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Research Article
On-Farm Phenotypic and Morphological Characterization of Indigenous Chicken Populations in Gambella Region, Ethiopia

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Abstract
Background and Objective: The first phase of characterization of indigenous chicken involves the identification of population based on morphological descriptors that can also provide useful information on the suitability of breeds for selection. The study was conducted to characterize on-farm phenotypic and morphological features of indigenous chicken population in selected districts of Gambella regional state, Ethiopia. **Materials and Methods:** Both purposive and random sampling techniques were used to collect the data and assessed through a semi-structured questionnaire survey. Data on visual appraisal and linear body measurements were obtained from a total of 600 matured local chickens of both sexes taken from 384 households. Linear body measurements were analyzed using the generalized linear model procedures. **Results:** The majority of the male chickens possessed red plumage color (30.5%) and most of chicken populations had single combs (80.84%), plain head shape (96.5%), yellow shanks color (85.34%) and feathered Shanks (1.67%). The male chickens were generally heavier (1.38 kg) than the female chickens (1.16 kg). The mean for body length, shank length, keel bone length, wingspan, wattle length, comb length and comb height of the cocks were 39.76, 10.19, 11.66, 65.77, 3.44, 5.28 and 2.15 cm, respectively. **Conclusion:** Variation in qualitative traits such as plumage color, feather distribution, comb type, earlobe color, shank feather, head shape and shank color indigenous chickens were evaluated in the study areas. The dominant plumage colour of the cocks was red followed by black and Gebsima (greyish with varying mixture) with other colors and in hens brown color followed by black and white.

Key words: Indigenous chicken, linear body measurements, morphological traits, phenotypic characterization, egg production

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Poultry is the largest livestock group in the world estimated to be about 23.39 billion consisting mainly of chickens, ducks and turkeys[1] and has remained to be important in the improvement of food security and livelihood[2] and contributing about 28-30% of all animal protein consumed in the world[1]. Such poultry species contributed important socio-economic roles for food securities, generating additional cash incomes and religious/cultural reasons[3,4]. Poultry products come either through commercial or backyard poultry rearing system. Under each system producers have distinct preferences for breeds, intensification and scales of operation. Commercial systems favor production of highly productive breeds under intensive system of management whereas the backyard/rural system prefer to rear indigenous breeds under extensive production system. The indigenous breeds though are less productive but have certain attributes of economic and cultural significance[5] and impact households' food security. Breeding for high productivity has caused loss of many commercial, research and indigenous genetic resources[6-8].

Many breeds are getting extinct leaving us without having even the very basic information about their characteristics and potential benefits. In such scenario, phenotypic characterization of available breeds is vital for proper management of these resources. Chickens play very significant socio-cultural and economic roles in most African societies. Native chicken production is vital in the livelihood of many house-holds member in the country, especially the resources for poor rural farmers providing nutrition for the family (good source of protein), a small cash flow reserve for times of celebrations or need and in some areas contributes to religious ceremonies and recreation[9,10]. Domestic fowl are important in the available market in the country given their organic way of being raised[10].

There are no cultural or religious taboos of any kind relating to the consumption eggs and poultry meat. Presently, food production is changing from being producers-driven to consumers-driven. The demand for certified products such as meat and eggs has emerged. The focus is now on local indigenous breeds or species[11]. Native chickens are widely distributed in the rural areas of tropical and sub-tropical countries, majority of which are found in the hand of the rural dwellers[12]. Among the major advantages of native chickens is general hardiness, ability to adapt to harsh environments, capable to survive on little or no inputs, in terms of feed, medications, shelter[12]. Native chickens are generally self-reliant, hardy, capable to withstand the harsh climate, minimal management and inadequate nutrition[13].

They survived largely on grasses, seeds, insects and other kitchen and farm wastes[14]. The indigenous poultry chickens represent valuable resources for livestock development especially in the rural poor's; this is because of their extensive genetic diversity which allows for rearing of poultry under varied environmental conditions[12].

Village chickens make substantial contributions to household food security throughout the developing world, as they represent almost 80% of poultry production in Africa[15]. Indigenous chickens serve as an investment for households in addition to their use as meat and egg sources both for consumption and selling[16,17]. These indigenous chickens are generally kept according to an extensive or scavenging system with few or no inputs for housing, feeding and health care[18]. These breeds are well adapted to the local climatic conditions, feed and management stresses, with better resistance to diseases[19]. Some major genes have been found potentially useful to the tropical production environment[20].

The first phase of indigenous chicken characterization involves the identification of populations based on morphological descriptors that can also provide useful information on the suitability of breeds for selection[21]. Up to now, the morphological traits of indigenous chickens has not been reported in Gambella regional state. In Gambella regional state, no previous studies have been carried out for the characterization and identification of local populations of chickens. Therefore, the present study sought first to characterize the local chickens of the Gambella regional state of selected districts based on some qualitative and quantitative traits.

MATERIALS AND METHODS

Description of the study area: The study was conducted in four districts of Gambella regional state of Ethiopia namely; Abobo, Gambella Ketema Zuria, Itang and Lareas shown in Fig. 1. The Gambella People's Regional State (GPRS) is located South West of Ethiopia between the geographical coordinates 6°28'38" to 8°34' North Latitude and 33° to 35°11'11" East Longitude, which covers an area of about 34,063 km^2. The Region is bounded to the North, North East and East by Oromia National Regional State, to the South and South East by the Southern Nations and Nationalities People's Regional State and to the Southwest, West and Northwest by the Republic of South Sudan. The mean annual temperature of the Region varies from 17.3-28.3°C and monthly temperature varies throughout the year from 27-35°C. The absolute maximum temperature occurs in mid-March and is about 45°C. The annual rainfall of the Region in the lower altitudes (500 m.a.s.l.) varies from 900-1500 mm. At higher altitudes

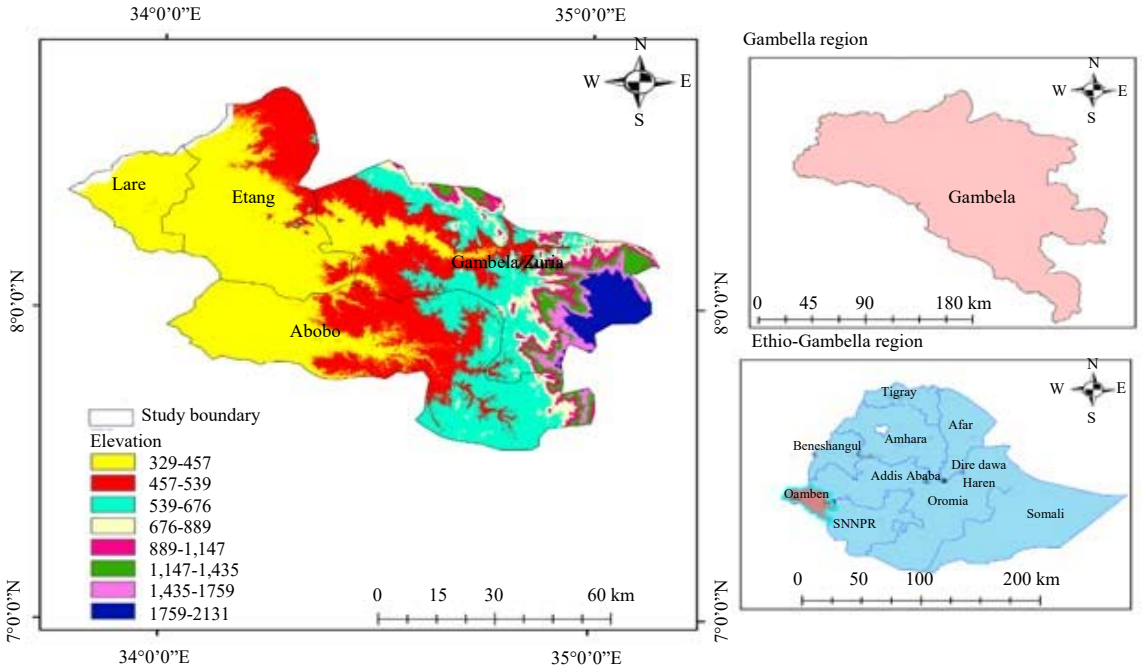

Fig. 1: Map of the study areas

(1900 m.a.s.l.), it ranges from 1,900-2,100 mm. The annual evapo-transpiration in the Gambella reaches about 1,612 mm and the maximum occurs in March is about 212 mm. Livestock population of the region is 285,102 cattle, 35,285 sheep, 107,083 goats, 904 horses, 100 mules, 2,150 donkeys, 301,531 poultry, 98,422 bee colonies[22].

Sampling techniques and data collection procedures: The field survey design and data collection procedure were performed according to the FAO's exploratory characterization approach[23]. Four districts were purposively selected from13 districts of the regional state namely Abobo, Gambella Ketema Zuria, Itang and Lare. A total of 384 households (96 households from each district) keeping chickens were randomly sampled for interview from the selected districts. The sample size was estimated by using the formula stated in a previous study conducted by Coletti[24].

$$N=\frac{Z^2 \propto 2\ P\ (1-P)}{d^2}=1.96^2\times\frac{0.5\ (1-0.5)}{0.05^2}=384$$

Where

P : Proportion of people who produces indigenous chicken

Z : 1.96 at 95% confidence interval

D : Expected margin of errors

0.05N : required sample size

Then, 96 households who possess a minimum of five adult chickens of indigenous ecotypes per household were randomly chosen from each district. Accordingly, a total of 384 households (96household's×4 districts) were used in the present study. Households possessing exotic chicken or their crosses in the neighborhood were purposely excluded in the study. Closely adjoining households were also skipped to avoid the risk of sampling chickens sharing the same cock.

Data collection: A semi-structured questionnaire was designed to collect data on flock characteristics, flock composition and production performances of the chickens. The interviews were conducted at farmers' houses. Moreover, phenotypic characterization of both qualitative and quantitative traits of local chicken populations was conducted ona total of 600 indigenous chickens of both sexes: 150 chickens (50 male and 100 female) from Abobo, 150 chickens (50 male and 100 female) from Gambella Ketema Zuria, 100 chickens (50 male and 100 female) from Itang and 150 chickens (50 male and 100 female) from Lare on matured chickens with approximately six months of age and above. Qualitative phenotypic data were collected based on feather

morphology, feather distribution, plumage colour, shank colour, earlobe colour, comb and head types following the checklist for phenotypic characterization of chickens[23].

Quantitative data on body weight, body length (the distance from the insertion of the neck to the tail), Neck length and shank length (length of the shank from the top of the flexed hock joint to the bottom of the footpad), comb length, wattle length, wingspan and keel bone length, were collected from both sex groups following the FAO's descriptor for chicken genetic resources[24]. Shank length, comb, wattle, keel lengths, wingspan, body length and neck length were measured using a tailor's graduated tape. Live body weight was measured in kilogram using a hanging scale.

Statistical analysis: Preliminary data exploration method (homogeneity test, normality test and screening of outliers) was employed before conducting the main data analysis. Discrete measurements on the qualitative morphological traits were performed using the frequency procedure of Chi-square (χ^2) test. Body weight and quantitative linear body measurements were analyzed using the Generalized Linear Model procedures[25]. Districts were fitted as fixed independent variables, whereas quantitative measurements were fitted as dependent variables. Means were compared using Tukey's Multiple Range Test procedure and were considered significant at $p<0.05$. Sex and location of the indigenous chickens were fitted as fixed independent variables. When differences were significant, means were compared using Tukey's studentized range test method. All statements of statistical differences in quantitative data were based on $p<0.05$.

RESULTS AND DISCUSSION

The flock composition of indigenous chickens in the study area: The flock composition households are presented in Table 1. The survey results indicated that, the average flock size per household in Abobo, Gambella Ketema Zuria, Itang and Lare districts were 15.76, 13.72, 13.44 and 11.42, respectively. The overall mean of the flock size per household in the study area was 13.59 and the overall number of hens, cocks, cockerels, pullets and chicks in the study areas was 4.89, 1.72, 1.52, 2.01 and 3.44, respectively. The chicken population per household of Abobo district is significantly higher than others. There was no significant difference ($p<0.05$) in mean hen number among Abobo, Gambella Ketema Zuria and Itang districts.

The means of chickens in different age groups and proportion of the households owning size of chickens are in line with Assefa *et al.*[26] who reported 13 chickens per household for the Sheka zone, south western Ethiopia and, Aberra[4] who reported 11.9 chickens per household for South eastern Oromia regional State of Ethiopia. However, this result is higher than the results of Dessie and Ogle[27] who found 7.10 chickens per household for the central highlands of Ethiopia.

The current result agrees with the findings of Assefa *et al.*[26] who reported 2.4 cockerels per household for the Sheka zone, south western Ethiopia and significantly higher than the results of Aberra[4] who reported 0.74 Cockerels per household for South eastern Oromia Regional State of Ethiopia. The earlier report on the mean pullets (1.31 per households) in southeastern Oromia regional state of Ethiopia by Aberra[4] are lower than that observed in the current study result. The flock structure size variations reported in different parts of the Ethiopia might be due to the occurrence of diseases, presence of predators, availability of feed resources as well as the overall management and economic status of the households who regularly sell chickens to meet their immediate financial needs.

Reproductive and Productive performance: The mean age at first egg lying, number of eggs per clutch, number of clutches hen^{-1} years^{-1} and number of eggs per hen per year were given in Table 2. According to the current study, the mean age at first egg was significantly ($p<0.05$) different among the study districts. Hens in Abobo and Gambella Ketema Zuria started egg laying earlier at 6.08 and 6.13 months than those in Itang (6.26 months) and Lare (6.35 months). This shows that pullets found in Itang and Lare districts relatively matured slower than those of the other

Table 1: Flock compositions of households in Gambella regional state (mean±SE)

Composition of flock.	Abobo (N = 96)	Gambella Ketema Zuria (N = 96)	Itang (N = 96)	Lare (N = 96)	Overall mean (N = 384)
Hens	5.24±0.82^{a}	5.06±0.54^{a}	4.97±0.97^{a}	4.32±0.98^{b}	4.89±0.06
Cocks	2.23±0.02^{a}	1.59±0.95^{b}	1.50±0.99^{b}	1.57±0.97^{b}	1.72±0.05
Cockerels	1.72±0.23	1.45±0.17	1.46±1.00	1.44±0.99	1.52±0.01
Pullets	2.39±0.22^{a}	1.95±0.20^{ab}	1.93±0.03^{ab}	1.76±0.84^{b}	2.01±0.02
Chicks	4.18±0.36^{a}	3.66±0.24^{a}	3.57±0.99^{a}	2.33±0.01^{b}	3.44±0.09
Avn/chicken/HH	15.76±0.03^{a}	13.72±0.94^{b}	13.44±0.4^{b}	11.42±0.01^{c}	13.59±0.16

^{a,b,c}Means across a raw with different superscript letters are significantly ($p<0.05$) different. SE: Standard error of the mean

Table 2: Reproductive and productive performance of indigenous chickens in Gambella region (Mean±SD)

Parameters	Abobo (N = 96)	Gambella Ketema Zuria (N = 96)	Itang (N = 96)	Lare (N = 96)	Overall mean (N = 384)
Age at first egg (months)	6.08±0.07^{c}	6.13±0.36^{bc}	6.26±0.13^{ab}	6.35±0.12^{a}	6.20±0.08
Number eggs per clutch	14.56±0.25^{a}	13.01±0.23^{b}	12.85±0.63^{b}	12.76±0.14^{b}	13.29±0.25
Number of clutches hen^{-1} years^{-1}	3.69±0.01	3.68±0.47	3.64±0.18	3.60±0.17	3.66±0.01
Number of eggs per hen per year	47.24±0.05^{a}	46.04±0.06^{ab}	44.7±0.08^{bc}	43.85±0.04^{c}	45.48±0.07
Eggs incubated per hen	10.74±0.13^{a}	9.66±0.12^{b}	9.58±0.11^{b}	8.56±0.04^{c}	9.64±0.19
Eggs hatched per incubated	8.03±0.33^{a}	6.78±0.32^{b}	6.54±0.31^{b}	5.67±0.35^{c}	6.76±0.36
Hatchability (%)	75.27±0.10^{a}	70.41±0.09^{b}	69.11±0.08^{bc}	66.69±0.05^{c}	70.37±0.11
Hatched chicks survived	4.95±0.22^{a}	3.94±0.21^{b}	3.69±0.13^{b}	3.22±0.17^{c}	3.95±0.23
Survivability (%)	61.73±0.01	57.76±0.04	56.58±0.03	56.48±0.01	58.14±0.02

^{a,b,c}Means within a row with different superscript letters are significantly different ($p<0.05$). SD: Standard deviation

districts. The current study showed that the overall mean age at first lay was 6.20 months. Similar results were found by Assefa *et al.*[26], who reported 6.3 months of mean age at first lay and the current finding was also agrees with Aberra[4], who reported 6.17 months of mean age at first lay. The overall mean age at first lay recorded in this study was longer than those reported by Mammo[28] and Halima[2], who found 5.35 and 5.5months of mean age at first lay, respectively for chickens. The reason for delayed age of sexual maturity of those chickens reared in the study areas could be attributed to lack of supplementary feeds and exposure of chickens to excessive high ambient temperatures, which are characteristics of all districts. The mean number of eggs per clutch of the Abobo chickens were significantly ($p<0.05$) higher than those of the other districts and the difference in the mean number of clutches per hen per year of the chickens were non-significant ($p<0.05$) among the study districts (Table 2). The mean numbers of clutches per hen per year of Abobo, Gambella Ketema Zuria, Itang and Lare districts were 3.69, 3.68, 3.64 and 3.60 respectively. The overall mean number of clutches per year (3.66) recorded in this study was higher than the findings of Assefa *et al.*[26], who reported the overall mean number of clutches per year 3.0 and lower than Moges *et al.*[29] and Aklilu *et al.*[30] who reported 3.83 and 5.2 per year respectively. This might be indicating the variation of broodiness behavior among the Ethiopian indigenous chickens. The average number of eggs per clutch found in the current study were14.56, 13.01, 12.85 and 12.76 in Abobo, Gambella Ketema Zuria, Itang and Lare districts respectively.

The number of eggs per clutch found in this study area agrees with the findings of Assefa *et al.*[26] who reported 11.2, 15.5 and 14.2 eggs in Yeki and racha and Masha respectively and the similar findings were reported by Eskindir *et al.*[30], Moges *et al.*[29] who found 15.0 and 12.94, 15.7 and 14.9 eggs in Horro, Jarso, Bure and Dale Worde's, respectively and lower than the results of previous study conducted by Dessie[3] who reported average17.7eggs per clutch per hen for five regions in Ethiopia. Accordingly, the mean egg production per hen per year of indigenous hens was estimated to be 47.24, 46.0, 444.7and 43.85 in Abobo, Gambella Ketema Zuria, Itang and Lare, respectively. Significant difference ($p<0.05$) was also observed in total egg production per hen per year among the studied districts.

The overall mean of the egg production per hen per year (45.48) in the study areas was similar with the findings of Assefa *et al.*[26] who reported 40.8 eggs per hen per year for the Sheka zone, south western Ethiopia. But, less than the that reported by Wondmeneh[31], who noted 66.5 eggs per hen per year of unimproved chickens. The overall average number of eggs incubated (9.64) and hatch ability percentage (70.37) of the current study were presented in Table 2. The results of this research is in accordance with the results of Aberra[4] who found 11.8 and 81.5% in South eastern Oromia Regional State of Ethiopia and Assefa *et al.*[26] who found 8.7 and 74.1% in Sheka zone, south western Ethiopia respectively. The current study showed the hatchability percentage more than that reported by Molla[32], (20%) and lower than that reported by Habte *et al.*[33] (98.6%) in Gomma Woreda, south western Ethiopia.

The current results was also comparable with that of Pedersen[34] who reported that the average number of eggs incubated per hen was 10.6 with average hatchability rate of 73%. The results observed in the present study are lower than those of Ssewannyana *et al.*[35] who reported higher hatchability percentage (87%) among native chickens of Uganda. These variations might be related to culling practices, nutritional and incubation management in different locations. Additionally, this could be explained by the management differences practiced by producers in different regions such as provision of supplementary feeding, housing, control of parasitic diseases and other managements. Hatchability of eggs among local chicken could be affected by several factors including age of the hen and the mating cock, type of nesting used, season and number of eggs incubated by the hen.

The mean survival rate of chicks in the current study (58.14 %) was concurrent with the findings of Edmew *et al.*,[36]; Assefa *et al.*,[26] who found 48.8 and 59.63% of survival rate of

Table 3: Plumage color variation of indigenous chickens in Gambella regional state

	Districts											
	Abobo			Gambella Ketema Zuria			Itang			Lare		
Parameters	M (50)	F (100)	Total (150)	M (50)	F (100)	Total (150)	M (50)	F (100)	Total (150)	M (50)	F (100)	Total (150)
Gebsima*	9(18)	5(5)	14(9.33)	7(14)	11(11)	18(12)	15(30)	8(8)	23(15.33)	17(34)	9(9)	26(17.33)
Red	21(42)	11(11)	32(21.33)	18(36)	12(12)	30(20)	13(26)	15(15)	28(18.67)	9(18)	19(19)	28(18.67)
White	5(10)	13(13)	18(12)	6(12)	21(21)	27(18)	4(8)	13(13)	17(11.33)	3(6)	15(15)	18(12)
Black	7(14)	17(17)	24(16)	9(18)	13(13)	22(14.66)	8(16)	29(29)	37(24.67)	9(18)	17(17)	26(17.33)
Grey	--	5(5)	5(3.33)	1(2)	3(3)	4(2.67)	3(6)	7(7)	10(6.67)	1(2)	5(5)	6(4)
Kokima*	2(4)	9(9)	11(7.33)	3(6)	7(7)	10(6.67)	1(2)	3(3)	4(2.67)	--	11(11)	11(7.33)
Key Teteruma*	--	3(3)	3(2)	--	2(2)	2(1.33)	-	1(1)	1(0.67)	1(2)	3(3)	4(2.67)
Lebework*	2(4)	7(7)	9(6)	1(2)	2(2)	3(2)	3(6)	5(5)	8(5.33)	5(10)	2(2)	7(4.66)
Tikur gebsat*	1(2)	4(4)	5(3.33)	3(6)	1(1)	4(2.67)	3(6)	--	3(2)	3(6)	1(1)	4(2.67)
Brown	1(2)	26(26)	27(18)	--	23(23)	23(15.33)	--	17(17)	17(11.33)	1(2)	18(18)	19(12.67)
Netch teteruma*	2(4)	--	2(1.33)	2(4)	5(5)	7(4.67)	--	2(2)	2(1.33)	1(2)	--	1(0.67)

Gebsima: Greyish with varying mixture, Lebework: White with golden breast color, Netch teteruma: White with black or red spots, Tikur gebsat: Black with wheaten or red strips; Key teteruma*: Red with white or black spots, Kokima: Grayish strips on brown background.*Names of plumage colors are in Amharic, Official Working Language of Ethiopia

chicks respectively and higher than the results of Molla[31]. The reasons of decreased survival rate of chickens in the current study was due to poor management, season, disease and predators. As indicated in Table 2, significant variations were also observed in some performance traits of indigenous chickens among the studied districts such as eggs hatched per incubated and chicks survived which might be due to the differences in management systems, availability of adequate feed resources in terms of quantity and quality, variations in disease prevalence and veterinary services[37]. Moreover, factors related to the genetic variations in key performance traits will give better opportunities to breeders to improve the genetic potentials of indigenous chickens through selection and systemic breeding[36].

Phenotypic and morphological variations in qualitative traits

Plumage color, feather morphology and distribution: Variation in qualitative traits such as plumage color, comb type, earlobe color, head shape and shank color of 600 indigenous chickens were evaluated in the study areas. The results indicated that the predominant plumage color of the indigenous chicken found in the Abobo and Gambella Ketema Zuria districts are red (21.33 and 20%) followed by black (16%) and white (18%) respectively (Table 3). The results of the current study indicated that the predominant plumage color of the indigenous chicken found in the Itang and Lare districts were black (24.67%) and red (18.67%) followed by red (18.67%) and black (17.33%) respectively (Table 3).

The predominant body feather color of the hens reared in the study districts of Abobo and Gambella Ketema Zuria was brown (26 and 23%) followed by black (17%)and white (21%) respectively and the body feather color of the hens reared in the districts of Itang and Lare was black (29%) and red (19%) observed predominantly. Hens with Netch teterma body feather were observed in all the study areas in few numbers. As shown in Fig. 2, the dominant body feather colour of the cocks was red followed by black with other colours. The indigenous chicken populations studied in the four districts showed a total of eleven distinct plumage colors (Table 3). The plumage colors found in the current study are in line with previous studies by Halima[2], Bogale[38], Aklilu *et al.*[30] and Hailemichael[39] for the Ethiopian indigenous chicken. The possible explanation for this is that several genes determining feather colors and patterns[40] and in the absence of selection on a preferred phenotype, they do segregate in the population[41].

Feather morphology of the studied chicken populations was normal (Table 4). This is similar with the findings of Bogale[37] and Hailemichael[39], who reported normal feather morphology in all the local chicken populations in Fogera woreda, Ethiopia and chicken populations in southern zone of Tigray, Ethiopia. The results of the present study indicated that 33.33% of the observed chickens were male, whereas 66.67% were female birds. The studied chicken populations had normal and naked neck feather distribution (Fig. 3). The normal feather distribution in the chicken populations was observed dominantly by 88.67, 94, 90 and 92.67% in Abobo, Gambella Ketema Zuria, Itang and Lare districts, respectively, while naked neck feather was dominant in Abobo and Itang districts (Table 4). Majority of the chicken populations in Abobo, (98%) Gambella Ketema Zuria (95.33%), Itang (96.67%)

Fig. 2(a-f): Plumage color distributions indigenous chickens in the study areas

Fig. 3: Naked neck, single and doublex combs of indigenous chickens observed in the study areas

Table 4: Morphological characteristics of indigenous chickens in Gambella regional state

	Districts				
Traits (Frequency, %)	Abobo [N (%)]	Gambella Ketema Zuria [N (%)]	Itang [N (%)]	Lare [N (%)]	Overall percentile (%)
Feather morphology -	150	150	150	150	
Normal	150(100)	150(100)	150(100)	150(100)	600(100%)
Feather distribution					
Normal	133(88.67)	141(94)	135(90)	139(92.67)	548(91.33%)
Naked neck	17(11.33)	9(6)	15(10)	11(7.33)	52(8.67%)
Shank color					
white	--	-	-	-	-
Red	5(3.33)	7(4.67)	2(1.33)	4(2.67)	18(3%)
Yellow	133(88.67)	129(86)	127(84.67)	123(82)	512(85.33%)
Grey	12(8)	14(9.33)	21(14)	23(15.33)	70(11.67%)
Ear lobe color					
White	12(8)	17(11.33)	11(7.33)	9(6)	49(8.17%)
White and Red	23(15.33)	19(12.67)	15(10)	35(23.33)	92(15.33%)
Red	28(18.67)	31(20.67)	33(22)	42(28)	134(22.33%)
Yellow	87(58)	83(55.33)	91(60.67)	64(42.67)	325(54.17%)
Comb type					
Single	118(78.67)	125(83.33)	127(84.67)	115(76.67)	485(80.83%)
Rose	1(0.67)	3(2)	2(1.33)	1(0.67)	7(1.17%)
Strawberry	2(1.33)	4(2.67)	1(0.67)	3(2)	10(1.67%)
Double	29(19.33)	18(12)	20(13.33)	31(20.66)	98(16.33%)
Head shape					
Plain	147(98)	143(95.33)	145(96.67)	144(96)	579(96.5%)
Crest	3(2)	7(4.67)	5(3.33)	6(4)	21(3.5%)
Hen spur					
Present	57(38)	61(40.67)	59(39.33)	64(42.67)	241(40.17%)
Absent	93(62)	89(59.33)	91(60.67)	86(57.33)	359(59.83%)
Shank feather					
Present	2(1.33)	1(0.67)	3(2)	4(2.67)	10(1.67%)
Absent	148(98.67)	149(99.33)	147(98)	146(97.33)	590(98.33%)

and Lare (96%) had plain head and chicken populations in Gambella Ketema Zuria (4.67%) had relatively more crested head (Table 4). This result agrees with a previous study by Hailemichael[39] who reported that chicken populations in Endamehoni (56.25%) and Ofla (57.92%) had plain head while chicken populations in Raya-azebo (53.33%) had crested head.

The difference within and among each district in terms of head shape could be considered as one of the most important morphological characteristics to classify different populations of indigenous chickens. According to Aberra and Tegene[42], 83.2% of the chicken populations in southern region of Ethiopia had normal feather distribution followed by Naked-neck (7.9%), feathery shank and feet (2.0%). However, in the current study chickens with feathery shank were rarely observed in Abobo (1.33%), Gambella Ketema Zuria (0.67%), Itang (2%) and Lare (2.67%) (Table 4). The reason might be due to the difference in breed type and the agro-ecology of the environment in which the birds inhabited.

From the investigated chicken populations four comb types were observed in single, doublex, strawberry and rose comb types were the most dominant ones, respectively (Table 4). The single combed chicken populations from Abobo, Gambella Ketema Zuria, Itang and Lare were observed 78.67%, 83.33, 84.67 and 76.67% respectively, whereas doublex comb were 19.33, 12, 13.33 and 20.66% in the respective districts. These frequencies are almost similar with the findings of Badubi *et al.*[43] who reported about 90% of the indigenous chickens in Botswana to be single combed, while very low proportion were rose (4.9%) and pea (1%) combs. But, these frequencies are in agreement with the findings of Aklilu *et al.*[30] who reported that 33.49 and 48.65% of chicken in Horro and Jarso were single comb type. Halima[2] and Dana *et al.*[44] reported that 50.72 and 53% of chicken population had pea comb in North West Ethiopia and other different parts of Ethiopia.

Four shank colors were observed in both the studied indigenous chicken populations (Table 4). The color of the shank in chickens was predominantly yellow in all districts. The proportion of chickens having yellow shanks was dominant in Abobo, (88.67%) Gambella KetemaZuria (86 %) Itang (84.67%) and Lare (82%). The results of the current study agrees with

the findings of Hailemichael[39] who reported that the proportion of chickens having yellow shanks was dominant in Ofla (68.33%) and in Endamehoni (47.08%). This result also agrees with the findings of Nigussie *et al.*[44] and Halima[2] who reported yellow shank as the most prevalent trait in indigenous chicken populations found in other parts of Ethiopia. Grey colored shank (15.33%) was predominant in chicken populations of Lare district. This result contradicts with the findings of Egahi *et al.*[45] who reported 42.2% black shank in Nigerian indigenous chickens. Yellow is due to dietary carotenoid pigments in the epidermis when melanic pigment is absent.

Varying shades of black are the result of melanic pigment in the dermis and epidermis. When there is black pigment in dermis and yellow in epidermis, the shanks have greenish appearance. In the complete absence of both pigments, the shanks are white. In the current study four earlobe colors were observed in the characterized chicken populations (Table 4). The yellow earlobe was the commonest color in Abobo (58%), Gambella Ketema Zuria (55.55 %), Itang (60.67%) and Lare (42.67%) districts. The proportion of chickens with yellow earlobe was almost comparable among studied districts. The current result contradicts with the finding of Hailemichael[39] who reported 54.58% white earlobe in Endamehoni and 32.92% red earlobe in Ofla; whereas, the white (35.83%) earlobe was dominant in Raya-azebo. According to Dana *et al.*[44], the proportion of white, red and yellow earlobe was 40, 52 and 8%, respectively in indigenous chickens. The current findings contradict with Aberra and Tegene[43] who reported that the white earlobe ranged from 30.4-34.9% and agree with Eskindir *et al.*[30] who found 49.5% red earlobe in Horro and Jarso ecotypes.

Quantitative traits and their Variations in both sexes: The body weight and other measurements of male and female chicken populations in the four districts are presented in Table 5. The mean body weight of adult males and females were significantly ($p<0.05$) different between the study districts. The adult male and female chickens in Abobo and Gambella Ketema Zuria were significantly heavier when compared to their counterparts in Itang and Lare districts. The body weight of adult males were 1.54, 1.37, 1.32 and 1.28 kg in Abobo, Gambella Ketema Zuria, Itang and Lare district respectively, this result agrees with the findings of Hailemichael[39], who reported that the body weight of adult males were 1332, 1246 and 1241 g in Raya-azebo, Endamehoni and Ofla district, respectively. Aberra[4] reported that the body weights for adult male indigenous chickens were 1.40, 1.37 and 1.40 kg in the high-, mid- and lowland agro-ecological zones of Southeastern Ethiopia. Eskindir *et al.*[30] also reported 1690 g body weight for Horro and 1420 g for Jarso male ecotypes which is lower than the findings of Halima[2] (2049 g) for males in northwest Ethiopia. While the body weight for adult females were 1.25, 1.19, 1.12 and

Table 5: Linear body measurements of indigenous chicken populations in Gambella region, Ethiopia (mean±SE)

		Districts				
Morphological traits	Sex	Abobo (n = 150)	Gambella Ketema Zuria (n = 150)	Itang (n = 150)	Lare (n = 150)	Overall Mean±SE
Body weight (kg)	M	1.54±0.04^{a}	1.37±0.02^{b}	1.32±0.02^{b}	1.28±0.01^{c}	1.38±0.02
	F	1.25±0.01^{a}	1.19±0.03^{b}	1.12±0.02^{b}	1.09±0.03^{c}	1.16±0.02
Back length (cm)	M	21.12±0.84	21.36±1.45	21.33±1.46	21.42±1.11	21.31±1.22
	F	20.06±1.50	20.67±0.75	20.05±1.41	19.23±0.95	20.00±1.15
Body length (cm)	M	38.92±2.52^{b}	40.32±3.48^{a}	40.22±3.49^{a}	39.58±3.91^{b}	39.76±3.35
	F	37.35±3.93^{a}	37.66±1.96^{a}	37.24±3.93^{a}	35.48±2.07^{b}	36.93±2.97
Neck length (cm)	M	18.04±1.10	18.88±1.16	18.87±1.17	18.08±2.35	18.47±1.45
	F	17.29±1.36	16.96±1.25	17.19±1.35	16.25±0.94	16.92±1.23
Shank length (cm)	M	10.46±0.31	10.23±0.76	10.11±0.63	9.95±0.42	10.19±0.53
	F	8.62±0.31^{a}	8.59±0.22^{a}	8.40±0.25^{a}	7.81±0.47^{b}	8.36±0.31
Keel bone length (cm)	M	11.95±0.50	11.72±0.95	11.69±0.96	11.29±0.96	11.66±0.84
	F	10.52±0.49^{a}	10.22±0.35^{a}	10.08±0.89^{a}	8.45±0.26^{b}	9.82±0.49
Wingspan (cm)	M	67.18±5.41	65.42±5.55	66.43±5.54	64.06±9.12	65.77±6.41
	F	58.48±6.01^{a}	56.55±4.53^{b}	57.47±6.01^{b}	54.82±5.09^{c}	56.83±5.41
Wattle length (cm)	M	3.67±0.25	3.42±0.62	3.43±0.63	3.22±0.32	3.44±0.46
	F	1.00±0.12	1.04±0.10	1.01±0.12	1.00±0.08	1.01±0.11
Comb height (cm)	M	2.23±0.32^{a}	2.15±0.4^{ab}	2.14±0.43^{b}	2.06±0.19^{b}	2.15±0.35
	F	0.98±0.06	1.02±0.13	0.99±0.05	0.97±0.09	0.99±0.08
Comb length (cm)	M	5.28±0.57	5.35±0.84	5.25±0.85	5.23±0.79	5.28±0.76
	F	2.43±0.19	2.57±0.36	2.42±0.18	2.39±0.17	2.45±0.23

^{a,b,c}Means within a row with different superscript letters are significantly different ($p<0.05$)

1.09 kg in Abobo, Gambella Ketema Zuria, Itang and Lare districts, respectively which is in line with the findings of Hailemichael[41] who reported 1081, 1011 and 1007g body weight in Raya-azebo, Endamehoni and Ofla districts. The result of the current study also agrees with the findings of Aberra[4] who reported 1.24, 1.2, 1.23 kg body weight in the high-, mid- and lowland agro-ecological zones of Southeastern Ethiopia. Alemu and Dessi[46] found the body weight for adult female chickens (1035 g) in the Central Highlands of Ethiopia. Aklilu *et al.*[30] reported the body weight for Horro (1289 g) and Jarso (1116 g) which is higher (847.77 g) than the findings of Halima[2] for north-west Ethiopia and lower than the findings of Choprakarn and Wongpichet[47] who reported that male and female chickens enter maturity at 8-12 and 6-8 months of age and with 1.8-2.3 and 1.4-1.8 kg body weight, respectively.

The mean shank and keel length of adult males and females in Abobo and Gambella KetemaZuria districts were significantly ($p<0.05$) different from the other districts. The mean shank length (10.19 cm) of males found in this study is comparable with the findings of Dana *et al.*[44] who reported average of 9.1cm for the five chicken ecotypes in Ethiopia and Moges *et al.*[29] who reported 11.3 cm in Horro and 10 cm in Jarso ecotypes. But longer than the results of Hailemichael[39] who reported 8.69 cm in Southern Zone of Tigray, Ethiopia andAberra[4] who reported 7.50, 7.37, 7.41 cm in the high-land, mid-land and lowland agro-ecological zones of Southeastern Ethiopia respectively.

Similarly, the average female shank length (8.36 cm) is in line with the shank length (9.2 cm) in Horro and (8.5 cm) in Jarso ecotypes[30]. But longer than (6.6-7.8 cm) the five ecotypes of Ethiopia[44] and 7.07 cm in Southern Zone of Tigray, Ethiopia[39]. The body weight to shank length ratio is an indicator of degree of fleshing in relation to body size and the heavier the bird the higher would be the ratio[48]. Significantly long legs, large combs and wattles were observed in Abobo male chicken populations, which are important morphological traits that allow better heat dissipation in the tropical hot environment. The comb and wattles have a major role in sensible heat losses. This specialized structure makes up about 40% of the major heat losses, through radiation and convection of heat produced from body surfaces at the environmental temperature above 26.7°C[49].

As presented in the current study, the shank length, keel bone length and comb height are highly correlated with body weight ratio for all the study districts. Thus, the presence of variations in both morphologies and phenotypes among the indigenous chickens indicates an opportunity for genetic improvement through selection of the indigenous chicken genetic resources. According to Remes and Szekeley[50], difference in sizes of males and females is perceived as a key evolutionary feature that is related to ecology, behavior and life histories of organisms.

CONCLUSION

The overall mean of the flock size per household in the study area was significantly different ($p<0.05$) among the study districts. Variation in qualitative traits such as plumage color, feather distribution, comb type, earlobe color, shank feather, head shape and shank color indigenous chickens were evaluated in the study areas. The dominant plumage colour of the cocks was red followed by black and Gebsima with other colors. The main body feather color in hens was brown followed by black and white. The colour of the shank in cocks and hens was predominantly yellow, followed by grey. The average age at first mating and lay of indigenous chickens was significantly different among the study districts. Significant variations were also observed in some performance traits of indigenous chickens among the studied districts such as egg production per hen per year, eggs hatched per incubated and chicks Survived. The mean of body weight to shank length, keel bone length and comb height ratio for both groups of chickens were comparable across all the four districts. The authors' recommended an in-depth molecular characterization of the local chickens using the standard of characterization approach to identify suitable chicken ecotypes for defined production purposes.

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