ISSN 1682-8356
ansinet.com/ijps

INTERNATIONAL JOURNAL OF

POULTRY SCIENCE

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http://ansinet.com

OPEN ACCESS International Journal of Poultry Science

ISSN 1682-8356
DOI: 10.3923/ijps.2020.111.123

Research Article
Qualitative Traits Characterization of Three Local Chicken Ecotypes of Western Zone of Tigray, Northern Ethiopia

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Abstract

Background and Objective: Characterization of local chicken ecotypes based on qualitative morphological traits is very crucial to generate useful information for designing appropriate holistic breeding strategies that enhance sustainable management, utilization and conservation of the local chicken genetic resources. The study was conducted to characterize three local chicken ecotypes (lowland, midland and highland) in the western zone of Tigray, Ethiopia based on qualitative morphological traits. **Materials and Methods:** A total of 1642 matured chickens (619 from lowland, 548 from midland and 475 highland chicken ecotypes) were observed for phenotype expression of qualitative traits (body shape, spur presence, head shape, comb size, comb type, comb color, eye color, skin color, plumage color, breast feather color, back feather color, neck feather color, shank color, feather morphology, feather growth, feather distribution, earlobe presence, earlobe color and shank feather). Descriptive statistics using frequency procedure of SPSS version 22 was used to analyze the observed qualitative traits. Kruskal-Wallis Test was employed to test the effects of chicken ecotypes and sexes on the distribution of the observed qualitative traits. **Results:** The frequency of the distribution of eye color, comb color, plumage color, breast feather color, back feather color, neck feather color, earlobe color and shank color were significantly varied across three chicken ecotypes and sexes. The distribution of head shape, feather morphology, feather growth, earlobe presence and shank feather were similar among chicken ecotypes and sexes. The distribution of skin color, feather distribution and comb type was significantly different among chicken ecotypes but not between chicken sexes. The distribution of body shape, spur presence and comb size was significantly varied between chicken sexes but not among chicken ecotypes. **Conclusion:** The Variations in qualitative traits of the three local chicken ecotypes indicated that there is genetic diversity of the chicken population of the three local chicken ecotypes that may call for designing community based genetic improvement programs.

Key words: Qualitative traits, local chicken, ecotype, plumage color, comb type, comb color, earlobe color, shank color

Received: November 27, 2018 Accepted: May 24, 2019 Published: February 15, 2020

Citation: S. Markos, B. Belay and T. Dessie, 2020. Qualitative traits characterization of three local chicken ecotypes of western zone of tigray, Northern Ethiopia. Int. J. Poult. Sci., 19: 111-123.

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Competing Interest: The authors have declared that no competing interest exists.

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

INTRODUCTION

Ethiopia has 59.5 million poultry populations of which 90.85% are indigenous chickens, 4.76% are hybrid chickens and 4.39% are exotic breeds[1]. This huge local chicken populations reveal how they are nationally important. Farm Animal Genetic Resources are playing significant contributions in food security attainment, income generation and malnutrition and poverty reduction of Ethiopian populations. Local Chickens play great roles in pest and weed control, disease mitigation, healing, recreation, local timing, sources of organic fertilizer and serving as sanitizing agent and good converter of household wastes and leftover grains into valuable proteins (eggs and meat)[2]. They also create employment for underprivileged society members in many local communities[3]. Chickens can provide the start of the owner climbing the "Livestock ladders" leading to other livestock species or serve as "transport (transitional) bridge" from small livestock to large livestock species production[4]. They are the initial step on the livestock ladder "poultry are the seeds you sow to get the fruits, cattle"[5]. Generally, chickens are considered as "movable poor man's bank" because of ease management of chickens and their short reproduction cycles[6].

Ethiopian indigenous chicken ecotypes are heterogeneous population with no standardized characteristics and performances. They exhibit variations in qualitative and quantitative attributes[7-12]. This indicates the presences of a considerable diversity of phenotypic characters within and between indigenous chicken ecotypes and used as a huge potential for genetic improvements. Future sustainable improvement, utilization and conservation of local chicken genetic resources are dependent upon the genetic variations exist within and among them[13]. Design of appropriate holistic breeding programs is impossible for chicken breeds that have not been adequately characterized either phenotypically and/or genetically[14]. This call for Characterization of local chicken ecotypes in their production system paves way for designing appropriate holistic breeding programs and explores the variability. Genetic characterization is the most accurate method to evaluate genetic diversity between and within chicken breeds but needs high technology and cost[15,16]. Phenotypic characterization based on a large sample size provides a reasonable representation of overall genetic performance[17].

Several scholars have done different researches on Ethiopian local chickens to enhance sustainable poultry productivity through characterization of genetic variation among genotypes and their production environments. For instance, phenotypic and genetic characterizations of indigenous chickens have been done in selected areas of Ethiopia[8,18,19].

Phenotypic characterization based on morphological traits of Ethiopian indigenous chickens has been also made to generate information on genetic variations which are crucial to decisions on conservation and sustainable utilization[7,9,20-23]. No or little work has been done to characterize the local chicken ecotypes of western zone based on qualitative traits. Thus, this research was designed to contribute to filling the gap through characterizing the local chicken ecotypes of the western zone of Tigray by taking qualitative traits into consideration.

MATERIALS AND METHODS

Description of study area: The study was conducted in the three rural weredas (Kafta Humera, Welkait and Tsegede) of Western Zone of Tigray Regional State, North West Ethiopia. It is one of the five administrative zones of Tigray regional state and it has 4 districts (Setit Humera, Kafta Humera, Welkait and Tsegede) comprising of 81 kebeles in which 77 kebeles are rural (24, 25 and 28 kebeles from Kafta Humera, Tsegede and Welkait weredas, respectively) and 4 urban kebeles with distance that ranges 580-750 km from Mekelle, the capital city of Tigray.

It covers an area of 1.5 million hectares with Kafta Humera accounts 48.13%, Setit Humera accounts 0.82%, Tsegede accounts 23.43% and Welkait accounts 27.62% (HuARC, Unpublished). The total cultivated land of the zone is 573,285 hectares (38.2%) while the uncultivated land accounts 927,000 hectares (62.8%). Of the total, 36.8% of the uncultivated land (341,195.25 ha) is covered by different plant species excluding Boswellia and Acacia Senegal while 185,510 ha (20%) of the unfarmed land is solely covered by both Boswellia and Acacia Senegal. The zone consists of three agro-ecological zones (lowland, midland and highland) in which kolla (lowland) represents 75%, weynadegga (midland) account for 15.7% and dega (highland) account for 9.3% of the land coverage of the zone.

The geographical location of the zone is 13°42-14°28 north latitude and 36°23-37°31 east longitude. The annual rainfall of the zone ranges from 600-1800 mm while the annual temperature ranges from 27-45°C in the lowland areas (Kolla) and 10-22°C in both midland and highland areas of the zone. The altitude of the zone ranges from 500-3008 m.a.s.l. The zone shares borders with Tahtay Adibayo, Tselemti and Asgede Tsimbla in the East, Sudan in West, Amhara region in

South and Eritrea in the North. The study area represents a remote, tropical climate where extensive agriculture is performed manually by large numbers of migrant laborers.

Throughout the zone, livestock is the predominant economic activity with about 95% of the total population engaged directly or indirectly in it[24]. Main cattle breeds raised in the Western Zone are the local Arado (in both high land and mid land areas) and Begait cattle (in lowland areas). Semi-intensive production is practiced in Humera district, which is more urban, while extensive production system is dominant in the Welkait and Tsegede districts. The main crops cultivated in the lowland areas of the zone are sesame, cotton and sorghum while teff, wheat, barley, noug, lentils, finger millet, field peas and fababeans are cultivated crops in both midland and high land areas of the zone.

Data collection: Visual appraisal of the appearance (observation of qualitative traits) of village chicken ecotypes was done and recorded, using a structured format for morphological description, following standard descriptor[25]. A total of 1642 of matured chickens were observed for phenotype expression of (qualitative or discrete traits) (presences of spur, plumage color and pattern, skin color, eye color, earlobe color and shank color and, feather morphology and distribution, comb type, comb size) and others following the phenotypic descriptor developed by FAO[25].

Statistical analysis: The qualitative morphological traits (plumage color and pattern, skin color, eye color, earlobe color and shank color and, feather morphology and distribution, comb type, comb size and others), of the local chicken ecotypes were analyzed for descriptive statistics using frequency procedures and cross-tabulation of SPSS version 22[26] . The Kruskal-Wallis Test option of the non-parametric tests of SPSS was employed to test the effects of the agro-ecology and sex of chickens on the proportion of each qualitative morphological trait.

RESULTS

Body shape, head shape and spur presence: Two body shape, two head shape and spur presences of local chicken ecotypes were observed in the study area (Table 1). Of the total chicken population studied only 16.1% were identified as blocky bodied, the remaining chickens had wedge body shape. The distribution of both blocky and wedge bodied chickens differed between sexes but not among chicken ecotypes. Higher proportion of both blocky and wedge bodied chickens was observed more in females than males.

The occurrence of crest headed chickens (55.8%) was more frequent than plain headed chickens in the study area even though the proportion of plain and crest headed chickens was not significantly differed between sexes and among chicken ecotypes.

The proportion of chickens with spur (56.8%) was more frequent than the proportion of chickens without spurs (43.2%). However, the distributions of chickens with and without spur were not significantly different among chicken ecotypes and sexes.

Comb size, comb type and comb color: The most frequent comb size of local chickens was small (59.7%) while large (27.5%) and medium (12.9%) were the second and third comb sizes of local chickens, respectively in the study area (Table 1). The distribution of the identified comb size was significantly different between chicken sexes but not among the three chicken ecotypes. A large comb (27.2%) was the first most frequent comb size of male local chickens and followed by medium (6.1%) and small size (2.6%). However, small comb (57.1%) was the first predominant comb size in female local chickens while medium comb (6.8%) was the second frequent comb size. The frequency of large comb size (0.2%) in female chickens was very rare.

Five comb types of local chickens (rose, single, pea, walnut/ strawberry and Duplex /v-shape, double) were identified in the study (Table 1). The Proportions of the identified comb types were significantly different among chicken ecotypes but not between chicken sexes. Overall, rose comb type appeared most frequently (53.3%) followed by single (24.4%), pea (17.7%), walnut/strawberry (2.7%) and Duplex/v-shape, double/(1.9%). Rose comb type was the most common (53.3%) comb type and was predominant in all chicken ecotypes and sexes.

Four comb colours (Pale, Red, Black and brown) were observed in this study with a marked difference among chicken ecotypes and between chicken sexes (Table 1). Most (61.9%) chickens had pale combs, followed by red combed chickens (37.4%). A higher proportion of pale combed chickens was observed in lowland ecotype (23%) than in midland (19.3%) and highland (19.6%) chicken ecotypes. Similarly, the proportions of pale combed chickens were higher in females (43.5%) than males (18.5%).

Plumage color: Diverse plumage colors of chickens were observed in the study area (Table 2). The proportions of plumage color attributes were significantly different across chicken ecotypes and sexes. Red plumage color was the most frequent plumage color in all chicken ecotypes and sexes. Red

Table 1: Proportionate (%) occurrences of body shape, head shape, comb type and size, spur presence, comb color, eye color and skin color of local chicken ecotypes by agro-ecologies and sex

		Agro-ecology					Sex			
Character	Attributes	Lowland (n = 619)	Midland (n = 548)	Highland (n = 475)	Total (n = 1642)	X^2-test	Male (n = 590)	Female (n = 1052)	Total (n = 1642)	X^2-test
Body shape	Blocky	6.3	5.4	4.5	16.1	ns	4.0	12.2	16.1	*
	Wedge	31.4	28.0	24.4	83.9		32.0	51.9	83.9	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Spur presence	Present	21.9	19.2	15.7	56.8	ns	29.7	27.1	56.8	*
	Absent	15.8	14.1	13.3	43.2		6.2	37.0	43.2	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Head shape	Plain/*Ebab ras*	17.0	14.5	12.7	44.2	ns	15.7	28.5	44.2	ns
	Crest/*Cutyo*	20.7	18.9	16.2	55.8		20.2	35.6	55.8	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Comb size	Small	22.5	19.9	17.4	59.7	ns	2.6	57.1	59.7	**
	Medium	4.4	5.1	3.3	12.9		6.1	6.8	12.9	
	Large	10.8	8.4	8.2	27.5		27.2	0.2	27.5	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Comb type	Rose	17.0	21.7	14.7	53.3	*	25.0	28.4	53.3	ns
	Pea	8.5	2.7	6.5	17.7		1.6	16.1	17.7	
	Walnut/strawberry	0.7	0.4	1.6	2.7		0.4	2.3	2.7	
	Single	10.7	8.2	5.5	24.4		7.9	16.4	24.4	
	Duplex/v-shape, double)	0.9	0.4	0.6	1.9		1.0	0.9	1.9	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Eye color	Black	1.0	0.4	0.1	1.5	*	0.2	1.3	1.5	*
	Orange	12.7	9.2	9.9	31.9		10.2	21.6	31.9	
	Brown	3.1	5.2	1.9	10.2		2.8	7.4	10.2	
	Red	20.9	18.6	16.9	56.5		22.7	33.7	56.5	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Skin color	White	37.3	33.3	28.4	99.0	*	35.3	63.6	99.0	ns
	Yellow	0.1	0.1	0.3	0.5		0.2	0.2	0.4	
	Red	0.2	0.0	0.2	0.4		0.4	0.1	0.5	
	Pink	0.1	0.0	0.0	0.1		0.0	0.1	0.1	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Comb color	Red	14.3	13.8	9.3	37.4	*	17.5	19.9	37.4	*
	Pale	23.0	19.3	19.6	61.9		18.5	43.5	61.9	
	Brown	0.0	0.2	0.0	0.2		0.0	0.2	0.2	
	Black	0.4	0.0	0.0	0.4		0.0	0.4	0.4	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	

*: Significant at $p<0.05$; ns: non-significant at $p>0.05$ and n: No. chickens observed

plumages appeared most frequently (51.2%) and followed by *Gebsima* (grayish) (18.2%), *Anbesima* (multicolor) (8.9%), *Netch Teterma* (5.2%), white (4.7%) and *Key Teterma* (4%). Whereas *zagrama* (2.3%), black (2%), *Kokima* (1.5%), *Seran*/white with red spots/(1.2%) and black *Teterma* (1%) were the rarely occurred plumage colors across chicken ecotypes and sexes. The presences of the huge variation in plumage colors might be attributed to absences of selection of breeders for this trait.

Feather distribution, feather morphology and breast feather color: All chickens had normal feather morphology. Normal feathered chickens (92%) were most frequent feather distribution while the occurrence of nacked neck chickens (8%) was very rare in the study area. Significant variations with respect to distributions of both normal feathered and nacked neck chickens were observed among the local chicken ecotypes. The frequency of nacked neck chickens was less frequent than normal feathered chickens in all three chicken ecotypes. However, the frequency of nacked neck chickens in the lowland ecotype was much higher (7% of the chicken population) than in both midland (0.7%) and highland chicken ecotype (0.1%).

Significant variations with respect to proportions of breast feather colors were observed among chicken ecotypes and both sexes (Table 2). Overall, red color was the most frequent breast feather color (79.5%) and followed by white (10.1%), black (3%), *Zagrama* (2.3%), *Gebsima* (1.6%), *Anbesima* (1.2%), *Netch Teterma* (1.2%), *Kokima* (0.9%) and *key Teterma* (0.2%). Chickens with red breast feather colors were most frequent across the three chicken ecotypes and both sexes.

Table 2: Proportionate (%) occurrences of plumage, breast, earlobe and shank colors, feather morphology, growth and distribution, earlobe presences and shank feather of local chicken ecotypes by agro-ecologies and sex

		Agro-ecology					Sex			
Character	Attributes	Lowland (n = 619)	Midland (n = 548)	Highland (n = 475)	Total (n = 1642)	X^2-test	Male (n = 590)	Female (n = 1052)	Total (n = 1642)	X^2-test
Plumage color	White	1.8	1.0	1.9	4.7	*	1.6	3.1	4.7	*
	Black	1.2	0.5	0.3	2.0		0.2	1.8	2.0	
	Red	20.5	18.0	12.7	51.2		24.7	26.5	51.2	
	Gebsima/grayish	6.7	6.5	5.1	18.2		2.1	16.1	18.2	
	Anbesima/multicolor	2.4	3.2	3.3	8.9		3.5	5.4	8.9	
	Key Teterma[1]	1.4	1.2	1.5	4.0		1.3	2.7	4.0	
	Netch Teterma[2]	1.8	1.6	1.7	5.2		1.5	3.7	5.2	
	Kokima[3]	0.2	0.2	1.0	1.5		0.1	1.4	1.5	
	Seran (white with red spots)	0.7	0.1	0.4	1.2		0.6	0.5	1.2	
	Zagrama [4]	0.6	0.8	0.9	2.3		0.1	2.1	2.3	
	Black *Teterma*[5]	0.3	0.4	0.3	1.0		0.2	0.8	1.0	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Breast feather color	Black	1.4	0.9	0.7	3.0	*	0.5	2.6	3.0	*
	Red	30.5	27.3	21.7	79.5		30.6	48.8	79.5	
	White	4.2	2.2	3.7	10.1		3.5	6.6	10.1	
	Anbesima/multicolor	0.1	0.7	0.4	1.2		0.7	0.5	1.2	
	Key Teterma[1]	0.1	0.1	0.1	0.2		0.1	0.1	0.2	
	Gebsima/grayish	0.5	0.6	0.5	1.6		0.1	1.6	1.6	
	Zagrama[4]	0.6	0.8	0.9	2.3		0.1	2.1	2.3	
	Netch Teterma[2]	0.2	0.6	0.4	1.2		0.3	0.9	1.2	
	Kokima[3]	0.1	0.1	0.7	0.9		0.0	0.9	0.9	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Shank color	Yellow	14.8	12.3	14.0	41.1	*	18.1	23.0	41.1	*
	Black	0.5	0.6	1.1	2.3		0.3	1.9	2.3	
	White	15.5	15.4	10.9	41.9		14.7	27.2	41.8	
	Blue	3.1	2.5	0.2	5.8		0.9	5.0	5.8	
	Green	3.4	1.9	2.7	8.0		1.9	6.1	8.0	
	Green-blue	0.3	0.7	0.0	1.0		0.1	0.9	1.0	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Feather morphology	Normal	37.7	33.4	28.9	100.0	ns	35.9	64.1	100.0	ns
	Others	0.0	0.0	0.0	0.0		0.0	0.0	0.0	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Feather growth	Fast	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
	slow	0.0	0.0	0.0	0.0	ns	0.0	0.0	0.0	ns
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Feather distribution	Normal	30.5	32.6	28.9	92.0	*	33.4	58.6	92.0	ns
	Necked neck	7.2	0.7	0.1	8.0		2.6	5.5	8.0	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Earlobe color	White	1.7	1.4	0.3	3.3	*	0.4	3.0	3.3	*
	Red	8.4	8.7	8.3	25.5		13.0	12.5	25.5	
	Black	0.8	0.3	0	1.1		0.1	1.0	1.1	
	White-red	26.8	23.0	20.3	70.1		22.5	47.6	70.1	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Earlobe presences	Absent	0.0	0.0	0.0	0.0	ns	0.0	0.0	0.0	ns
	Present	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Shank feather	Present	0.0	0.0	0.0	0.0	ns	0.0	0.0	0.0	ns
	Absent	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	

*: Significant at $p<0.05$; ns: non-significant at $p>0.05$ and n: No. chickens observed

Eye color: Four eye colors (black, orange, brown and red) were observed in this study with marked differences across chicken ecotypes and sexes (Table 1). Most (56.5%) of chickens had red eye color, followed by orange (31.9%), brown (10.2%) and black (1.5%). The occurrences of red and orange- eyed chickens were higher in lowland than both midland and highland chicken ecotypes. Similarly, red and orange-eyed chickens were more frequent in females than in males.

Table 3: Proportionate (%) occurrences of neck and back colors of local chicken ecotypes by agro-ecologies & sex

		Agro-ecology					Sex			
Character	Attributes	Lowland (n = 619)	Midland (n = 548)	Highland (n = 475)	Total (n = 1642)	X^2-test	Male (n = 590)	Female (n = 1052)	Total (n = 1642)	X^2-test
Back feather color	White	1.8	1.0	1.9	4.8	*	1.6	3.2	4.8	*
	Black	1.3	0.6	0.3	2.2		0.3	1.9	2.2	
	Red	20.6	17.8	12.8	51.2		24.6	24.6	51.2	
	Gebsima[6]	6.5	6.5	5.0	18.0		2.1	15.9	18.0	
	Anbesima[7]	2.5	3.2	3.3	9.0		3.6	5.4	9.0	
	Key Teterma[1]	1.4	1.2	1.5	4.0		1.3	2.7	4.0	
	Netch Teterma[2]	1.8	1.6	1.7	5.2		1.5	3.7	5.2	
	Kokima[3]	0.2	0.2	0.9	1.4		0.0	1.4	1.4	
	Seran[8]	0.7	0.1	0.4	1.2		0.6	0.5	1.2	
	Zagrama[4]	0.6	0.8	0.9	2.3		0.1	2.1	2.3	
	Black *Teterma*[5]	0.2	0.4	0.3	0.9		0.2	0.7	0.9	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	
Neck feather color	White	3.4	1.8	3.2	8.3	*	2.5	5.8	8.3	*
	Black	1.5	0.9	0.6	2.9		0.4	2.5	2.9	
	Red	25.6	23.2	18.3	67.2		28.0	39.2	67.2	
	Gebsima[6]	4	3.5	2.2	9.7		0.6	9.1	9.7	
	Anbesima[7]	0.9	1.6	1.4	3.8		2.3	1.5	3.8	
	Key Teterma[1]	0.5	0.4	0.7	1.6		0.7	0.9	1.6	
	Netch Teterma[2]	1.0	1.0	0.8	2.7		1.1	1.6	2.7	
	Kokima[3]	0.2	0.2	0.9	1.3		0.0	1.3	1.3	
	Seran[8]	0.1	0.0	0.1	0.1		0.1	0.0	0.1	
	Zagrama[4]	0.6	0.8	0.9	2.3		0.1	2.1	2.3	
	Black *Teterma*[5]	0.1	0.0	0.0	0.1		0.0	0.1	0.1	
	Total	37.7	33.4	28.9	100.0		35.9	64.1	100.0	

*: Significant at $p<0.05$; ns: non-significant at $p>0.05$ and n: No. chickens observed. *Key Teterma*[1]: Red with white Strips, Netch Teterma[2]: White with black or red strips, Kokima[3]: Red brownish, *Zagrama*[4]: Brownish and Black *Teterma*[5]: Black with white strips, Gebsima[6]: Grayish, *Anbesima*[7]: Multicolor and *Seran*[8]: White with red spots

Skin color: The first predominantly frequent skin color in the studied chicken populations was white (99%) while the remaining yellow (0.5%), red (0.4%) and pink (0.1%) were the least frequent skin colors. Significant differences were observed among chicken ecotypes with respect to skin colors but not between chicken sexes (Table 1). Both lowland and midland chicken ecotypes had higher occurrences of chickens with white skin (37.3 and 33.3%, respectively) than highland ecotype (28.4%).

Shank feather and color: All chickens observed had shank without feather. Various shank colors (yellow, black, white, blue, green and green-blue) were identified in the study area (Table 2). Both white (41.9%) and yellow (41.1%) shank colors were most frequent and followed by green (8%), blue (5.8%), black (2.3%) and Green-blue (1%). There were significant differences with respect to shank colors' proportions among chicken ecotypes and between chicken sexes. In both lowland and midland ecotypes, the predominant shank color (15.5 and 15.4%, respectively) was white shank color while yellow shank color (14%) was the predominantly frequent shank colors of the highland chicken ecotype in the study area. Similarly, yellow shank color (18.1%) was the most frequent shank color of male chickens whereas white shank color (27.2%) appeared to be the predominately frequent shank color of female chicken populations.

Earlobe presences and color: All chickens had earlobes. Differences in earlobe colors were observed among chicken ecotypes and between chicken sexes (Table 1). Generally, most (70.1%) of the chickens had white-red earlobes. The second most frequent earlobe color was red (25.5%) while 3.3% of the chickens had white earlobes and 1.1% of the chickens had black earlobe which was the least frequent earlobe color. Higher proportions of chickens with white –red earlobes were observed in females (47.6%) than in males (22.5%) chickens. However, relatively higher proportions of chickens with red earlobes were observed in male (13%) than female (12.5%) chickens. Likewise, the frequency of chickens with white-red colored earlobe was higher in lowland chicken ecotype (26.8%) than midland (23%) and highland chicken ecotype (20.3%).

Back and neck feather color: Diversified back feather colors of local chicken ecotype (white, black, red, *Gebsima* (grayish), *Anbesima* (multicolor), *Key Teterma* (red with white strips),

Netch Teterma (white with black or red strips), *Kokima* (red brownish), *Seran* (white with red spots), *Zagrama* (brownish) and black *Teterma* (black with white strips) were identified in the study area (Table 3). Overall, most of the local chicken ecotypes observed in the study area had red (51.2%) back feather color followed by *Gebsima* (18%) and *Anbesima* (9%). The remaining back feather colors observed were *Netch Teterma* (5.2%), white (4.8%), *Key Teterma* (4%), *Zagrama* (2.3%), black (2.2%), *Kokima* (1.4%), *Seran* (1.2%) and black *Teterma* (0.9%), black *Teterma* being the least occurring back feather color. Relatively higher proportions of chickens with red back feather color were found in lowland ecotype (20.6%) than midland (17.8%) and highland (12.8%) chicken ecotypes. Equal proportions of chickens with red back feather color (24.6%) were found in both chicken sexes. However, the proportion of chickens with *Gebsima*/grayish back feather color was higher in female chickens (15.9%) than in male chickens (2.1%).

Various neck feather colors (white, black, red, *Gebsima*, *Anbesima*, *Key Teterma*, *Netch Teterma*, *Kokima*, *Seran*, *Zagrama* and black *Teterma*) were observed in the study area (Table 3). The occurrences of the neck feather color attributes were significantly different among chicken ecotypes and both chicken sexes. Most of the chickens had red neck feather colors (67.2%). The second neck feather color was *Gebsima* (9.7%) while 8.3 and 3.8% of chickens had white and *Anbesima* neck feather colors, respectively. The remaining neck feather colors observed were black (2.9%), *Netch Teterma* (2.7%), *Zagrama* (2.3%), *Key Teterma* (1.6%), *Kokima* (1.3%), *Seran* (0.1%) and black *Teterma* (0.1%) which were rarely occurring neck feather colors of local chicken ecotypes. Higher proportions of red neck feather colored chickens were observed in females (39.2%), than males (28%).

DISCUSSION

Diversified plumage, eye, skin, comb, shank and earlobe colors and body and head shapes, comb size and types of the local chicken ecotypes were detected. Significant variations were observed among the local chicken ecotypes in the majority of the studied qualitative traits. The significant variations in qualitative traits among the local chicken ecotypes indicate their genetic variations and environmental heterogeneity. This will serve as row material for designing and developing chicken ecotype specific demand driven and holistic genetic improvement programs which ultimately enhances new breed development, performance improvement, conservation and sustainable utilization of these local chicken genetic resources.

The higher proportion of wedge bodied local chickens reported in the current study agrees with the findings reported for most of the Fogera chicken population with wedge (88%) and with few blocky (12%) body shapes[9]. It, however, contradicted by the report that the presence of Blocky, Triangular and wedge of local male (76.4, 14.4 and 9.2%, respectively) and female chickens (95.4, 4.4 and 0.2%, respectively) in the indigenous chicken populations of Ethiopia[11].

The majority of the local chickens in this study have spurs while few with no spurs. This result was slightly agreed with the report that 71 and 29% of the Fogera chicken population had spurs and no spurs, respectively[9]. It, however, contradicted the findings reported that the non-spurred chickens are more frequent than the spurred ones in the local chicken populations of the central zone of Tigray[23] and Guji zone of Oromia National Regional states of Ethiopia, respectively[27].

The result also revealed that the occurrence of crest headed chickens were higher than plain headed chickens in this study. This may be due to farmers preferred to rear crest headed to plain headed chickens in the study area which is negative selection against plain head trait. This result agreed with the report that 51.8% plain headed and 48.8% crest head chickens were found in North West East[8]. However, it was much lower from 7% plain headed, 93% crest headed chickens reported in Fogera district[9], 28.83% crest headed and 71.7% plain in Horro district and 4.59% crest headed and 95.41% plain headed chickens in Jarso district[28], 28.2% crest and 71.8% plain headed in the central zone of Tigray[23] and 82.22% plain headed and 17.78% Crest was reported in Nigeria[29]. Other research findings also indicated that flat headed (46%) chickens are the most frequent followed by crest (34%) and snake (20%) headed chickens in the indigenous chicken populations of Ethiopia[11]. The crest has an autosomal incompletely dominant mode of inheritance and associated with ectopic expression of HOXC8 gene[30].

Three comb sizes (small, medium and large) of local chickens were identified in the study area. This result corroborated the findings reported that 54.5, 29.6 and 15.9% of the Tanzanian chicken populations to be small, medium and large comb sized chickens, respectively[31]. The same authors also reported that small (51.8%) and medium (22.2%) were found to be most predominant comb sizes in female chickens and large (12.3%) and medium (7.36%) comb sizes were most frequently observed comb sizes in male chicken populations in Tanzania. Furthermore, small combs are the most frequent comb sizes in the indigenous chicken population of Ethiopia[11]. Moreover, small combs (41.7%) were

the most frequent, followed by medium (36%) and large (22.3%) comb sizes of village chickens' genetic resources in the Abu-Dhabi Emirate of United Arab Emirate[32]. However, it disagrees with the findings reported that large combs were the most frequent combs in the local chickens of Ethiopia[33] and Nigeria[34]. Combs are important head characteristics of chickens that allow for better heat loss in the tropical areas[34,35].

All local chicken ecotypes had normal feather morphology in the study area. This result is in line with the findings reported that village chickens in the Philippines had normal feather morphology[36]. Furthermore, 100% of Pakistani, Fayomi and rare chicken breeds of the Abu-Dhabi Emirate had normal feather and 87.5 and 12.5% of the Kuwaiti chickens of the Abu-Dhabi Emirate had normal and silky feather morphologies, respectively[32]. However, it contradicted by the findings reported that the feather morphology of Ethiopian village chickens[11] and Kerala chickens[32] had silky and frizzle feather, respectively. Variety of feather morphologies of village chickens had been reported in Sri-Lanka[37]. Such morphological variations may be arising due to variations in single qualitative genes in the gene pool of village chickens[37,38].

Normal feathered chickens were most frequent while the occurrences of nacked neck chickens were very rare in the study area. However; the frequency of nacked neck chickens in the lowland ecotype was much higher than in both midland and highland chicken ecotypes. Because they are highly adaptable to a very hot ecological zone (lowland) than cold (both highland and midland) zones[39]. This might be due to their nacked-neck character which is described as the expression of the major gene found in local chicken populations of the tropics and has desirable effects on heat tolerances[40]. A nacked neck gene is a dominant gene responsible for feather loss in the neck region[41] and it may also increase feed efficiency, growth rate, disease résistance and had desirable effects on heat tolerance and adult fitness[11,42]. Moreover, the reason for the rare occurrences of the nacked-neck chickens might be farmers under the study area prefer to rear normal feathered chickens as they have higher market demand and consumers prefer to consume products (meat and eggs) of normal feathered chickens. This is an indication of a negative selection against nacked neck character. Generally, most of the households following an Orthodox Tewahdo Religion responded that necked neck chickens are Muslim followers' chickens. The proportion of nacked-neck chickens in this study was slightly similar to value (6.79%) reported from village chickens of Bekwarra, Nigeria[43] but higher than (0%) reported from Fogera district of Ethiopia[9], from five (Farta, Mandura, Horro, Konso and Sheka) districts of Ethiopia (2%)[11], from Tanzania (5.48%)[31], Abu Dhabi Emirate, UAE (2.3%)[32] and central zone of Tigray (0.6%)[23].

The proportions of the identified comb types were significantly different among chicken ecotypes but not between chicken sexes. Rose comb type was the most common comb type and was predominant in all chicken ecotypes and sexes. This result agrees with the findings reported that rose comb type was predominant comb type of local chicken populations in Fogera (53%)[9] and Horro (48.2%)[28] districts. Moreover, the majority of the central Tigray local chickens possessed comb type with rose (44.3%) followed by single (39%) and pea (15.7%)[23]. However, it disagrees with the findings reported that 50.72, 53 and 33.49% of chickens in North West Ethiopia[8], five (Farta, Mandura, Horro, Konso and Sheka) districts[11] and Jarso district[28] of Ethiopia to be a pea comb type, respectively. It was also reported that 100, 43.33 and 87.4% of chickens from Bangladesh[10], Nigeria[29] and Tanzania[31] to be a single comb type, respectively. Moreover, 96.45% of Nigerian local chickens had single comb type and 0.44% pea comb type[34]. In Sir-Lanka, single comb was the most frequent comb type among six phenotypic groups (normal village chicken, nacked neck chicken, Crest/crown chicken, Giri raj chicken, commercial cross and frizzle feather chicken) while the longer leg chickens possessed pea and rose comb types[37]. The variation in the occurrence of comb types may be attributed to the difference in the frequencies of alleles and interaction of different genes responsible for the comb types and their expression. The heredity of comb types of chickens is also attributed to two autosomal pairs of genes (RR for Rose type and PP for Pea type) [44]. Research findings in Philippines[45], Nigeria[43] and India[46] revealed that single comb was the most common comb types of chickens. This might be due to the fact that the presence of single comb helps to reduce 40% of body heat, hence advantageous in tropical conditions[7].

The proportion of the identified eye colors were significantly different across chicken ecotypes and sexes ($p<0.05$). The majority of the chickens possessed red-eye color followed by orange, brown and black. However, contrasting reports had been reported that 100% of the chickens were found to be black-eyed chickens in Debrezeit Agricultural Research Center of Ethiopia[7]. Research findings indicated 87.84 and 9.01, 72.48 and 24.31% of chickens of Horro and Jarso districts of Ethiopia to be orange and red eye colours, respectively[28]. Orange eye (73.4%) and brown eye (16.3%) colors were found to be the first and second most frequent eye colors in Tanzanian chicken populations[31]. It was also

reported that the orange eye (96.6%) and Brown eye (2.2%) were the first and second most frequent eye colors of local chickens in the central zone of Tigray[23]. In Northwest Algeria, chickens with orange eyes (81.7%) were the most predominant ones followed by chickens with yellow (10.37%) and dark-brown (7.92%) eye colors[47]. Moreover, black (44.72%) and brown (27.74%) were the first and second most frequent eye colors of local chickens of Bekwarra, Nigeria[43]. Variation in eye colors to a large extent depends on the pigmentation (carotenoid pigments) and blood supply to a number of structures (Iris, retina, Uveal tract, Giliary) within the eye[28,44].

Significant differences were observed among chicken ecotypes with respect to skin colors but not between chicken sexes. White color was the most frequent while pink color was the least frequent skin color of chickens in the study area. This corroborated with findings reported that (77.03%) and (22.07%) and 68.81 and 28.44% of the chickens were found to be white and yellow-skinned chickens in Horro and Jarso districts of Ethiopia, respectively[28]. Similar results have been reported from Tanzania[31] where white skin color seemed to be more frequent (51.2%) than yellow (48.8%). Moreover, white (75.85%) and yellow (24.15%) were the most frequent skin colors of indigenous chickens of Bekwarra, Nigeria[43]. In contrary, bluish black (45%) and white (32%) were the first and second frequent skin colors of chickens in Fogera district[9]. Research findings also indicated that red (83.1%) was the first predominant skin color of chickens in Debrezeit Agricultural Research Centre[7]. Recent research findings also indicated that 53.1 and 42.9% of the chickens were found to be chickens with yellow and white-skin colors in North Gondar Zone of Ethiopia, respectively[39]. Yellow (52%) and white (48%) skin colors were found to be the first and second predominant skin colors of chickens in Ethiopia[11]. The variations in skin colors observed among chicken ecotypes might be due to differences in feedstuffs availability of chickens in the respective agro-ecologies. White skin color is the result of the absences of carotenoid pigments while yellow skin color is the result of presences of Carotenoid pigments (Xanthophylls) which are consumed through feeds and deposited under skin[48]. This could also be due to different genetic determination. Even if chickens are exposed to diets containing carotenoid, some chickens may be unable to deposit the pigment under the skin. The variations in the skin colors of chicken might have also some implication on the origin of different chicken groups as the literature revealed that the yellow skin color was inherited from Grey jungle fowl (*G. sonnerati*) and Ceylon jungle fowl (*G. lafayetti*) which hybridized with red jungle fowl (*G. gallus*)[45].

Diverse plumage color attributes (red, *Gebsima*/grayish, *Anbesima*/multicolor, *Netch Teterma*/white with black or red stripes, white, *Key Teterma*/red with white stripes, *Zagrama* (brownish), black, *Kokima* (red brownish), *seran*/white with red spots) of local chickens were observed in the study area. Red plumage color was the predominantly frequent plumage color in all chicken ecotypes and sexes. Similar results have been reported from Fogera districts[9], Debrezeit Agricultural Research Center[7] and North Gondar Zone of Ethiopia[39] where red plumage color seemed to be more frequent (39, 20.8 and 26.9%, respectively) than others. This result corroborated the findings reported that 32% red, 17.5% grayish/*Sigem*,17.1% brownish/*bunama*, 7.8% wheaten, 6.9% multicolor, 6.5% black, 5.4% white and 5.2% gold were the dominant plumage colors of chickens in the central zone of Tigray[23] . However, contrasting results have also been reported from North West Ethiopia[8], five (Farta, Mandura, Horro, Konso and Sheka) districts[11] and North Wollo Zone[20] where white plumage colored chickens (25.49, 18 and 17.6%, respectively) were found to be the most predominantly frequent. Research findings also indicated that black plumage color (33.3 and 32.22%, respectively) was the predominantly frequent plumage color of chickens in Bangladesh[10] and Nigeria[29]. Black (39.43%) and white (23.02%) were the first two predominant plumage colors of Nigerian indigenous chickens of Bekwarra[43]. Contrasting results have also been reported from Tanzania[31] where multicolored plumages appeared most frequently (50.8%) followed by black (18.6%), brown (9.81%) and white (8.37%). The occurrences of diversified plumage colors of local chicken populations across the three agro-ecologies might be the result of uncontrolled breeding of chickens in the rural areas since random mating is a typical breeding practice under scavenging production system. Previous findings indicated that huge variation in chicken plumage colors might be attributed to lack of conscious selection and breeding programs directed towards the choice of plumage colors[46,49,50]. This is also in support of findings reported that social preference, unconscious selection in addition natural selection and adaptation could be the main causes for the variations in plumage colors[51]. Such plumage color variations may also be due to culture and religion that arises from the ethnic and religious preference differences of keepers. Diversified plumage colors could be serving as a bright future for improvement of genetic potential of local chicken ecotypes through selection. The reason for the higher occurrences of chickens with red plumage colors might be people under the study area prefer to rear chickens with red plumage colors as they have higher market demand and consumers prefer to consume chicken products of red plumage colored chickens.

This is an indication of a positive selection against red plumage color or negative selection against other plumage colors might be practiced.

Significant variations with respect to proportions of breast feather colors were observed among the chicken ecotypes and sexes. In general, the red color was the most frequent breast feather color and followed by white, black, *Zagrama* (brownish), *Gebsima* (grayish), *Anbesima* (multicolor), *Netch Teterma* (white with black or red stripes), *Kokima* (red brownish) and *key Teterma* (red with white stripes). Chickens with red breast feather colors were most frequent across the three local chicken ecotypes and sexes.

The proportion of the identified diversified shank colors was significantly different among chicken ecotypes and sexes. Both white and yellow shank colors were the most frequent while Green-blue shank color was the least frequent shank color of chickens. Likewise, yellow and white shank colors were the most frequent shank color of male and female chickens, respectively. This result was in line with the results reported from Bangladesh that white (35%) and yellow (31%) shank colors were most frequent shank colors of chickens[10]. Moreover, similar results have been reported from Fogera districts[9], North West Ethiopia[8], five (Farta, Mandura, Horro, Konso and Sheka) weredas[11], Tanzania[31] and North Gondar zone of Ethiopia[39] where yellow shank color was the most predominantly frequent (44, 64.4, 60, 34.7 and 53.1%, respectively) shank colors of local chicken populations. Other research findings have also indicated that yellow and white shank colors (79.28 and 60.09 and 16.67 and 25.23%) were the first and second frequent shank colors of local chickens in Horro and Jarso districts of Ethiopia, respectively[28]. This result disagreed with the findings reported that chickens with black plumage colors were found to be most frequent chickens in Nigeria[29]. In general, diversified shank colors of local chicken populations were identified across the agro-ecologies of the study. This could be vital for future genetic improvement of local chicken ecotypes through selection. The occurrence of diversified shank colors might have been due to combinations of pigment controlling genes responsible for color determination. Production of carotenoid, dermal melanin and epidermal melanin is controlled by W+ and w; Id and id+ and E and e+ genes, respectively, with the consequent occurrence of various shank color shades[52]. Shank colors were also affected by social preferences and natural selection[53].

Diversified back feather colors of local chicken ecotypes were identified in the study area with marked differences among chicken ecotypes and sexes. Overall, most of the local chicken ecotypes observed in the study area had red back feather color followed by *Gebsima* (grayish) and *Anbesima* (multicolor). The remaining back feather color types observed were the least occurring back feather colors of local chickens. Relatively higher proportions of chickens with red back feather color were found in lowland ecotype than midland and highland chicken ecotypes. Equal proportions of chickens with red back feather color were found in both chicken sexes. However, the proportion of chickens with *Gebsima*/grayish back feather color was higher in female chickens than in male chickens.

Various neck feather color attributes were observed in the study area with significant differences among chicken ecotypes and exes. Generally, most of the chickens had red neck feather colors followed by Gebsima (grayish), white and *Anbesima* (multicolor) neck feather colors. The remaining neck feather color types observed were rarely occurring neck feather colors of local chicken ecotypes. Higher proportions of red neck feather colored chickens were observed in females than males.

Four comb colors (Pale, Red, Black and brown) were observed in this study with a marked difference among chicken ecotypes and between chicken sexes. Pale comb was the most frequent comb colors while brown comb was the least frequent comb colors of local chickens in the study area. Other research findings indicated that the pale combs (55.1%) were found to be the most frequent comb colors of local chicken ecotypes in Debrezeit Agricultural Research Centre of Ethiopia[7]. However, contrasting results have been reported in Bangladesh[10] and Tanzania[31] that red combs (55 and 73.9%, respectively) were found to be the first predominant comb colors. Research findings indicated that red comb (95.5%), brown comb (2.4%) and black comb (2.2%) were the common comb colors of chickens in the central zone of Tigray[23]. Dark red (77.83%) and light red (22.16%) were the two predominant comb colors of local chickens of the north west of Algeria[47]. The light colors of comb and skin might contribute to the birds' tolerance of heat stress[29].

All chickens had earlobes. Differences in earlobe colors were observed among chicken ecotypes and between chicken sexes. White-red earlobes were the most frequent while black earlobe color was the least frequent earlobe colors of chickens in the study area. This result was in line with the results reported that 60% of the chickens in Fogera district[9] and 49.54% of the chickens in Jarso district of Ethiopia[28] had white-red earlobes. Other research findings also indicated that Red (35.6%), white-red (33.6%) and white (28.7%) were the predominant earlobe colors while black, white-black and orange were the least frequent earlobe colors of local chickens in the central zone of Tigray[23]. Similar results have also been

reported from the southern highlands of Tanzania that 42.9% of chickens were with white-red earlobe colors[31]. In Northwest Algeria, white (73.96%) and red (16.81%) were the most frequent earlobe colors of indigenous chickens[47]. However, contrasting results have been reported from Debrezeit Agricultural Research Center of Ethiopia[7], Bangladesh[10] and Nigeria[29] that 67, 68.33 and 73.02% of the chickens had white earlobes, respectively. It has also reported that 44.8 and 52% of chickens in Horro district[28] and five weredas (Farta, Mandura, Horro, Konso and Sheka) of Ethiopia[11], respectively, had red earlobes. The variation in earlobe color of the local chickens observed in this study might be of genetic origin as earlobe colour is dependent upon several genetic factors. This is in support of findings reported that breeds or individuals with the same earlobe colors may differ considerably in genetic constitution with respect to earlobe color loci[54].

The existence of huge variations in plumage, back feather, neck feather and breast feather color, eye, skin, comb, shank and earlobe color might be attributed to their geographical isolation as well as long periods of natural and artificial selection. The sizes and colors of combs and wattles of chickens are also associated with gonad development and secretion of sex hormones[55]. Large wattle and long legs are important morphological traits that allow better heat dissipation in the tropical hot environment. This is also strengthened by the findings reported that these morphological traits make up about 40% of the major heat losses by radiation, convection and conduction of heat produced from body surfaces[55]. Gene coding for these traits are not major genes but the result of multiple genes and their interactions[40].

CONCLUSION

Diversified colors of plumage, eye, skin, comb, shank and earlobe, as well as body shape, head shape, feather morphology, feather distribution, comb size and types of the local chicken ecotypes were detected. The occurrence of different attributes of the majority of the investigated qualitative traits varied significantly among the three local chicken ecotypes. The significant variations in qualitative traits among the local chicken ecotypes indicate their genetic variations and environmental heterogeneity. The significant variations in qualitative traits among the local chicken ecotypes indicate their genetic variations. Red and white were the most dominant plumage and eye and skin and shank colors of chickens, respectively. Pale and white-red were the most dominant comb and earlobe colors, respectively. Wedge and crest, small and rose were the most dominant body and head shapes, comb size and types of chickens, respectively.

SIGNIFICANCE STATEMENT

The study discovered the diversified colors of plumage, eye, skin, Comb, shank and earlobe, as well as body shape, head shape, comb size and types of the local chicken ecotypes. The result of the study could be used as row material for designing and developing chicken ecotype specific demand driven and holistic genetic improvement programs which ultimately enhances new breed development, performance improvement, conservation and sustainable utilization of these local chicken genetic resources.

ACKNOWLEDGMENTS

The authors acknowledge the financial support from Humera Agricultural Research Center (HuARC) of Tigray Agricultural Research Institute (TARI) awarded to S. Markos (Gran Number: 2130207).

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