken ecotype (Table 3). This result is in agreement with the previous findings that indicated significant and strong positive correlation between body weight and shank length and between body weight and wingspan in local male chickens of Lake Victoria basin of Uganda [28]; and between body weight and shank length in the Thai native black-bone indigenous chickens [42]. Strong and positive correlations between body weight and body length; body weight and shank length; body weight and wing span; body weight and comb length and body weight and beak length were also reported for local cocks of Bale zone of Oromia regional state of Ethiopia [21]. Daikwo *et al*. [33] also reported that body weight was strongly and positively correlated with body length, shank length and comb length but not significantly correlated with beak length in the Local chickens in Dekina. Similarly, significant strong and positive correlations between body weight and body length, body weight and wing span, and body weight and shank length were reported in local chickens of southern highlands of Tanzania [29] and intensively managed Nigerian local and exotic chickens [39].

Body length was positively correlated with shank length, comb length, comb width, earlobe width, skull length, skull width, neck length; spur length and wing span but not significantly correlated with the remaining considered quantitative traits in *Kolla* male (Table 3). Moreover, body length was only positively and significantly correlated with skull length, skull width), neck length, shank length and wingspan in midland male chicken ecotype (Table 3). Body length was strongly, positively and significantly correlated with shank length, comb width, earlobe length, skull length, skull width, spur length and wing span; and weakly and positively correlated with comb length, comb index, earlobe length, earlobe index, wattle length, skull index and neck length but not significantly correlated with the remaining studied traits in *Dega* male chicken (Table 3). This result corroborated the previous reports that showed significant positive correlations between body length and shank length in Thai native black – bone indigenous chickens [42] and in Sasso, Kuroiler and Nigerian Fulani chickens [40]. Significant strong and positive correlations between body length and shank length, and body length and wing span were reported in local cocks of bale zone of Oromia regional state of Ethiopia [21], local chickens of southern highlands of Tanzania [35] and intensively managed Nigerian local and exotic chickens [39]. Daikwo *et al*. [33] also reported that body length was positively and significantly correlated with shank length, comb length and beak length in the Local chickens in Dekina.

Table 2. *Least square means for quantitative traits of local chicken ecotypes in three agro-climate zones of western zone of Tigray (Lsmeans ±SEM).*

Traits	**Agro-climatic zones**						
	Sex of chicken	***Kolla* (N = 310)**	***Weynadega* (N = 260)**	***Dega* (N = 200)**	**Total**	**Overall (N = 770)**	**CV**
Body length (cm)	Male	39.53 ±0.09^{a}	36.08 ±0.10^{b}	32.50±0.12^{c}	36.04±0.06 ^{a}	30.18±0.04	3.72

Traits	Agro-climatic zones						
	Sex of chicken	*Kolla* (N = 310)	*Weynadega* (N = 260)	*Dega* (N = 200)	Total	Overall (N = 770)	CV
	Female	24.23 ±0.09^{e}	24.92 ±0.09^{d}	23.82 ±0.11 ^{f}	24.32 ±0.06 ^{b}		
Body wt(gm)	Male	1.676 ±0.01^{a}	1.579 ±0.01^{b}	1.451 ±0.01^{c}	1.569 ±0.004^{a}	1.415 ±0.003	5.34
	Female	1.272 ±0.01^{d}	1.270 ±0.01^{d}	1.192 ±0.01^{e}	1.261 ±0.004^{b}		
Shank length (cm)	Male	12.93 ±0.05^{a}	10.81 ±0.06^{b}	9.87 ±0.06^{c}	11.20 ± 0.03^{a}	9.83 ±0.023	6.24
	Female	8.81 ±0.05^{c}	8.29 ±0.05^{e}	8.27 ±0.06^{e}	8.46 ± 0.03^{b}		
Comb length (cm)	Male	7.50 ±0.04^{a}	6.68 ±0.04^{b}	5.49 ±0.05^{c}	6.55 ±0.02^{a}	4.62 ±0.02	10.1
	Female	2.73 ±0.03^{d}	2.57 ±0.04^{e}	2.78 ±0.04^{d}	2.69 ± 0.02^{b}		
Comb width(cm)	Male	3.81 ±0.02^{a}	2.75 ±0.02^{c}	3.09 ±0.02^{b}	3.22 ±0.01^{a}	2.35 ±0.01	9.47
	Female	1.47 ±0.02^{d}	1.51 ±0.02^{d}	1.47 ±0.02^{d}	1.48 ±0.01^{b}		
Comb index	Male	1.98 ±0.02^{b}	2.44 ±0.02^{a}	1.78 ±0.03^{de}	2.07 ± 0.01^{a}	1.95 ±0.01	13.22
	Female	1.87 ±0.02^{cd}	1.71 ±0.02^{e}	1.89 ±0.02^{bc}	1.83 ±0.01^{b}		
Earlobe length (cm)	Male	3.55 ±0.01^{a}	2.53 ±0.02^{c}	3.06 ±0.02^{b}	3.05 ±0.01^{a}	2.32 ±0.01	7.85
	Female	1.63 ±0.01 ^{e}	1.27 ±0.01^{f}	1.88 ±0.02^{d}	1.59 ±0.01^{b}		
Earlobe width(cm)	Male	2.19 ±0.02 ^{a}	1.32 ±0.02^{c}	1.86 ±0.02^{b}	1.79 ± 0.01^{a}	1.37 ±0.01	13.92
	Female	0.91 ±0.01^{e}	0.71 ±0.02^{f}	1.23 ±0.02 ^{d}	0.95 ±0.01^{b}		
Earlobe index	Male	1.64 ±0.02^{c}	1.96 ± 0.03^{a}	1.66 ±0.02^{c}	1.75 ± 0.01^{a}	1.75 ±0.01	15.65
	Female	1.84 ±0.02^{b}	1.8 4 ±0.02^{b}	1.57 ±0.03^{c}	1.75 ±0.01^{a}		
Wattle length (cm)	Male	6.21 ± 0.05^{a}	4.46 ±0.06^{c}	5.30 ±0.06^{b}	5.32 ±0.03^{a}	3.67 ±0.02	16.83
	Female	2.12 ±0.05^{d}	2.02 ±0.05^{d}	2.08 ± 0.06^{d}	2.07 ±0.03^{b}		
Wattle width(cm)	Male	3.93 ± 0.04^{a}	2.77 ±0.04^{c}	3.37 ±0.05^{b}	3.36 ±0.03^{a}	2.32 ±0.02	21.69
	Female	1.38 ±0.04^{d}	1.08 ±0.04^{e}	1.39 ±0.05^{d}	1.28 ±0.02^{b}		
Wattle index	Male	1.61 ±0.02^{bc}	1.71 ±0.03^{b}	1.66 ±0.04^{b}	1.66 ±0.02^{b}	1.69 ±0.01	20.82
	Female	1.61 ± 0.03^{bc}	2.02 ±0.03^{a}	1.52 ±0.05^{c}	1.71 ±0.02^{a}		

Ls means with different superscripts are significantly different ($p<0.05$)

***Table 2**. Continued.*

Traits		Agro-climatic zones					
	Sex of chicken	*Kolla* (N = 310)	*Weynadega* (N = 260)	*Dega* (N = 200)	Total	Overall (N = 770)	CV
Skull length(cm)	Male	6.63 ±0.07^{b}	7.04 ±0.08^{a}	6.63 ± 0.09^{b}	6.77 ±0.04^{a}	6.46 ±0.03	12.91
	Female	5.78 ±0.06^{d}	6.27 ±0.07^{c}	6.38 ±0.08^{bc}	6.15 ± 0.04^{b}		
Skull width(cm)	Male	4.18 ±0.05^{a}	4.18 ±0.06 ^{a}	3.87 ±0.07^{b}	4.08 ±0.03^{a}	3.79 ±0.02	16.57
	Female	3.41 ±0.05^{c}	3.51 ±0.05^{c}	3.59 ±0.06^{c}	3.50 ±0.03^{b}		
Skull index	Male	1.64 ±0.02 ^{c}	1.72 ± 0.02^{bc}	1.73 ±0.03^{abc}	1.70 ±0.01^{b}	1.75 ±0.01	14.54
	Female	1.76 ± 0.02^{ab}	1.82 ±0.02 ^{a}	1.80 ±0.02^{ab}	1.8 ±0.01^{a}		

Traits		Agro-climatic zones					
	Sex of chicken	*Kolla* (N = 310)	*Weynadega* (N = 260)	*Dega* (N = 200)	Total	Overall (N = 770)	CV
Neck length(cm)	Male	15.70 ±0.07^{b}	16.93 ±0.08^{a}	13.70±0.09^{c}	15.44±0.05^{a}	14.30±0.03	6.30
	Female	13.73±0.07^{c}	13.61±0.08^{c}	12.15 ±0.09^{c}	13.16±0.05^{b}		
Beak length(cm)	Male	2.23±0.02^{a}	2.07±0.02^{b}	1.99 ±0.02^{c}	2.10±0.01^{a}	2.07±0.01	9.29
	Female	2.03 ±0.02^{bc}	2.06±0.02^{b}	2.06 ±0.02^{bc}	2.05±0.01^{b}		
Beak width(cm)	Male	1.24±0.01^{a}	0.97±0.02^{cd}	1.04 ±0.02^{bc}	1.08±0.10^{a}	1.05±0.01	16.98
	Female	1.08 ±0.01^{b}	0.93 ±0.02^{d}	1.03 ±0.02^{bc}	1.01±0.01^{b}		
Beak index	Male	1.80±0.03^{d}	2.17 ±0.03^{b}	1.93 ±0.04^{cd}	1.97±0.02^{b}	2.04±0.01	17.81
	Female	1.97 ±0.03^{c}	2.35±0.03^{a}	2.01 ±0.03^{c}	2.11±0.02 ^{a}		
Spur length(cm)	Male	2.44 ±0.01^{a}	1.48 ±0.01^{c}	1.87 ±0.02^{b}	1.93±0.01^{a}	1.17±0.01	13.48
	Female	0.42 ±0.01^{d}	0.37 ±0.01^{d}	0.41±0.01^{d}	0.40± 0.01^{b}		
Wing span(cm)	Male	47.52 ±0.14^{a}	40.01 ±0.15^{b}	36.80 ±0.18^{c}	41.44±0.09^{a}	37.93±0.06	4.41
	Female	36.05±0.13^{d}	34.39±0.14^{e}	32.83±0.16^{f}	34.42±0.08^{b}		

Lsmeans with different superscripts are significantly different (P<0.05)
Total under the last column indicates effect of sex on quantitative traits
N= number of sampled matured local chickens per agro-climate

Table 3. *Phenotypic correlations between quantitative traits for Kolla (N=146), Weynadega (N=120) and Dega (N=92) male chicken ecotypes.*

	Bl	Shl	Cbl	Cbw	Cbx	Erl	Erw	Erx	Wal	Waw
Kolla										
Bwt	0.29***	0.43***	0.45***	0.36***	0.06	0.48***	0.46***	-0.06	0.42***	0.40***
Bl	1.00	0.22**	0.34**	0.23**	0.06	0.16	0.17	-0.07	0.16	0.14
Shl		1.00	0.36***	0.31***	0.03	0.26**	0.49***	-0.47***	0.30***	0.37***
Cbl			1.00	0.86***	-0.05	0.60***	0.53***	-0.12	0.76***	0.71***
Cbw				1.00	-0.49***	-0.58***	0.48***	-0.09	0.65***	0.67***
Cbx					1.00	-0.08	-0.07	0.07	-0.02	-0.10
Erl						1.00	0.80***	0.01	0.72***	0.68***
Erw							1.00	0.54***	0.66***	0.62***
Erx								1.00	-0.15	-0.16
Wal									1.00	0.91***
Waw										1.00
Wax										
Skl										
Skw										
Skx										
Nel										
Bel										

	Bl	Shl	Cbl	Cbw	Cbx	Erl	Erw	Erx	Wal	Waw
Bew										
Bex										
Spl										
Weynadega										
Bwt	0.21*	0.19*	0.05	0.11	-0.10	0.18	0.17	-0.10	0.20*	0.15
Bl	1.00	0.27**	-0.09	0.01	-0.14	0.06	0.07	0.06	0.05	-0.02
Shl		1.00	0.29**	0.33**	-0.05	0.45***	0.39***	-0.15	0.47***	0.52***
Cbl			1.00	0.86***	0.05	0.66***	0.64***	-0.28**	0.73***	0.63***
Cbw				1.00	-0.43***	0.59***	0.60***	0.20*	0.65***	0.56***
Cbx					1.00	-0.02	-0.07	-0.11	0.02	0.02
Erl						1.00	0.91***	-0.29**	0.72***	0.72***
Erw							1.00	-0.35***	0.71***	0.70***
Erx								1.00	-0.25**	-0.22**
Wal									1.00	0.91***
Waw										1.00
Wax										
Skl										
Skw										
Skx										
Nel										
Bel										
Bew										
Bex										
Spl										

	Wax	Skl	Skw	Skx	Nel	Bel	Bew	Bex	Spl	Wn
Kolla										
Bwt	0.01	0.51***	0.42***	-0.07	-0.17	0.21*	-0.19*	0.31***	0.66***	0.38***
Bl	0.03	0.32***	0.26**	-0.12	0.17	0.07	-0.09	0.13	0.23**	0.45***
Shl	-0.31***	0.40***	0.19*	0.04	-0.65***	0.23**	-0.02	0.14	0.58***	0.10
Cbl	0.07	0.55***	0.63***	-0.30***	0.003	0.36***	-0.11	0.28***	0.62***	0.47***
Cbw	-0.06	0.50***	0.65***	-0.36***	0.02	0.36***	-0.03	0.21*	0.55***	0.31***
Cbx	0.14	-0.04	-0.17	0.20*	-0.05	-0.09	0.22*	0.17	-0.06	0.13
Erl	0.09	0.66***	0.72***	-0.31***	-0.07	0.38***	-0.14	0.36***	0.58***	0.42***
Erw	0.02	0.55***	0.49***	-0.19*	-0.26**	0.30***	0.04	0.12	0.61***	0.45***
Erx	0.12	-0.04	0.14	-0.05	0.35***	-0.03	-0.26**	0.26**	-0.22**	-0.05
Wal	0.16	0.58***	0.61***	-0.26**	0.02	0.34***	-0.07	0.24**	0.59***	0.47***
Waw	0.24**	0.52***	0.57***	-0.27**	-0.13	0.27***	-0.08	0.23**	0.62***	0.32***

	Wax	Skl	Skw	Skx	Nel	Bel	Bew	Bex	Spl	Wn
Wax	1.00	0.13	0.08	0.03	0.41***	0.13	0.02	0.02	-0.14	0.30***
Skl		1.00	0.81***	-0.25**	-0.12	0.48***	-0.23**	0.49***	0.52***	0.48***
Skw			1.00	-0.52***	0.06	0.44***	-0.24**	0.48***	0.46***	0.44***
Skx				1.00	-0.14	-0.15	0.10	-0.18	-0.16	-0.15
Nel					1.00	-0.13	0.07	-0.17	-0.33***	0.37***
Bel						1.00	0.20*	0.34***	0.39***	0.25**
Bew							1.00	-0.83***	-0.10	0.05
Bex								1.00	0.31***	0.06
Spl									1.00	0.38***
Weynadega										
Bwt	0.04	0.25**	0.26**	-0.10	0.13	0.13	0.10	-0.05	0.24**	0.28**
Bl	0.15	0.48***	0.46***	-0.12	0.67***	0.09	0.01	0.04	0.08	0.25**
Shl	-0.32***	0.46***	0.49***	-0.17	0.12	0.21*	0.16	-0.08	0.33***	0.45***
Cbl	0.03	0.20*	0.24**	-0.15	0.21*	0.05	0.13	-0.14	0.63***	0.17
Cbw	0.02	0.27**	0.29**	-0.15	-0.13	-0.03	0.03	-0.09	0.65***	0.21*
Cbx	0.04	-0.13	-0.11	0.02	-0.08	0.14	0.16	-0.08	-0.19*	-0.06
Erl	-0.17	0.33***	0.33***	-0.11	-0.19*	0.21*	0.34***	0.30***	0.63***	0.39***
Erw	-0.17	0.28**	0.26**	-0.05	-0.24**	0.17	0.26**	-0.25**	0.66***	0.40***
Erx	-0.02	-0.03	-0.05	-0.03	0.14	-0.12	-0.13	0.09	-0.18*	-0.14
Wal	-0.11	0.35***	0.39***	-0.19*	-0.06	0.13	0.13	-0.08	0.66***	0.40***
Waw	-0.46***	0.31***	0.36***	-0.15	-0.13	0.12	0.12	-0.08	0.58***	0.43***
Wax	1.00	0.04	-0.02	-0.03	0.24**	-0.01	0.07	-0.10	-0.003	0.25**
Skl		1.00	0.79***	-0.12	0.49***	0.33***	0.39***	-0.23*	0.28**	0.45***
Skw			1.00	-0.57***	0.41***	0.36***	0.34***	-0.19*	0.30***	0.37***
Skx				1.00	-0.08	-0.07	-0.03	0.03	-0.17	-0.02
Nel					1.00	0.002	-0.09	0.16	-0.13	0.24*
Bel						1.00	0.60***	-0.03	0.20*	0.10
Bew							1.00	-0.79***	0.21*	0.17
Bex								1.00	-0.13	-0.11
Spl									1.00	0.27**

* (P<0.05), ** (P<0.01) and *** (P<0.001)

NB: Bwt= body weight(kg); Bl= body length(cm); Shl= Shank length(cm); Cbl= comb length (cm); Cbw= comb width(cm); Cbx= Comb index; Erl= Earlobe length(cm); Erw= earlobe width (cm); Erx= earlobe index; Wal= wattle length (cm); Waw= wattle width(cm); Wax= wattle index; Skl= skull length (cm); Skw=skull width (cm); Skx= skull index; Nel =Neck length (cm); Bel= Beak length (cm); Bew= Beak width (cm); Bex= Beak index; Spl=Spur length (cm) and Wn= wing span (cm).

***Table 3**. Continued.*

	Bl	Shl	Cbl	Cbw	Cbx	Erl	Erw	Erx	Wal	Waw
Dega										
Bwt	0.15	0.12	0.31**	0.30**	-0.07	0.12	0.24*	-0.16	0.22*	0.19*
Bl	1.00	0.69***	0.21*	0.39***	-0.30**	0.61***	0.31**	0.20*	0.27**	0.13
Shl		1.00	0.07	0.28**	-0.31**	0.53***	0.23*	0.24*	0.16	0.002
Cbl			1.00	0.70***	0.17	0.19*	0.42***	-0.34***	0.66***	0.66***
Cbw				1.00	-0.49***	0.40***	0.52***	-0.27**	0.52***	0.54***
Cbx					1.00	-0.39***	-0.25*	-0.04	0.03	0.01
Erl						1.00	0.63***	0.15	0.37***	0.23*
Erw							1.00	0.66***	0.35***	0.50***
Erx								1.00	-0.10	-0.39***
Wal									1.00	0.84***
Waw										1.00
Wax										
Skl										
Skw										
Skx										
Nel										
Bel										
Bew										
Bex										
Spl										

	Wax	Skl	Skw	Skx	Nel	Bel	Bew	Bex	Spl	Wn
Dega										
Bwt	-0.001	-0.01	-0.09	0.03	-0.04	0.11	-0.03	0.11	0.16	-0.04
Bl	0.18	0.77***	0.39***	0.21*	0.21*	-0.002	-0.02	0.03	0.58***	0.63***
Shl	0.25*	0.60***	0.24*	0.26*	0.02	0.09	-0.09	0.18	0.22*	0.63***
Cbl	-0.24*	-0.07	-0.09	0.003	0.32**	0.03	0.07	-0.06	0.28**	0.12
Cbw	-0.24*	0.12	0.06	-0.003	0.26*	-0.11	-0.13	0.09	0.44***	0.15
Cbx	0.06	-0.28**	-0.18	0.001	0.07	0.23*	0.26*	-0.17	-0.26*	-0.11
Erl	0.11	0.70***	0.41***	0.14	0.12	-0.08	-0.07	0.04	0.45***	0.44***
Erw	-0.41***	0.36***	0.21*	0.16	0.10	-0.13	-0.25*	0.21*	0.15	0.14
Erx	0.61***	0.23*	0.12	-0.03	-0.01	0.08	0.26*	-0.25*	0.18	0.27**
Wal	-0.06	0.12	0.09	0.02	0.31**	0.07	0.07	-0.04	0.32**	0.20*
Waw	-0.58***	0.01	0.02	0.03	0.23*	-0.04	-0.09	0.08	0.14	0.04
Wax	1.00	0.18	0.06	-0.03	0.05	0.18	0.27**	-0.18	0.19	0.27**
Skl		1.00	0.63***	0.18	0.05	0.04	-0.05	0.09	0.37***	0.59***

	Wax	Skl	Skw	Skx	Nel	Bel	Bew	Bex	Spl	Wn
Skw			1.00	-0.38***	0.08	0.006	0.09	-0.11	0.31**	0.24*
Skx				1.00	-0.18	0.05	-0.03	0.11	-0.08	0.08
Nel					1.00	0.11	0.02	0.04	0.21*	0.16
Bel						1.00	0.54***	-0.004	0.002	0.10
Bew							1.00	-0.84***	0.04	0.08
Bex								1.00	-0.05	0.21*
Spl									1.00	0.26*

* (P<0.05), ** (P<0.01) and *** (P<0.001)
NB: Bwt= body weight(kg); Bl= body length(cm); Shl= Shank length(cm); Cbl= comb length (cm); Cbw= comb width(cm); Cbx= Comb index; Erl= Earlobe length(cm); Erw= earlobe width (cm); Erx= earlobe index; Wal= wattle length (cm); Waw= wattle width(cm); Wax= wattle index; Skl= skull length (cm); Skw=skull width (cm); Skx= skull index; Nel =Neck length (cm); Bel= Beak length (cm); Bew= Beak width (cm); Bex= Beak index; Spl=Spur length (cm) and Wn= wing span (cm).

Shank length was Strongly and significantly correlated with comb length, earlobe width, earlobe index, wattle width, skull length, neck length, spur length; and weakly correlated with comb width, earlobe length, wattle length, wattle index, skull index and beak length but not significantly correlated with wing span, beak width and comb, beak and skull indices in *Kolla* male chicken (Table 3). Likewise shank length was strongly and significantly correlated with earlobe length, earlobe width, wattle length, wattle width, skull length, skull width, wing span; and moderately correlated with comb length, comb width, wattle index and spur length; and weakly correlated with beak length but not significantly correlated with neck length, beak width; and comb, earlobe, skull and beak indices in *Weynadega* male chicken (Table 3). In the *Dega* male chicken, shank length was strongly, positively and significantly correlated with earlobe length, skull length and wingspan; and moderately correlated with comb width and comb index; and weakly correlated with earlobe width, earlobe index, wattle index, skull width, skull index and spur length but not significantly correlated with neck length, comb length, beak length, beak width, beak index, wattle length and wattle width (Table 3). This result is in close agreement with the previous findings that showed shank length positively and significantly correlated with wing span, comb length, wattle length and beak length in local cocks of bale zone of Oromia regional state of Ethiopia [21]. Daikwo *et al*. [33] reported that Shank length was significantly correlated with comb length (r=0.744) and beak length (r=-0.312) in the Local chickens in Dekina. Significant positive and strong correlation between shank length and wingspan was reported in local chickens of southern highlands of Tanzania [29] and intensively managed Nigerian local and exotic chickens [39].

Comb length was positively and significantly correlated with comb width, earlobe length, earlobe width, wattle length, wattle width and spur length in all three local male chicken ecotypes. These results imply that selecting these local male chicken ecotypes for increase in comb length will result in simultaneous increase in these positively correlated traits. Moreover, comb length was positively and significantly correlated with skull length and skull width in both *Kolla* and *Weynadega* male chicken ecotypes but not in *Dega* male chicken ecotype. Comb length also significantly correlated with skull index, beak length, beak index and wing span in *Kolla* male chicken ecotype but not in both *Weynadega* and *Dega* male chicken ecotypes. Significant correlations were observed between comb length and neck length; and comb length and earlobe index in both *Weynadega* and *Dega* male chicken but not in *Kolla* male chicken ecotype. Weak, negative and significant correlation was observed between comb length and wattle index (r=-0.24) in *Dega* male chicken but not in both *Kolla* and *Weynadega* male chicken ecotypes. However, comb length was not correlated with both comb index and beak width in all three male chicken ecotypes.

Comb width was strongly, positively and significantly correlated with earlobe width, wattle length, wattle width and spurs length and negatively and significantly correlated with comb width in all three male chicken ecotypes. Moreover, comb length was strongly, positively and significantly correlated with earlobe length in both *Kolla* and *Weynadega* male chicken ecotypes but this correlation was negative in *Dega* male chicken ecotype. Weak, negative and significant correlation was observed between comb width and earlobe index in both *Kolla* and *Weynadega* male chickens but not in *Dega* male chicken ecotype. Comb width was also significantly correlated with skull length; skull width and wing span in both *Weynadega* and *Dega* male chicken ecotypes but not in *Kolla* male chicken ecotype. There were also significant correlations between comb width and wattle index, and comb width and neck length in *Kolla* male chicken but not in both *Weynadega* and *Dega* male chicken ecotypes. Furthermore, comb width was significantly correlated with skull index, beak length and beak index in *Dega* male chicken ecotype but not in *Kolla* and *Weynadega* male chicken ecotypes. No significant correlation was observed between comb width and beak width in all three male local chicken ecotypes.

Comb index was significantly correlated with earlobe length, earlobe width, skull length, beak length, beak width and spur length but not significantly correlated with wattle length, wattle width, wattle index, earlobe index, beak index, skull width, skull index, neck length and wingspan in *Dega* male ecotype (Table 3). However, comb index was only weakly correlated with spur length but not significantly correlated with earlobe length, earlobe width, earlobe index, wattle length, wattle width, wattle index, skull length, skull width, skull index, beak length, beak width, beak index, neck length and wing span in *Weynadega* male chicken ecotype (Table 3). In the *Kolla* male chicken, comb index was weakly correlated with skull index and beak width but not significantly correlated with earlobe length, earlobe width, earlobe index, wattle length, wattle width, wattle index, skull length, skull width, beak length, beak index, neck length, spur length and wing span (Table 3).

Earlobe length was positively and significantly correlated with earlobe width, wattle length, wattle width, skull length, skull width, spur length and wing span in all three male chicken ecotypes. Significant correlations were observed between earlobe length and beak length, and earlobe length and beak index in both *Kolla* and *Weynadega* male chicken ecotypes but not in Dega male chicken ecotype. Likewise, earlobe length was negatively correlated with skull index (r=-0.31) in *Kolla* male chicken but not in both *Weynadega* and *Dega* male chicken ecotypes. Weak and significant correlations were observed between earlobe length and neck length (r=-0.19), earlobe length and beak width (r=0.34) and earlobe length and earlobe index (0.29) in *Weynadega* cock but not in *Kolla* and *Dega* male chicken ecotypes. However, there was no significant correlation was observed between earlobe length and wattle index in all three male chicken ecotypes.

Earlobe width was significantly correlated with earlobe index, wattle length, wattle width, skull length and skull width in all three male chicken ecotypes. Moreover, earlobe width was significantly correlated with neck length, spur length and wing span in both *Kolla* and *Weynadega* male chicken but not in *Dega* male chicken ecotype. Weak and significant correlations were observed between earlobe width and beak width; and earlobe width and beak index in both *Weynadega* and *Dega* male chicken but not in *Kolla* male chicken ecotype. Earlobe width was significantly correlated with skull index and beak length in *Kolla* male chicken but not in both *Weynadega* and *Dega* male chicken ecotypes. Strong, negative and strong correlation was observed between earlobe width and wattle index in *Dega* male chicken ecotype but not in both *Kolla* and *Weynadega* male chicken ecotypes.

Earlobe index was significantly correlated beak width and beak index in both *Kolla* and *Dega* male chicken ecotypes but not in *Weynadega* male chicken ecotype. Moreover, weak and negative correlation was observed between earlobe index and spur length in both *Kolla* and *Weynadega* male chicken ecotypes but not in *Dega* male chicken ecotype. Earlobe index was negatively correlated with wattle width in both *Weynadega* and *Dega* male chicken ecotypes but not in *Kolla* male chicken ecotype. In *Dega* male chicken, earlobe index was significantly correlated with wattle index, skull length and wingspan but not in both *Kolla* and *Weynadega* male chicken ecotypes. Moderate correlation was observed between earlobe index and neck length in *Kolla* male chicken but not in both *Weynadega* and *Dega* male chicken ecotypes. Earlobe index was weakly, negatively and significantly correlated with wattle length (r=-0.25) in *Weynadega* male chickens but not in both *Kolla* and *Dega* male chicken ecotypes. However, earlobe index was not significantly correlated with skull width, skull index and beak length in all three male chicken ecotypes.

Wattle length was significantly correlated with wattle width, spur length and wing span in all three male chicken ecotypes. Moreover, wattle length was significantly correlated with skull length, skull width and skull index in both *kolla* and *Weynadega* male chicken ecotypes but not in *Dega* male chicken ecotype. In *Kolla* male chicken, wattle length was weakly and significantly correlated with beak length and beak index but not in both *Weynadega* and *Dega* male chicken ecotypes. Wattle length was significantly correlated with neck length (r=0.31) in highland male chicken but not in both *Kolla* and *Weynadega* male chicken ecotypes. However, wattle length was not correlated with wattle index and beak width in all three male chicken ecotypes.

A strong negative correlation was observed between wattle width and wattle index in *Weynadega* (r=-0.46) and *Dega* (r=-0.58) male chicken ecotypes but this correlation was weak and positive in *Kolla* male chicken ecotype. Wattle width was positively and significantly correlated with skull length, skull width, spur length and wingspan in both *Kolla* and *Weynadega* male chicken ecotypes but not in *Dega* male chicken ecotype. Moreover, wattle width was significantly correlated with skull index, beak length and beak index in *Kolla* male chicken but not in both *Weynadega* and *Dega* male chicken ecotypes. Weak and significant correlation was observed between wattle width and neck length in *Dega* male chicken but not in both *Kolla* and *Weynadega* male chicken ecotypes. On the other hand, wattle width was not correlated with beak width in all three male chicken ecotypes.

Wattle index was weakly and significantly correlated with wingspan in all three male chicken ecotypes. Likewise, wattle index was significantly correlated with neck length in both *Kolla* and *Weynadega* male chicken ecotypes but not in *Dega* male chicken ecotype. Weak correlation was observed between wattle index and beak width in *Dega* male but not in both *Kolla* and *Weynadega* male chicken ecotypes. However, wattle index was not correlated with skull length, skull width, skull index, beak length, beak index and spur length in all three male chicken ecotypes.

Skull length was positively and significantly correlated with skull width, spur length and wing span in all three male chicken ecotypes. Moreover, skull length was significantly correlated with beak length, beak width, beak index in both *Kolla* and *Weynadega* male chicken but not in *Dega* male chicken ecotype. A weak negative correlation was observed between skull length and skull index in *Kolla* male but not in both *Weynadega* and *Dega* male chicken ecotypes. Skull length was significantly correlated with neck length in *Weynadega* male but not in both *Kolla* and *Dega* male chicken ecotypes.

Skull width was significantly correlated with skull index, spur length and wingspan in all three male chicken ecotypes. Moderate and significant correlation was observed between skull width and neck length in *Weynadega* male but not in both *Kolla* and *Dega* male chicken ecotypes. Skull width was correlated with beak length, beak width and beak index in both *Kolla* and *Weynadega* male chicken ecotypes but not in *Dega* male chicken ecotype.

Skull index was not correlated with neck length, beak length, beak width, beak index, spur length and wing span in all three male chicken ecotypes. Significant correlation was observed between neck length and spur length in both *Kolla* and *Dega* male chicken but not in *Weynadega* male chicken ecotype. Moreover, neck length was correlated with wingspan in both *Kolla* and *Weynadega* male chicken but not in *Dega* male chicken ecotype. However, neck length was not correlated with beak length, beak width and beak index in all three male chicken ecotypes.

Strong positive and significant correlation was observed between beak length and beak width in both *Weynadega* (r=0.60) and *Dega* (r=0.54) male chickens but this correlation was weak in *Kolla* (r=0.20) male chicken ecotype. Beak length was correlated with spur length in both *Kolla* and *Weynadega* male chickens but not in *Dega* male chicken ecotype. Moreover, beak length was correlated with beak index and wing span in *Kolla* male chicken but not in both *Weynadega* and *Dega* male chicken ecotypes.

Strong negative and significant correlation was observed between beak width and beak index in all three male chicken ecotypes. Likewise, beak width was correlated with spur length in *Weynadega* male chicken but not in both *Kolla* and *Dega* male chicken ecotypes. However, there was no significant correlation between beak width and wingspan in all three male chicken ecotypes.

Significant correlation was observed between beak index and spur length in *Kolla* male chicken but not in both *Weynadega* and *Dega* male chicken ecotypes. Beak index was negatively correlated with wing span in *Dega* male chicken but not in both *Kolla* and *Weynadega* male chicken ecotypes. Furthermore, spur length was correlated with wingspan in all three male chicken ecotypes.

3.3. Phenotypic Correlations Between Quantitative Traits of Three Female Local Chicken Ecotypes

Significant positive correlations occurred between body weight and comb length in all three female chicken ecotypes (Table 4). Body weight was significantly correlated with comb width, earlobe length, earlobe width, wattle width, skull length, skull width, spur length and wingspan in *Kolla* female chickens but not in both *Weynadega* and *Dega* female chicken ecotypes. Moreover, body weight was weakly correlated with wattle length and wattle index in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken ecotype. Weak positive correlation was observed between body weight and shank length (r=0.28) in *Dega* female chicken but not in both *Kolla* and *Weynadega* female chicken ecotypes. However, body weight was not correlated with body length, earlobe index, earlobe index, skull index, neck length, beak length, beak width and beak index in all three female chicken ecotypes. This result is in close agreement with the previous reports that showed body weight significantly and positively correlated with body and shank lengths of both mature chickens with 8-10 months and greater than 10 months ages but not significant correlation in mature chickens with 6-8 months age in local chickens of Lake Victoria basin of Uganda [28]. In contrast, body weight was significantly and positively correlated with body length (r =0.57), shank length (r=0.57), wingspan (r=0.54), comb length (r=0.43) and wattle length (r=0.40) for local hens of bale zone of Oromia regional state of Ethiopia [21].

Table 4. *Phenotypic correlations between quantitative traits for Kolla (N=164), Weynadega (N=140) and Dega (N=108) female chicken ecotypes.*

	Bl	Shl	Cbl	Cbw	Cbx	Erl	Erw	Erx	Wal	Waw
Kolla										
Bwt	-0.07	0.18	0.45***	0.33***	0.02	0.27***	0.29***	0.05	0.22**	0.28***
Bl	1.00	-0.10	0.13	0.01	0.08	-0.002	-0.06	0.05	-0.01	-0.05
Shl		1.00	0.23**	0.34***	-0.28***	0.58***	0.44***	-0.05	0.52***	0.51***
Cbl			1.00	0.80***	-0.01	0.36***	0.35***	-0.15	0.45***	0.46***

	Bl	Shl	Cbl	Cbw	Cbx	Erl	Erw	Erx	Wal	Waw
Cbw				1.00	-0.58***	0.54***	0.44***	-0.13	0.57***	0.59***
Cbx					1.00	-0.42***	-0.29***	0.06	-0.36***	-0.39***
Erl						1.00	0.78***	-0.19*	0.69***	0.76***
Erw							1.00	-0.61***	0.59***	0.69***
Erx								1.00	-0.15	-0.24**
Wal									1.00	0.86***
Waw										1.00
Wax										
Skl										
Skw										
Skx										
Nel										
Bel										
Bew										
Bex										
Spl										
Weynadega										
Bwt	-0.08	-0.08	0.23**	0.10	0.18	0.13	0.16	0.16	0.28***	0.18
Bl	1.00	-0.04	-0.15	-0.12	-0.03	0.03	0.07	-0.10	0.02	0.16
Shl		1.00	0.18	0.14	0.05	0.24**	0.18	0.06	0.19*	0.22**
Cbl			1.00	0.61***	0.51***	0.36***	0.36***	0.20*	0.47***	0.40***
Cbw				1.00	-0.36***	-0.005	-0.06	-0.01	0.13	0.06
Cbx					1.00	0.42***	0.46***	0.24**	0.42***	0.41***
Erl						1.00	0.83***	0.22**	0.54***	0.62***
Erw							1.00	0.23**	0.53***	0.68***
Erx								1.00	0.13	0.15
Wal									1.00	0.87***
Waw										1.00
Wax										
Skl										
Skw										
Skx										
Nel										
Bel										
Bew										
Bex										
Spl										

	Wax	Skl	Skw	Skx	Nel	Bel	Bew	Bex	Spl	Wn
Kolla										
Bwt	-0.20**	0.28***	0.29***	-0.18	0.06	-0.01	-0.16	0.10	0.21**	0.21**
Bl	0.06	0.18	0.18	-0.19*	0.19*	-0.09	-0.15	0.08	-0.02	0.32***
Shl	-0.31***	0.45***	0.31***	-0.04	-0.41***	0.56***	0.18	0.15	0.46***	-0.04
Cbl	-0.22**	0.25**	0.24**	-0.22**	0.11	0.18	-0.20*	0.25**	0.24**	0.05
Cbw	-0.32***	0.30***	0.28***	-0.20*	-0.11	0.37***	0.05	0.07	0.30***	0.05
Cbx	0.30***	-0.21**	-0.16	0.03	0.40***	-0.38***	-0.36***	0.07	-0.20**	0.02
Erl	-0.47***	0.63***	0.55***	-0.24**	-0.44***	0.62***	0.24**	0.12	0.55***	0.07
Erw	-0.42***	0.57***	0.36***	-0.02	-0.38***	0.53***	0.20*	0.11	0.40***	-0.09
Erx	0.19*	-0.14	0.05	-0.18	0.18	-0.16	-0.02	-0.09	-0.01	0.11
Wal	-0.30***	0.46***	0.43***	-0.17	-0.19*	0.44***	0.23**	0.02	0.39***	0.03
Waw	-0.68***	0.59***	0.50***	-0.19*	-0.32***	0.52***	0.18	0.11	0.34***	-0.04
Wax	1.00	-0.44***	-0.34***	0.10	0.38***	-0.37***	-0.10	-0.10	-0.16	0.14
Skl		1.00	0.77***	-0.34***	-0.24**	0.43***	0.15	0.08	0.42***	0.18
Skw			1.00	-0.77***	-0.05	0.24**	0.07	0.09	0.48***	0.26**
Skx				1.00	-0.19*	0.08	0.07	-0.06	-0.27***	-0.32***
Nel					1.00	-0.55***	-0.35***	0.02	-0.35***	0.39***
Bel						1.00	0.36***	0.24**	0.47***	-0.19*
Bew							1.00	-0.72***	0.16	-0.15
Bex								1.00	0.16	0.02
Spl									1.00	-0.03
Weynadega										
Bwt	0.20*	-0.16	-0.16	0.11	-0.03	-0.09	-0.04	0.03	0.15	0.01
Bl	-0.25**	0.31***	0.37***	-0.19*	0.01	0.11	0.12	-0.05	0.06	0.31***
Shl	-0.14	0.39***	0.34***	-0.12	0.11	0.40***	0.35***	-0.20*	0.16	0.32***
Cbl	-0.01	-0.02	-0.01	-0.04	-0.15	0.07	0.10	-0.06	0.30***	-0.03
Cbw	0.05	0.03	0.04	-0.03	0.09	-0.05	-0.01	0.02	0.13	0.12
Cbx	-0.08	-0.05	-0.05	-0.01	-0.25**	0.13	0.11	-0.07	0.20*	-0.16
Erl	-0.24**	0.04	-0.002	0.04	-0.52***	0.26**	0.45***	-0.39***	0.39***	-0.06
Erw	-0.28***	0.14	0.11	-0.04	-0.51***	0.20*	0.39***	-0.34***	0.52***	0.04
Erx	0.0005	-0.07	-0.10	0.03	-0.18	-0.06	0.04	-0.09	0.04	0.03
Wal	0.04	0.14	0.18	-0.15	0.22**	0.11	0.18	-0.12	0.41***	0.07
Waw	-0.42***	0.27**	0.28**	-0.16	-0.34***	0.21*	0.30***	-0.24**	0.51***	0.19*
Wax	1.00	-0.26**	-0.20*	0.06	0.22**	-0.23**	-0.26**	0.19*	-0.18	-0.21*
Skl		1.00	0.77***	-0.25**	0.23**	0.32***	0.25**	-0.08	0.35***	0.60***
Skw			1.00	-0.72***	0.22**	0.28***	0.18	-0.03	0.22*	0.67***
Skx				1.00	-0.06	-0.14	-0.07	0.01	-0.03	-0.42***
Nel					1.00	0.02	-0.33***	0.51***	-0.21*	0.24**

	Wax	Skl	Skw	Skx	Nel	Bel	Bew	Bex	Spl	Wn
Bel						1.00	0.60***	-0.13	0.20*	0.08
Bew							1.00	-0.81***	0.30***	0.13
Bex								1.00	-0.22*	-0.05
Spl									1.00	0.11

* (P<0.05), ** (P<0.01) and *** (P<0.001)
NB: Bwt= body weight(kg); Bl= body length(cm); Shl= Shank length(cm); Cbl= comb length (cm); Cbw= comb width(cm); Cbx= Comb index; Erl= Earlobe length(cm); Erw= earlobe width (cm); Erx= earlobe index; Wal= wattle length (cm); Waw= wattle width(cm); Wax= wattle index; Skl= skull length (cm); Skw=skull width (cm); Skx= skull index; Nel =Neck length (cm); Bel= Beak length (cm); Bew= Beak width (cm); Bex= Beak index; Spl=Spur length (cm) and Wn= wing span (cm).

Table 4. *Continued.*

	Bl	Shl	Cbl	Cbw	Cbx	Erl	Erw	Erx	Wal	Waw
Dega										
Bwt	-0.04	0.28**	0.22*	0.09	0.18	0.09	0.11	-0.09	0.09	0.10
Bl	1.00	-0.11	0.04	0.07	-0.11	0.18	0.05	0.10	-0.003	-0.003
Shl		1.00	0.09	0.002	0.06	0.07	0.20*	-0.15	-0.09	-0.042
Cbl			1.00	0.71***	0.11	0.34***	0.30**	-0.04	0.57***	0.59***
Cbw				1.00	-0.58***	0.32***	0.14	0.17	0.51***	0.52***
Cbx					1.00	-0.22*	0.03	-0.27**	-0.10	-0.10
Erl						1.00	0.54***	0.09	0.19*	0.23*
Erw							1.00	-0.74***	0.35***	0.39***
Erx								1.00	-0.16	-0.15
Wal									1.00	0.90***
Waw										1.00
Wax										
Skl										
Skw										
Skx										
Nel										
Bel										
Bew										
Bex										
Spl										

	Wax	Skl	Skw	Skx	Nel	Bel	Bew	Bex	Spl	Wn
Dega										
Bwt	-0.03	-0.13	-0.11	0.04	-0.01	0.08	-0.01	0.08	0.18	0.18
Bl	-0.03	28**	0.10	0.14	0.04	0.05	0.002	0.05	0.06	0.15

	Wax	Skl	Skw	Skx	Nel	Bel	Bew	Bex	Spl	Wn
Shl	-0.10	0.22*	0.26**	-0.05	0.03	0.01	0.27	-0.05	0.056	0.40***
Cbl	-0.05	-0.23*	-0.29**	0.02	0.08	-0.07	-0.05	-0.05	0.04	-0.15
Cbw	-0.03	-0.07	-0.16	-0.002	0.07	0.07	-0.01	0.07	0.002	-0.13
Cbx	-0.02	-0.25**	-0.15	0.12	0.003	-0.14	-0.09	-0.12	-0.01	0.02
Erl	-0.09	0.39***	0.09	-0.08	0.13	0.03	0.08	-0.05	0.13	0.12
Erw	-0.10	0.20*	0.05	-0.04	0.20*	-0.09	0.11	-0.10	-0.01	0.17
Erx	0.01	0.05	-0.01	-0.01	-0.21*	0.07	-0.07	0.07	0.04	-0.14
Wal	0.16	-0.35***	-0.29**	0.03	0.10	-0.06	-0.04	-0.05	-0.15	-0.20*
Waw	-0.27**	-0.27**	-0.35***	0.11	0.11	-0.01	-0.06	0.01	-0.16	-0.16
Wax	1.00	-0.21*	0.12	-0.25**	-0.12	-0.13	0.05	-0.14	-0.01	-0.16
Skl		1.00	0.61***	-0.06	0.16	0.08	0.19	0.04	0.08	0.46***
Skw			1.00	-0.56***	-0.11	-0.12	0.29**	-0.18	0.09	0.30**
Skx				1.00	0.25**	0.15	-0.25**	0.20*	-0.17	-0.07
Nel					1.00	0.04	-0.12	0.06	0.30**	0.38***
Bel						1.00	0.01	0.98***	-0.10	-0.05
Bew							1.00	-0.19*	-0.06	0.12
Bex								1.00	-0.08	-0.07
Spl									1.00	0.38***

* (P<0.05), ** (P<0.01) and *** (P<0.001)

NB: Bwt= body weight(kg); Bl= body length(cm); Shl= Shank length(cm); Cbl= comb length (cm); Cbw= comb width(cm); Cbx= Comb index; Erl= Earlobe length(cm); Erw= earlobe width (cm); Erx= earlobe index; Wal= wattle length (cm); Waw= wattle width(cm); Wax= wattle index; Skl= skull length (cm); Skw=skull width (cm); Skx= skull index; Nel =Neck length (cm); Bel= Beak length (cm); Bew= Beak width (cm); Bex= Beak index; Spl=Spur length (cm) and Wn= wing span (cm).

Body length was significantly correlated with skull length in both *Weynadega* and *Dega* female chickens but not in *Kolla* female chicken ecotype. Moreover, body length was correlated with wing span and skull index in both *Kolla* and *Weynadega* chickens but not in *Dega* female chicken ecotype. Body length was also significantly correlated with wattle index and skull width in *Weynadega* female chicken but not in both *Kolla* and *Dega* female chicken ecotypes. On the other hand, body length was not correlated with shank length, comb length, comb width, comb index, earlobe length, earlobe width, earlobe index, wattle length, wattle width, neck length, beak length, beak width, beak index and spur length in all three female chicken ecotypes (table 4). This result disagreed with the findings of Daikwo *et al*. [33] who reported positive significant correlations between body length and shank length (r=0.568), body length and comb length (r=0.506) and body length and beak length (r=0.204) for local chickens in Dekina. Strong positive and significant correlation between body length and shank length had also been reported for the Thai native black – bone indigenous chickens to northern Thailand [42]. Tareke *et al*. [21] also reported that body length positively correlated with shank length (r=0.54), wingspan(r=0.55) and wattle length (r=0.23) but weakly correlated with comb length (r=0.17) and beak length (r=-0.01) in local hens of bale zone of Oromia regional state of Ethiopia.

Shank length was significantly correlated with skull length and skull width in all three female chicken ecotypes (Table 4). Likewise, shank length was positively and significantly correlated with earlobe length, wattle length, wattle width and beak length in both *Kolla* and *Weynadega* female chicken ecotypes but not in *Dega* female chicken ecotype. Positive significant correlation was observed between shank length and earlobe width in *Kolla* and *Dega* female chicken ecotypes but not in *Weynadega* female chicken ecotype. Shank length was significantly correlated with wing span in both *Weynadega* and *Dega* female chickens but not in *Kolla* female chicken ecotype. Shank length was correlated with comb length, comb width, comb index, wattle index, neck length and spur length in *Kolla* female chickens but not in *Weynadega* and *Dega* female chicken ecotypes. Shank length was correlated with beak width and beak index in *Weynadega* female chicken but not in *Kolla* and *Dega* female chicken ecotypes. However, shank length was not correlated with earlobe and skull indices in all three female chicken ecotypes (Table 4). Shank length significantly and positively correlated with wingspan (r=0.52), comb length (r=0.24) and wattle length (r=0.26) but non-significantly correlated with beak length (r=0.14) in the local hens of bale zone of Oromia regional state of Ethiopia [21].

Comb length was strongly, positively and significantly correlated with comb width, wattle length and wattle width; and moderately correlated with earlobe length and earlobe width in all three female chicken ecotypes (Table 4). Moreover, comb length was weakly and negatively correlated with wattle index, skull index and beak width; and positively correlated with beak index in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chicken ecotypes. Comb length was strongly and significantly correlated with comb index and weakly correlated with earlobe index in *Weynadega* female chicken but not in both *Kolla* and *Dega* female chicken ecotypes. Likewise, comb length was correlated with skull length and skull width in both *Kolla* and *Dega* female chickens but not in *Weynadega* female chicken ecotype. Weak positive correlation was obtained between comb length and spur length in both *Kolla* and *Weynadega* female ecotypes but not in *Dega* female chicken ecotype. Nevertheless, comb length was not correlated with neck length, beak length and wingspan in all three female chicken ecotypes (Table 4). This agreed with the previous report that showed significant correlation between comb length and wattle length (r=0.68) and non-significant correlation between comb length and beak length (r=0.08) in the local hens of bale zone of Oromia regional state of Ethiopia [21].

Negative significant correlation was observed between comb width and comb index in all three female chicken ecotypes (Table 4). Comb width was strongly, positively and significantly correlated with wattle length and wattle width in both *Kolla* and *Dega* female chickens but not in *Weynadega* female chicken ecotype. Moreover, the correla*tion between comb width and earlobe length was positive* and strong in *Kolla* female chicken and weak in *Dega* female chicken but not in *Weynadega* female chicken ecotype. Comb width was correlated with earlobe width, wattle index, skull length, skull width, skull index, beak length and spur length in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chicken ecotypes. However, comb width was not correlated with earlobe index, neck length, beak width, beak index and wingspan in all three female chicken ecotypes.

Significant correlation between comb index and earlobe length was observed in all three female chicken ecotypes (table 4). Comb index was significantly correlated with earlobe width, wattle length, wattle width, neck length and spur length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female ecotype. Weak negative correlation was observed between comb index and skull length in both *Kolla* and *Dega* chickens but not in *Weynadega* female chicken ecotype. Similarly, comb index was correlated with neck length in both *Kolla* and *Weynadega* chickens but not in *Dega* female chicken ecotype. Significant correlation was observed between comb index and earlobe index in both *Weynadega* and *Dega* chickens but not in *Kolla* female chicken ecotype. Comb index was significantly correlated with wattle index (r=0.30), beak length (r=-0.38) and beak index (r=-0.36) in *Kolla* female chicken but not in both *Weynadega* and *Dega* chicken ecotypes. However, comb index was not correlated with skull width, skull index, beak index and wing span in all three female chicken ecotypes.

Strong, positive and significant correlation was observed between earlobe length and earlobe width in all three female chicken ecotypes (table 4). Moreover over, earlobe length was significantly correlated with wattle length, wattle width and wattle index in all three female chicken ecotypes. Earlobe length was significantly correlated with earlobe index, neck length, beak length, beak width and spur length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken ecotype. Earlobe length was strongly, positively and significantly correlated with skull length and skull width and weakly and negatively correlated with skull index in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chicken ecotypes. Strong negative correlation was observed between earlobe length and beak index in *Weynadega* female chickens but not in both *Kolla* and *Dega* female chicken ecotypes. However, there was no significant correlation between earlobe length and wing span in all three female chicken ecotypes.

Earlobe width was strongly, positively and strongly correlated with wattle length and wattle width in all three female chicken ecotypes (table 4). This implies that selection for improvement in earlobe width might lead to improvement in both wattle length and wattle width. Moreover, earlobe width was significantly correlated with earlobe index and neck length in all three female chicken ecotypes. Earlobe width was also correlated with wattle index, beak length, beak width and spur length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken ecotype. Earlobe width was significantly correlated with skull length in both *Kolla* and *Dega* female chickens but not in *Weynadega* female chicken ecotype. Moderate correlation was observed between earlobe width and skull width (r=0.36) in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chicken ecotypes. Earlobe width was moderately negatively correlated with beak index in *Weynadega* female chickens but not in both *Kolla* and Dega female chicken ecotypes. Nevertheless, earlobe width was not correlated with skull index and wingspan in all three female chicken ecotypes.

Earlobe index was weakly correlated with wattle width (r=-0.24) and wattle index (r=0.19) in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chicken ecotypes. Moreover, weak negative correlation was observed between earlobe index and neck length in *Dega* female chicken but not in both *Kolla* and *Weynadega* female chicken ecotypes. However, earlobe index was not correlated with wattle length, skull length, skull width, skull index, beak length, beak width, beak index, spur length and wing span in all three female chicken ecotypes.

Strong positive significant correlation was observed between wattle length and wattle width (r=0.86, r=0.87, r=0.90, respectively) in all three female chicken ecotypes. Wattle length was significantly correlated with skull length and skull width in both *Kolla* and *Dega* female chickens but not in *Weynadega* female chicken ecotype. Moreover, wattle length was correlated with neck length and spur length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken ecotype. Wattle length was also significantly correlated with wattle index, beak length and beak width in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chickens. Weak negative correlation was observed between wattle length and wing span in *Dega* female but not in both *Kolla* and *Weynadega* female chickens. However, wattle length was not correlated with skull and beak indices in all three female chicken ecotypes.

Wattle width was significantly correlated with wattle index, skull length and skull width in all three female chicken ecotypes. Moreover, wattle width was correlated with neck length, beak length and spur length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken. Weak negative correlation was obtained between wattle width and skull index in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chickens. Wattle width was significantly correlated with beak width, beak index and wingspan in *Weynadega* female but not in both *Kolla* and *Dega* female chickens.

Negative significant correlation was observed between wattle index and skull length in all three female chickens. Furthermore, wattle index was significantly correlated with skull width, neck length and beak length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken ecotype. Weak negative correlation was obtained between wattle index and skull index in *Dega* female chicken but not in both *Kolla* and *Weynadega* female chickens. In *Weynadega* female chicken, wattle index was weakly correlated with beak width, beak index and wingspan but not in both *Kolla* and *Dega* female chickens. However, wattle index was not correlated with spur length in all female chicken ecotypes.

Strong positive significant correlation was observed between skull length and skull width in all three female chicken ecotypes. Skull length was significantly correlated with skull index, neck length, beak length and spur length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken. Weak positive correlation was obtained between skull length and beak width in *Weynadega* female but not in both *Kolla* and *Dega* female chickens. Skull length was strongly, positively and significantly correlated with wingspan in both *Weynadega* and *Dega* female chickens but not in *Kolla* female chicken. However, skull length was not correlated with beak index in all three female chicken ecotypes (table 4).

Skull width was significantly correlated with skull index and wing span in all three female chicken ecotypes. Moreover, skull width was correlated with beak length and spur length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken. Skull width was also correlated with neck length in *Weynadega* female chicken but not in both *Kolla* and *Dega* female chickens. Similarly, weak positive correlation was observed between skull width and beak width in *Dega* female chicken but not in both *Kolla* and *Weynadega* female chickens. Nonetheless, skull width was not correlated with beak index in all three female chickens.

Weak significant correlation was observed between skull index and neck length in both *Kolla* and *Dega* female chickens but not in *Weynadega* female chicken. Skull index was weakly correlated with beak width and beak index in *Dega* female chickens but not in both *Kolla* and *Weynadega* female chickens. Weak negative correlation was observed between skull index and spur length in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chickens. Moreover, skull index was negatively correlated with wingspan in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken. However, skull index was not correlated with beak length in all three female chickens.

Neck length was significantly correlated with spur length and wingspan in all three female chickens. Moderate negative correlation was observed between neck length and beak width in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken. Strong negative correlation was obtained between neck length and beak length in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chickens. Moreover, neck length was strongly positively and significantly correlated with beak index in *Weynadega* female chicken but not in both *Kolla* and *Dega* female chickens.

Beak length was positively significantly correlated with beak width and spur length in both *Kolla* and *Weynadega* female chickens but not in *Dega* female chicken. Moreover, beak length was correlated with beak index in both *Kolla* (r=0.24) and *Dega* (r=0.98) female chickens but not in *Weynadega* female chicken. Weak negative correlation was observed between beak length and wingspan in *Kolla* female chicken but not in both *Weynadega* and *Dega* female chickens.

Negative significant correlation was observed between beak width and beak index in all three female chickens. Beak width was positively correlated with spur length in *Weynadega* female chicken but not in both *Kolla* and *Dega* female chickens. However, beak width was not correlated with wingspan in all three female chickens. Weak negative correlation was observed between beak index and spur length in *Weynadega* female chicken (r=-0.22) but not in both *Kolla* and *Dega* female chickens. On the other hand, beak index was not correlated with wingspan in all three female chickens. Spur length was positively correlated with wingspan in *Dega* female (r=0.38) but not in both *Kolla* and *Weynadega* female chickens.

4. Conclusions

Significant variations in morphometric traits among the three local chicken ecotypes, as well as between male and female chickens were detected. These variations were observed in various body and head traits, indicating distinct physical differences among the local chicken populations in different agro-ecological zones. The findings suggest the presence of genetic diversity among the local chicken ecotypes, highlighting the potential for improving the genetic potential of indigenous chickens through selective breeding methods.

The strength and direction of the significant correlations among the quantitative traits varied across chicken ecotypes and sexes. Positive correlations among traits imply that improvements in one trait through breeding programs could lead to simultaneous enhancements in other positively correlated traits. However, such improvements may have negative effects on traits inversely associated with the target trait.

It is recommended to explore the village production systems and validate the detected morphometric trait variations at molecular levels. This would help assess genetic similarity and diversity among chicken ecotypes, facilitating the development and registration of local chicken breeds nationally and internationally. Environmentally friendly genetic improvement programs tailored to local communities should be developed and implemented to ensure sustainable improvement, utilization, and conservation of indigenous chicken genetic resources.

Abbreviations

CSA	Centeral Statistical Agency
Cm	Centimeter
EARO	Ethiopian Agricultural Research Organization
FAO	Food and Agriculture Organization
Masl	Meter Above Sea Level
Mm	Millimeter
PROC GLM	General Linear Model Procedure

Acknowledgments

The authors gratefully acknowledge the financial support received from the Humera Begait Research Center (HuBRC) of Tigray Agricultural Research Institute (TARI). We extend our heartfelt thanks to the individuals, peasant associations administrations, farmers, and agricultural offices in Kafta Humera, Welkait, and Tsegede districts, as well as the experts and development agents who were directly or indirectly involved in the project's implementation.

Author Contributions

Shishay Markos: Conceptualization, Resources, Data curation, Software, Formal Analysis, Funding acquisition, Validation, Investigation, Writing - original draft, Methodology, Visualization, Project administration, Writing - review & editing

Berhanu Belay: Conceptualization, Software, Formal Analysis, Supervision, Funding acquisition, Validation, Methodology, Visualization, Project administration, Writing - review & editing

Tadelle Dessie: Conceptualization, Resources, Software, Supervision, Validation, Investigation, Project administration, Writing - review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] The Economist. 2011. FAO Statistics data Global-Livestock -counts. Retrived from web site: http://www.economist.com/blogs/dailychart/2011/07/global-livestock-counts

[2] FAO. 2012a. GLOBAL POULTRY TRENDS 2012. Reterived from web site: http://www.thepoultrysite.com/articles/2515/global-poultry-trends-2012-poultry-increases-its-share-of-global-meat-production

[3] Alders RG, Pym RAE. 2009. Village Poultry: Still Important to Millions, Eight Thousand Years after Domestication. *World Poultry Sci J*. 65: 181–190. https://doi.org/10.107/S0043933909000117

[4] Fayeye, T. R., Ayorinde, K. L., Ojo, V. and Adensina, O. M. 2006. Frequency and Influence of some major Genes on body weight and body size parameters of Nigerian local Chickens. Livestock Research Rural Development. Vol. 8.

[5] Gueye, E. F. 1998. Village Egg and Fowl Meat Production in Africa. *World Poultry Sci J*, 54: 73–86. https://doi.org/10.1079/WPS1998000

[6] Gueye, E. F. 2002. Employment and Income Generation through Family Poultry in Low-Income Food-Deficit Countries. *World Poultry Sci J.*, 58: 541–557.

[7] Aboe, P., Boa-Amponsem, K., Okantah, S., Dorward, P. & Bryant, M. 2006. Free-Range Village Chickens on the Accra Plains, Ghana: Their Contribution to Households. *Trop Anim Health Prod*, 38: 223–234. https://doi.org/10.1007/s11250-006-4357-9

[8] Faustin, V., Adégbidi, V. F., Garnett, S. T., Koudandé, D. O., Agbo, V. & Zander, K. K. 2010. Peace, Health or Fortune? Preferences for Chicken Traits in Rural Benin. Ecol Econ, 69: 1848–1857. https://doi.org/10.1016/j.ecolecon.2010.04.027

[9] Abdelqader, A., Wollny, C. B. A. & Gauly, M. 2007. Characterization of Local Chicken Production Systems and their Potential under Different Levels of Management Practice in Jordan. *Tropical Animal Health and Production*, 39(3): 155–164.

[10] Aklilu, H., Almekinders, C. J. M. and Vander, A. J. Z. 2007. Village Poultry Consumption and Marketing in relation to Gender, Religious Festivals and Market Access, Tropical animal health and Production, 39: 165-168. https://doi.org/10.1007/s11250-007-9002-8

[11] Besbes, B. 2009. Genotype Evaluation and Breeding of Poultry for Performance under Suboptimal Village Conditions, *World poultry Science Journal*, 65: 260-271. https://doi.org/10.1017/S0043933909000221

[12] Minga, U. M., Msoffe, P. L. and Gwakisa, P. S. 2004. Biodiversity (Variation) in disease resistance and in pathogens with in rural chickens. Proceeding of the 22nd World Poultry Congress, Istanbul, Turkey.

[13] CSA (Central Statistical Agency). 2021. Agricultural Sample Survey 2020/21. Statistical Bulletin II: 589 Report on Livestock and Livestock Characteristics, Addis Ababa.

[14] CSA (Central Statistical Agency). 2011. Agricultural Sample Survey 2010/11. Statistical Bulletin 2: 505 Report on Livestock and Livestock Characteristics, Addis Ababa.

[15] Pagani, P. & Abebe, W. 2008. Review of the new features of the Ethiopian poultry sector Biosecurity implications. Food and Agriculture Organizations of the United Nations. Pp3-4.

[16] FAO. 2012b. Phenotypic Characterization of Animal Genetic Resources. FAO Animal Production and Health Guidelines No. 11. Rome.

[17] Humphreys, M. O. 1991. A Genetic Approach to the Multivariate Differentiation of Perennial Ryegrass (Lolium PerenneL.) Cultivars. *Heredity*. 66: 437-443.

[18] Dana, N., J. A. M. VanArendonk, L. H. Vander Waaij and T. Dessie. 2010. Production Objectives and Trait Preferences of Village Poultry Producers of Ethiopia: Implications for Designing Breeding Schemes Utilizing Indigenous Chicken Genetic Resources. *Trop Anim Health Prod.*, 42: 1519-1529. https://doi.org/ 10.1007/s11250-010-9602-6

[19] Chencha, C. and Hailemikael, N. 2016. Performances, Breeding Practices and Trait Preferences of Local Chicken Ecotypes in Southern zone of Tigray, Northern Ethiopia. *Asian J. Poult. Sci*., 10: 158-164.

[20] Assefa, H., and Melesse, A. 2018. Morphological and Morphometric Characterization of Indigenous Chicken Populations in Sheka Zone, South Western Ethiopia. *Poult Fish Wildl Sci*., 6(2): 1-9. https://doi.org/10.4172/2375-446X.1000200

[21] Tareke, M., Assefa, B., Abate, T. & Tekletsadik. E. 2018. Evaluation of Morphometric Differences among Indigenous Chicken Populations in Bale Zone, Oromia Regional State, Ethiopia. *Poult. Sci. J*. 6(2): 181-190. https://doi.org/10.22069/psj.2018.14974.1329

[22] Dana, N., J. A. M. VanArendonk and L. H. Vander Waaij. 2011. Genetic and Phenotypic Parameter Estimates for Body weight and Egg production in Horro Chicken of Ethiopia. *Trop Anim Health Prod*., 43: 21-28. https://doi.org/10.1007/s11250-010-9649-4

[23] Mekonnen, H., Kalayou, S., Kyule, M., Asfaha, M., & Belihu, K. 2011. Effect of Brucella Infection on Reproduction Conditions of Female Breeding Cattle and Its Public Health Significance in Western Tigray, Northern Ethiopia. *Veterinary medicine international*. 354943. https://doi.org/10.4061/2011/354943

[24] EARO (Ethiopian Agricultural Research Organization). 2000. Summary of livestock research strategies. Animal science Directorate, EARO, Addis Ababa, Ethiopia. 73p.

[25] Cochran, W. G. (1963). Sampling Techniques, 2nd Ed., New York: John Wiley and Sons, Inc.

[26] Francesch, A., Villalba, I. & Cartañà, M. 2011. Methodology for Morphological Characterization of Chicken and Its Application to Compare Penedesenca and Empordanesa Breeds. *Animal Genetic Resources*, 48: 79–84. https://doi.org/10.1017/S2078633610000950

[27] SAS. 2008. Statistical Analysis System. Version 9.2, SAS Institute Inc., Cary, NC., USA.

[28] Semakula, J., Lusembo, P., Kugonza, D. R., Mutetikka, D., Ssennyonjo, J. and Mwesigwa, M. 2011. Estimation of live body weight using zoometrical measurements for improved marketing of indigenous chicken in the Lake Victoria basin of Uganda. Livestock Research for Rural Development. Volume 23.

[29] Guni, F. S., Katule, A. M. and Mwakilembe, P. A. A. 2013. Characterization of Local Chickens in Selected Districts of the Southern Highlands of Tanzania: II. Production and Morphometric Traits. Livestock Research for Rural Development. *25(190*). Retrieved March 14, 2019, from http://www.lrrd.org/lrrd25/11/guni25190.htm

[30] Dahloum, L., Moula, N., Halbouche, M. and Mignon-Grasteau, S. 2016. Phenotypic characterization of the indigenous chickens (Gallus gallus) in the northwest of Algeria. *Arch. Anim. Breed.* 59: 79-90. https://doi.org/10.5194/aab-59-79-2016

[31] Olawunmi, O. O., salako, A. E. and Afuwape, A. A. 2008. Morphometric differentiation and assessment of function of the Fulani and Yoruba ecotype indigenous chickens of Nigeria. Int. J. Morphol., 26(4): 975-980.

[32] Yakubu A., Kuje D. & Okpeku, M. 2009. Principal Components as Measures of Size and Shape in Nigerian Indigenous Chickens. *Thai Journal of Agricultural Science*, 42(3): 167-176.

[33] Daikwo, I. S., Okpe, A. A. & Ocheja, J. O. 2011. Phenotypic Characterization of Local Chickens in Dekina. *International Journal of Poultry Science*, 10(6): 444-447.

[34] Al-Qamashoui, B., Mahgoub, O., Kodim, I. & Schlecht, E. 2014. Towards Conservation of Omani Local Chicken: Phenotypic Characteristics, Management Practices and Performance Traits. *Asian Australas. J. Anim. Sci*., 27(6): 767-777. https://doi.org/10.5713/ajas.2013.13541

[35] 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 for Rural Development,* 25(9).

[36] Addis, G., Kefyalew, A. & Zewdu, W. 2014. Phenotypic Characterization of Indigenous Chicken Ecotypes in North Gondar Zone, Ethiopia. *Global Veterinaria*, 12(3): 361-368.

[37] Alemu, Y. & Tadelle, D. 1997. The Status of Poultry Research and Development in Ethiopia, Research Bulletin No. 4, Poultry Commodity Research Program Debrezeit Agricultural Research Center. Alemaya University of Agriculture, Ethiopia. pp. 62.

[38] Brown, M. M., B. Alenyorege, G. A. Teye and R. Roessler. 2017. Phenotypic Diversity, Major Genes and Production Potential of local Chicken and Guinea Fowl in Tamale, Northern Ghana, Asian-Australas J. Anim Sci., 30(10): 1372-1381. https://doi.org/10.5713/ajas.17.0145

[39] Ajayi, O. O., M. A. Adeleke, M. T. Sanni, A. Yakubu S. O. Peters, I. G. Imumorin, M. O. Ozoje, C. O. N. Ikeobi and O. A. Adebambo. 2012. Application of Principal Component and Discriminant Analyses to Morpho-Structural Indices of Indigenous and Exotic Chickens Raised under Intensive Management System. *Trop Anim Health Prod*., 44: 1247-1254. https://doi.org/10.1007/s11250-011-0065-1

[40] Yakubu, A. and Ari, M. M. 2018. Principal component and discriminant analyses of body weight and conformation traits of Sasso, Kuroiler and indigenous Fulani chickens in Nigeria. JAPS; Journal of Animal and Plant Sciences, 28(1): 46-55.

[41] Rotimi, E. A., Egahi, J. O. and Adeoye, A. A. 2016.Phenotypic characterization of Indigenous chicken population in Gwer-West, Benue State, Nigeria. World Scientific News, 3(53): 343-353.

[42] Krittaphak, B., Charan, C., Chainarong, W. and Watchara, L. 2016. Phenotypic characterization of Thai native black –bone chickens indigenous to northern Thailand, *Thai J. Vet. Med.* 46(4): 547-554. https://doi.org/10.56808/2985-1130.2773