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Flock Composition and Socio-Economic Characteristics of Village Chicken Production System in Western Zone of Tigray, Northern Ethiopia

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Abstract: A survey was conducted in Western Tigray, Northern Ethiopia to assess flock composition, ownership, and gender roles in chicken production, as well as factors affecting chicken product consumption. Multi-stage sampling procedures were used to select three districts, nine sample peasant associations, and 385 respondents. Data was collected through a pretested, structured questionnaire and focused group discussions, and analyzed using SPSS software. The size of chicken flocks per household varied significantly among the three agroecologies, with an overall mean of 24.35±10.69 chickens per household. The effective population size (Ne) and rate of inbreeding (ΔF) were calculated to be 1263.69 and 0.04, respectively. Chicken and egg consumption were found to be influenced by cultural and religious festivals, farmer status, agroecology, breed, plumage color, shank type, comb type, feather distribution, and age. In all agroecologies, large-scale farmers had higher average annual chicken and egg consumption per household compared to small-scale farmers. The average annual chicken consumption per household was 7.76±0.68 for small-scale farmers and 20.79±0.68 for large-scale farmers. Similarly, the average annual egg consumption was 67.52±3.13 for small-scale farmers and 182.27±3.13 for large-scale farmers. Across the agroecologies, there were consistent preferences for certain plumage colors for chicken consumption. Red-colored chickens were ranked 1st, followed by greyish-colored chickens in 2nd place, and multicolored chickens in 3rd place. Chickens with full white and black colors were primarily used for mystical purposes in the study. The care of chickens involved participation from all family members, although the level of responsibility varied. Both husbands and wives were involved in the decision-making process related to chicken product utilization. Understanding flock composition, factors influencing chicken product consumption, ownership, and gender roles is essential for effective chicken breeding strategies.

Keywords: Egg, Consumption, Plumage Color, Inbreeding Coefficient, Agroecology

1. Introduction

Chickens play a vital role in the economies of small-scale farmers in developing countries like Ethiopia. According to the Rural Self-Help Development Agency (2011) [1], village poultry provides valuable resources to smallholder farmers in Africa, contributing to food security, poverty alleviation, and gender equality in disadvantaged groups. Village chicken production is globally recognized as an important means to accumulate capital, improve food security, and reduce malnutrition, poverty, and hunger in small households [2].

Poultry plays a crucial role in the growth, mental development, and school performance of small-scale farmers' children. It also improves labor productivity and reduces the risk of sickness by providing diverse food options [3]. Additionally, poultry serves as a scalable business opportunity, especially for larger livestock species [4], and is considered a pathway to poverty reduction and national food security [5].

Ethiopia's current poultry population is estimated to be 59.5 million, with non-descriptive native chickens accounting for 90.85%, hybrid chickens accounting for 4.76%, and exotic breeds accounting for 4.39% [6]. The significant population of indigenous chickens highlights the importance of farm animal genetic resources at the national level, as they contribute significantly to food security, revenue generation, malnutrition prevention, and poverty reduction in Ethiopian communities. The distribution of local chickens in Ethiopia, which accounts for approximately 97.3% of the total, across diverse agro-ecological zones demonstrates their robustness, adaptability to various environmental factors, and resilience to diseases and other challenges [7, 8].

Local chickens have an average of 4 clutches per year, with each clutch consisting of 12 eggs [6]. The live weight of local chickens at six months of age is approximately 1.6 kg for males and 1.3 kg for females [9]. However, their productivity falls short of expectations due to various factors. These include their low genetic potential, susceptibility to diseases and predators, limited access to feed resources, institutional and socioeconomic constraints, inadequate management practices [10-13], and a lack of comprehensive improvement strategies.

Understanding the flock composition, ownership, and gender roles in poultry production, as well as the effective population size of indigenous chicken ecotypes, is essential for designing and implementing sustainable breeding strategies and management interventions to improve chicken productivity and conserve local chicken genetic resources. Previous research has focused on various aspects, such as productive and reproductive [14] and carcass [15] performance evaluation of different local chicken ecotypes (Lowland, Midland, and Highland) in their natural breeding tracks. Additionally, studies have examined incubation and brooding practices [16], marketing and price determinants for chicken producers [17], production constraints and opportunities for village chickens [13], as well as breeding practices, objectives, and trait preferences of farmers [18]. Furthermore, egg quality characteristics of local chicken ecotypes have been evaluated under farmers' management conditions [19]. However, there is a lack of information on the flock composition, ownership, gender roles in chicken production, and effective population size of these local chicken ecotypes in the western Tigray region. This study aims to fill this gap by assessing these factors in the western Tigray region.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in three rural districts (Kafta Humera, Welkait, and Tsegede) of the Western Zone of the Tigray Regional State of Ethiopia in 2017. The study area is 580–750 km away from Mekele, Tigray's capital city. This covers an area of 1.5 million hectares with a total cultivated area of 573,285 hectares (38.2%), while uncultivated land accounts for 927,000 hectares (62.8%) [20]. The geographical location of the zone is 13° 42' to 14° 28' north latitude and 36° 23' to 37° 31' east longitude [21]. The zone's annual rainfall ranges from 600 to 1800 mm, whereas the annual temperature ranges from 27 to 40°C in the lowland areas to 10 to 22°C in the midland and highland areas of the zone. The Zone's altitude ranges from 500 to 3008 m a.s.l. The zone shares borders with East Ethiopia's Tahtay Adibayo, Tselemti, and Asgede Tsimbla, West Sudan, South Ethiopia's Amhara region, and North Eritrea.

2.2. Sampling Techniques

A multi-stage sampling technique was employed to select both peasant associations and respondents. All peasant associations of the three districts were stratified into lowland or kolla (500–1500 m.a.s.l.), midland or weynadega (1500–2500 m.a.s.l.), and highland or dega (>2500 m.a.s.l.) peasant associations (Markos *et al.*, 2017). Nine sample peasant associations were purposively selected to represent lowland, midland, and highland agro ecologies (four from lowland, three from midland, and two from highland) based on village chicken population density, chicken production potential, road accessibility, and agroecology representation. A total of 385 local chicken producers (160 from lowland, 131 from midland, and 94 from highland) were selected from the household package recipient list of each selected peasant association using the purposive random sampling technique. The number of respondents for each sample peasant associations was determined by proportionate sampling technique based on the households' size of the peasant associations sampled.

Sample Size Determination

The total number of respondents required for the study was determined on the basis of the formula developed by Cochran [22] for an infinite population (infinite population (infinite population ≥ 50,000).

$$\text{No} = \frac{Z^2pq}{e^2}$$

Where No= required sample size

Z= 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 (e.g. ±0.05% margin of error for confidence level of 95%)

d = desired absolute precision (5%)

p = is the degree of variation in the attributes calculated, which corresponds to the distribution of attributes in the population (50%), and q = 1-p. The estimated sample size was 385 respondents, and the numbers of respondents per single selected peasant association were determined by proportionate sampling technique as follows:

$$\text{W} = \frac{\text{ANo}}{\text{B}}$$

Where A=Total number of households (farmers) living in a single selected peasant association, B= Total sum of households living in all selected sample peasant associations and No = the total required calculated sample size.

2.3. Data Collection

Data on household characteristics, flock composition and size, ownership and gender roles in poultry production, labour division of household members in poultry management, and decision-making share of household members in poultry product utilization were collected through individual interviews using a pretested, well-structured questionnaire, and this was complemented by one focused group discussion per agroecology with 10–12 discussants per group.

2.4. Statistical Analysis

Qualitative survey data such as household characteristics, ownership and gender roles in poultry production, household members' labour division in poultry management, household members' decision-making share in poultry product utilization, foundation stock sources, and present breeding stocks were analyzed using descriptive statistics in SPSS version 22 [23]. The Kruskal-Wallis Test method of SPSS's non-parametric tests was used to test the effects of agroecology on the proportion of each qualitative survey's data. The GLM procedure of SAS 9.2 [24] was used to investigate the effects of agroecology on quantitative survey data.

Statistical Model:

$$Yij = \mu + Ai + Eij$$

Where Yij = the value of the respective quantitative survey data, μ = overall mean, Ai = the fixed effect of i^{th} agroecology and E ij =random error term.

Mean separation was carried out using the Tukey test for significant means. Ranking analyses were used for computing data on consumption preferences of chicken plumage colours and chicken product consumption prioritization among family members.

Indexes were used to calculate the data collected from rankings using weighed averages according to the following formula developed by Kosgey *et al*. [25] and: Musa *et al*. [26]

$$\text{Index} = \frac{\sum(Rn\times C1 + Rn-1\times C2 \ldots + R1\times Cn) \text{ for all individual factor}}{\sum(Rn\times C1 + Rn-1\times C2 \ldots + R1\times Cn) \text{ for all factors}}$$

and where R_n= the last rank (example if the last rank is 10^{th}, then R_n =10, R_{n-1} =9 and R_1 =1, C_n=% of respondents in the last rank and C = % of respondents ranked first.

2.5. Effective Population Size and Rate of Inbreeding

Both effective population size (Ne) and rate of inbreeding (F) were estimated for each agroecology separately, using the following formula developed by Falconer and Mackay [27]:

$$Ne = \frac{4NmNf}{Nm + Nf}$$

and the increase in inbreeding per generation (ΔF) = 1/ (2Ne) or (ΔF) =1/8Nm +1/8Nf; where Nm is the number of breeding cocks, Nf is the number of breeding hens and Ne is effective population size.

3. Results and Discussion

3.1. Household Characteristics of the Respondents

The demographic characteristics of households in the study zone are presented in Table 1. The sex analysis of the respondents revealed that the proportion of respondents of both sexes was homogenous across all agro ecologies. However, the proportions of male-headed households were higher than those of female-headed households in all agro ecologies. Overall, 83.4% of the total respondents were male heads, and the rest were female heads (16.6%). Similar results had been reported in the Tsegede district of Amhara [28], in the central zone of Tigray [29], and in the western zone of Tigray [14]. However, contrasting results have been reported from Ada'a and Lume districts of East Shewa of Ethiopia [30], in which the proportions of female-headed households were higher than those headed by males. The survey result also indicated that the proportions of the respondents' educational status significantly varied across agro ecologies. Of which, 41.3% of the respondents were illiterate, while 24.4% of them were found to be capable of reading and writing. About 15.3%, 11.4%, 6.5%, and 1% of the literate respondents had gone through the primary first cycle (1–4), primary second cycle (5–8), high school (9–12), and diploma program (12–3), respectively. Educational status identified under the current study was better than that reported from northwestern Ethiopia [7]. However, it was less than those reported from the Central Zone of Tigray [29] and Tsegede district of Amhara [28]. This might be due to the difference in access to educational services. The analysis of the marital status of the respondents showed that 82.1% of the respondents were married, whereas the remaining 7%, 10.6%, and 0.3% of the respondents were divorced, widowed, and unmarried, respectively.

Significant ($p<0.05$) variations were observed in the proportions of respondents following different religious types among agro ecologies. From the total respondents, 93.5% were followers of the Orthodox Christian church (93.5%), while the remaining 6.5% were Muslims. Similar results have been reported in both Atsbi-Wonberta and Alamata districts [31]. In contrast, Meseret [32] reported that there were more Muslim followers than Orthodox Christians in the Gomma district of Jimma zone. The existence of both religious groups in the study area implies that sustainable improvements in chicken productivity can be achieved if the interests of both religious followers are incorporated in the designing, planning, and implementation of holistic chicken productivity strategies.

Table 1. *Demographic characteristics of households (% of respondents).*

Household characteristics	Agro-ecological zones				X^2-test	P -value
	High altitude (n=94)	Mid altitude (n=131)	Low altitude (n=160)	Total (N=385)		
Sex of households					2.299 (n)	0.317
Male	80 (85.1)	113 (86.3)	128 (80)	321 (83.4)		
Female	14 (14.9)	18 (13.7)	32 (20)	64 (16.6)		
Educational status					6.126 (*)	0.047
Illiterate	40 (42.6)	64 (48.9)	55 (34.4)	159 (41.3)		
Read and write	21 (22.3)	31 (23.7)	42 (26.3)	94 (24.4)		
1^{st} -4^{th}	15 (16)	15 (11.5)	29 (18.1)	59 (15.3)		
5^{th} -8^{th}	9 (9.6)	14 (10.7)	21 (13.1)	44 (11.4)		
9^{th} -12^{th}	6 (6.4)	6 (4.6)	13 (8.1)	25 (6.5)		
12 +3	3 (3.2)	1 (0.8)	-	4 (1)		
Religion of households					8.116 (*)	0.017
Orthodox	87 (92.6)	117 (89.3)	156 (97.5)	360 (93.5)		
Muslim	7 (7.4)	14 (10.7)	4 (2.5)	25 (6.5)		
Marital status of households					3.058 (ns)	3.058
Married	80 (85.1)	111 (84.7)	125 (78.1)	316 (82.1)		
Divorced	7 (7.4)	7 (5.3)	13 (8.1)	27 (7)		
Widow /widower	7 (7.4)	13 (9.9)	21 (13.1)	41 (10.6)		
unmarried	-	-	1 (0.6)	1 (0.3)		

* ($p<0.05$) & ns ($p>0.05$) at p (0.05) and n = number households interviewed.

The average household age in the study area was 46.51±12.05 years (Table 2). This was far higher than the 36.9 and 37.7 years reported by Tadesse *et al.* [30] in Ada'a and Lume districts of East Shewa, respectively. It was also higher than 41.02, 40.86 and 43±10.9 years reported by Solomon *et al*. [33], Moges *et al*. [34] and Worku *et al*. [35] in Metekel zone of Northwest Ethiopia, Bure district of North West and west Amhara region of Ethiopia, respectively. The average family size in the Productive age category (≥15 and ≤60 years of age) was higher than the family size of the unproductive age categories (<15 and >60years of age). This will serve as an important input which will create a room for success in the design and implementation of sustainable poultry genetic improvement programs and the adoption of improved technologies in general. The overall mean family size of the study area was 6.01±2.35. This was higher than the national average of 5.2 persons [36], 4.02 persons per household for Metekel zone of Northwest Ethiopia [33] but comparable to 6.0±2.00 persons for west Amhara region [35] and 6.19±2.17 persons per household for Bure district of North West Ethiopia [34].

3.2. Flock/Herd Size and Species Composition

The mean livestock holdings and flock/herd structure per species per household are presented in Table 2. The mean number of oxen per household in the lowland was significantly lower than in the midland and highland agro ecologies (Table 2). This might be due to the variability in land cultivation methods practiced by farmers residing in all agro ecologies. In lowland, almost all farmers used tractors to cultivate their lands and human labour for threshing sorghum and sesame, and sometimes they used sorghum threshing machines, and they were not interested in keeping more than one ox with their herd. In addition, farmers with more than two oxen and/or steers typically select one ox or steer for breeding purposes and sell the remaining oxen. Whereas farmers usually keep more than one ox since they use oxen to cultivate their land and thresh cereal crops in both midland and highland agro ecologies. This was higher than the research findings of Moges *et al*. [34], who reported the mean number of cows, oxen, heifers, and steers, calves, and the mean total number of cattle per household were 0.99, 1.73, 0.62, 0.81, and 4.16 ±3.6, respectively, in Bure district of North West Ethiopia.

The average number of donkeys per household in highland and lowland was higher than in midland agroecology (Table 2). This might be due to the fact that people often use donkeys as carts for transporting water, cement, and other construction materials in addition to accomplishing their daily farming activities because most donkeys in the area, particularly in the lowlands, are large-sized donkeys called 'Sinnar'.

The overall mean herd and flock size per household were 11.93±8.67 for cattle, 15.73±14.06 for goats, 7.13±13.52 for sheep, and 1.2±1.2 for donkeys. This was higher than those reported in the Central Zone of Tigray [29] and Bure district of North West Ethiopia [34]. Significant variations in land sizes per household were observed among the three agro ecologies. The overall means of owned, rented, and total cultivated land size per household were 6.24±15, 6.93±10.14 and 13.15±20.9, respectively, in the study area. This was higher than the 1.28 hectares reported from the North West Amhara region [37], 1.23±1.23 hectares from the Bure district of North West Ethiopia [34], the 1.0 hectares [38], and the 0.58 hectares [29] from the lowland and midland of Central Tigray, and the national average landholding/household of 1.02 hectares [39].

Table 2. Socio-economic characteristics of households in the agro-ecologies of the study area.

Parameters	Agro-ecological zones			
	Highland mean ± SD	Midland mean ± SD	Lowland mean ± SD	Overall mean ±SD
Age (years)	42.95±10.82[b]	47.92±12.09[a]	47.46±12.35[a]	46.51±12.05
family size				
≤14 years	2.22±1.37[ab]	2.29±1.58[a]	1.93±1.31[b]	2.12±1.43
≥15 and ≤ 60	3.81±2.09[a]	4.02±2.20[a]	3.59±1.75[a]	3.79±2.00
> 60 years	0.04±o.25[b]	0.26±0.97[a]	0.13±0.39[ab]	0.15±0.64
Total	6.06±2.38[ab]	6.40±2.55[a]	5.67±2.12[b]	6.01±2.35
livestock holdings				
Cattle				
Cow	2.09±1.46[b]	6.26±5.51[a]	6.39±5.51[a]	5.30±5.17
Ox	1.86±1.00[a]	1.94±1.12[a]	1.43±1.23[b]	1.71±1.16
Heifers	1.26±0.79[c]	2.30±1.68[b]	3.74±2.53[a]	2.64±2.19
Steers	0.44± 0.52[c]	0.79±0.82[b]	1.04±1.01[a]	0.81±0.85
Calves	0.63±0.66[c]	1.41±1.16[b]	2.02±1.24[a]	1.47±1.22
Total	6.27±3.66[c]	12.70±8.26[b]	14.63±9.55[a]	11.93±8.67
Goat				
Doe (>6mth)	3.01±3.46[c]	7.80±5.40[b]	9.87±8.38[a]	7.50±7.00
Buck(> 6mth)	0.39±0.66[b]	0.78±0.74[a]	0.74±0.86[a]	0.68±0.78
Young female(3- 6 mth)	1.49±1.69[c]	3.73±2.51[b]	5.40±4.33 [a]	3.88±3.60
Young male (3-6mth)	0.66±0.92[b]	1.47±1.22[a]	1.55±1.64[a]	1.30±1.40
Kid (<3 mth)	1.13±1.42[c]	2.45±1.79[b]	3.09±2.62[a]	2.39±2.34
Total	6.68±7.63[c]	16.23±10.37[b]	20.64±16.81[a]	15.73±14.06
Sheep				
Ewe ((>6mth)	2.4±0.40[b]	1.91±4.30[b]	5.21±0.7[a]	3.41±7.11
Ram ((>6mth)	0.35±0.50[ab]	0.22±0.47[b]	0.44±0.99[a]	0.34±0.74
Young female(3- 6 mth)	1.287±1.81[b]	1.02±2.25[b]	2.32±4.6[a]	1.623±3.39
Young male(3- 6 mth)	0.5±0.799[b]	0.4±0.73[b]	0.86±16.81[a]	0.6±1.10
Lamb(<3 mth)	0.8±1.20[b]	0.7±1.60[b]	1.8±2.6[a]	1.2±2.10
Total	5.4±1.40[b]	4.2±1.20[b]	10.6±1.05[a]	7.13±13.52
Cultivated land (hectare)				
own	2.92±2.05[b]	3.59±4.5[b]	10.4±23.6[a]	6.24±15.90
rent	5.2±3.02[a]	7.32±12.4[a]	7.66±10.7[a]	6.93±10.14
total	8.08±3.55[b]	10.8±15.7[b]	18.04±28.5[a]	13.15±20.9

Values with different letters are significantly different ($p<0.05$)

3.3. Livestock Ownership and Role of Household Members

The analysis of the ownership of livestock species showed that the proportions of women and men owning cattle, small ruminants, and poultry differed among agro ecologies, but the ownership of equines was not significantly different across agro ecologies (Table 3). Respondents with cattle replied that men (40.5%) had the highest right to own cattle, followed by both women and men (35.6%), while women (11.9%) had the least right to own cattle in the study area. The respondents responded that men (37.1%) had the highest right to own a small ruminant in a given family, while women had the least right to own a small ruminant in a given family. However, the respondents replied that both men and women (76.9%) had the first-rank right to own poultry, while men (1%) had the least right to own poultry). Women (22.1%) had a much greater right to own poultry than men (1%) within a given family. Moreover, the respondents replied that equines were predominantly owned by men (34%), followed by both women and men (28.8%) and women (8.4%) in the study area.

The survey result revealed that all family members had participated in livestock management activities, even if the degree of involvement of the family members in all management aspects varied in the study areas (Table 4). The respondents indicated that both men and male children had the highest responsibility for taking care of cattle (56.7%), small ruminants (53.8%), and equines (48.3%), while men, women, and female children had the least responsibility for managing both cattle (0.3%) and equines (0.5%), and men, women, and male children had the least responsibility for taking care of small ruminants (0.3%) in the study area. In contrast, women and female children were the predominant poultry caretakers (59%) among the family members, followed by women (39.5%), and men and male children (0.3%) were the least responsible family members for taking care of poultry in the study area.

Table 3. Livestock ownership of household family members in three agro-ecological zones of western Tigray.

Livestock species	Agro- ecological zones				X^2-test	p- value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Cattle					13.64 (*)	0.001
Men	40 (42.6)	68 (51.9)	48 (30)	156 (40.5)		
Women	10 (10.6)	12 (9.2)	24 (15)	46 (11.9)		

Livestock species	Agro- ecological zones				X^2-test	p- value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
both	31 (33)	43 (32.8)	63 (39.4)	137 (35.6)		
No cattle	13 (13.8)	8 (6.1)	25 (15.6)	46 (11.9)		
Small ruminants					26.86 (*)	0.000
Men	32 (34)	67 (51.1)	44 (27.5)	143 (37.1)		
Women	9 (9.6)	13 (9.9)	18 (11.2)	40 (10.4)		
both	28 (29.8)	43 (32.8)	52 (32.5)	123 (31.9)		
No small\\ ruminants	25 (26.6)	8 (6.1)	46 (28.8)	79 (20.5)		
Equines					5.739 (ns)	0.057
Men	32 (34)	55 (42)	44 (27.5)	131 (34)	32 (34)	
Women	7 (7.4)	8 (6.1)	17 (10.6)	32 (8.4)	7 (7.4)	
both	21 (22.3)	38 (29)	52 (32.5)	111 (28.8)	21 (22.3)	
No equines	34 (36.2)	30 (22.9)	47 (29.3)	111 (28.8)	34 (36.2)	
Poultry					11.637 (*)	0.003
Men	0 (0)	2 (1.5)	2 (1.2)	4 (1)		
Women	16 (17)	20 (15.3)	49 (3.6)	85 (22.1)		
both	78 (83)	109 (83.2)	109 (68.1)	296 (76.9)		

*(P<0.05) & ns (P<0.05) at p (0.05) and n = number of households interviewed

Table 4. *General livestock management responsibility of household family members in three agro-ecological zones of western Tigray.*

Livestock species	Agro- ecological zones				X^2-test	p- value
	High land n (%)	Mid land n (%)	Low land n(%)	Total n (%)		
Cattle *					6.59 (*)	0.037
Men	1 (1.1)	1 (0.8)	8 (5)	10 (2.6)		
Women	-	1 (0.8)	5 (3.1)	6 (1.6)		
Men &women	12 (12.8)	20 (15.3)	13 (8.1)	45 (11.7)		
Men &male children	57 (60.6)	86 (65.6)	76 (47.5)	219 (56.9)		
Women & male children	9 (9.6)	10 (7.6)	19 (11.9)	38 (9.9)		
Men &female children	1 (1.1)	3 (2.3)	1 (0.6)	5 (1.3)		
Women and female children	1 (1.1)	1 (0.8)	1 (0.6)	3 (0.8)		
Men, women &male children	-	1 (0.8)	11 (6.9)	12 (3.1)		
Men, women & female children	-	-	1 (0.6)	1 (0.3)		
No cattle	13 (13.8)	8 (6.1)	25 (15.6)	46 (11.9)		
Small Ruminant*					0.005 (ns)	0.998
Men	1 (1.1)	1 (0.8)	8 (5)	10 (2.6)		
Women	1 (1.1)	-	3 (1.9)	4 (1)		
Men &women	9 (9.6)	20 (15.3)	11 (6.9)	40 (10.4)		
Men &male children	49 (52.1)	85 (64.9)	73 (45.6)	207 (53.8)		
Women & male children	7 (7.4)	12 (9.2)	16 (10)	35 (9.1)		
Men &female children	1 (1.1)	3 (2.3)	1 (0.6)	5 (1.3)		
Women and female children	1 (1.1)	1 (0.8)	-	2 (0.5)		
Men, women &male children	-	-	1 (0.6)	1 (0.3)		
Men, women & female children	-	1 (0.8)	1 (0.6)	2 (0.5)		
No small ruminant	25 (26.6)	8 (6.1)	46 (28.7)	79 (20.5)		
Equines *					5.541 (ns)	0.063
Men	-	1 (0.8)	3 (1.9)	4 (1)		
women	-	-	4 (2.5)	4 (1)		
Men &women	3 (3.2)	16 (12.2)	10 (6.2	29 (7.5)		
Men &male children	49 (52.1)	73 (55.7)	64 (40)	186 (48.3)		
Women & male children	6 (6.4)	6 (4.6)	4 (2.5)	16 (4.2)		
Men &female children	1 (1.1)	2 (1.5)	1 (0.6)	4 (1)		
women and female children	1 (1.1)	1 (0.8)	3 (1.9)	5 (1.3)		
Men, women &male children	-	1 (0.8)	23 (14.4)	24 (6.2)		
Men, women & female children	-	1 (0.8)	1 (0.6)	2 (0.5)		
No equines	34 (36.2)	30 (22.9)	47 (29.4)	111 (28.8)		
Poultry*					6.054 (*)	0.048
women	41 (43.6)	41 (31.3)	70 (43.8)	152 (39.5)		
Men & women	-	1 (0.8)	1 (0.6)	2 (0.5)		
Female children	-	-	1 (0.6)	1 (0.3)		
Women & female children	53 (56.4)	87 (66.4)	87 (54.4)	227 (59)		
Men & female children	-	2 (1.5)	-	2 (0.5)		

*: Provision of feed and water, keeping and housing of animals

3.4. Flock Composition and Size

The survey result revealed that the mean indigenous layers, cockerels, pullets, and total indigenous flock size per household in both midland and highland agro ecologies were not significantly different but significantly lower than those in lowland agroecology (Table 5). However, the mean number of indigenous cock and chicks per household was not significantly different among the agro ecologies. Overall, the average indigenous layers, cocks, cockerels, pullets, chicks, and total indigenous flock size per household were 5.50±3.50, 0.75±0.67, 2.51±1.82, 5.67±3.52, 8.41±5.09 and 22.83±10.60, respectively, in the study area. This was higher than the mean chicken flock size/household of 6.23±4.4 (ranged 1–16); 13.68±0.62 and 13.1±10 (ranged 1-57) reported by Meseret [32] in Gomma district of Jimma zone, Solomon *et al*. [33] in Metekel zone of Northwest Ethiopia, and Moges *et al*. [34] in Bure district of North West Ethiopia, respectively.

The mean number of exotic layers per household in both lowland and highland agro ecologies was not significantly different but significantly lower than that in midland agroecology. However, the mean exotic pullets per household in both midland and highland agro ecologies were not significantly different but significantly lower than those in lowland agro-ecology. Significantly more exotic chicks per household were obtained in highland agroecology than in mid- and lowland agro ecologies. Similarly, the mean exotic cockerel per household was significantly higher in highland than in lowland, but similar to midland. The mean exotic cock and total exotic flock size per household were not significantly different among the three agro ecologies. This could be attributed to the exotic breeds' different adaptability in response to different environmental factors across the agro ecologies.

The mean number of crossbred layers, cockerels, pullets, and total crossbred flock size per household were not significantly different among the agro ecologies. However, the mean crossbred cock per household was not significantly different in both midland and highland agro ecologies but significantly higher than those in lowland agro ecologies. In contrast, significantly higher mean crossbred chick sizes per household were obtained in the lowlands than in the midlands, but they were similar in the highlands.

Regardless of the breed of chicken, the survey showed that the overall means of the layers, cocks, cockerels, pullets, chicks, and total flock size in the study area were 6.00±3.60, 0.95±0.75, 2.81±1.97, 6.17±3.59, 9.44±4.95, and 24.35±10.69, respectively (Table 5). This indicates that households may have a mixture of chicken genotypes, which in turn, creates a wider opportunity for unplanned or indiscriminate cross breeding to occur among the flock. Indiscriminate cross breeding is the major threat to adapted indigenous livestock breeds through breed replacement [7, 40]. Maintenance of a well-adapted indigenous chicken gene pool diversity is crucial to satisfy current and future market demands, to serve as an insurance against environmental changes such as changes in the circumstances of production on a socio-economic, historic, and cultural level, and to provide adequate genetic material sources for sustainable utilization and improvement. In addition, village chicken flocks scavenge together and interbreed among themselves in the study area, and some breeding cocks are more dominant and aggressive than others. These situations will increase the chance of consecutive interbreeding among more related chickens, which in turn increases the incidence of inbreeding. Rotational mating is an effective system to reduce the short- and long-term inbreeding effects of animals, irrespective of the effective population size of the animals [41, 42]. Farmers therefore need to be encouraged to avoid mating of closely related individuals among their chicken flocks by keeping breeding cocks and exchanging them with other farmers located beyond the scavenging distance.

Community-based and environmentally friendly holistic genetic improvement programs should be designed and implemented to conserve, utilize, and improve sustainably well-adapted indigenous chicken genetic resources. Lwelamira *et al*. [43] reported that selection breeding programs of 5 to 10 generations were successful in improving the population mean of Tanzanian indigenous chicken ecotypes' body weight under village conditions from 974 gram to 1300 gram. Controlled and monitored cross breeding with appropriate records and improved management can be used as the last option for a genetic breeding program with indigenous genetic resources after checking that the lacking traits in the local chicken ecotypes are not improved by selection. Exotic germ plasms have been adopted for cross breeding with an emphasis on immediate financial gains from unique performance trait enhancements, which result in the unintended substitution of indigenous genes by exotic genes, which eventually contributes to the full replacement of indigenous genetic resources [25, 40]. Implementation of community-based conservation of indigenous chicken genetic resources is strongly encouraged, as it ensures sustainable utilization of local chicken ecotypes with the participation of chicken producers in their original production environments without the application of sophisticated modern reproductive technologies.

Table 5. *Chicken flock structures & sizes of indigenous, exotic & cross bred chickens in three agro-ecological zones of Western Tigray.*

Parameters	highland (Mean±SD)	Midland (Mean±SD)	Lowland (Mean±SD)	Overall (Mean±SD)
Indigenous chickens				
hen/layers	$4.26±2.74^b$	$4.88±3.01^b$	$6.73±3.87^a$	5.50±3.50
cock (>20 weeks)	$0.8±0.60^a$	$0.8±0.61^a$	$0.68±0.74^a$	0.75±0.67
Cockerel(8-20 weeks)	$2.05±1.67^b$	$2.4±1.90^b$	$2.88±1.78^a$	2.51±1.82
Pullet (8-20 weeks)	$4.69±2.73^b$	$5.36±3.10^b$	$6.50±4.06^a$	5.67±3.52
Chicks (0-8 weeks)	$8.07±4.71^a$	$7.92±4.67^a$	$9.0±5.57^a$	8.41±5.09

Parameters	highland (Mean±SD)	Midland (Mean±SD)	Lowland (Mean±SD)	Overall (Mean±SD)
Total	19.87±8.20[b]	21.36±9.68[b]	25.78±11.82[a]	22.83±10.60
Exotic chickens				
hen/layers	0.30±0.60[b]	0.50±0.76[a]	0.27±0.53[b]	0.36±0.64
cock (>20 weeks)	0.11±0.31[a]	0.11±0.34[a]	0.17±0.39[a]	0.14±0.36
Cockerel(8-20 weeks)	0.22±0.66[a]	0.15±0.43[ab]	0.10±0.34[b]	0.15±0.47
Pullet (8-20 weeks)	0.15±0.39[b]	0.18±0.48[b]	0.33±0.64[a]	0.24±0.54
Chicks (0-8 weeks)	0.23±0.65[a]	0.07±0.35[b]	0.03±0.22[b]	0.09±0.41
Total	1.01±2.24[a]	1.02±1.80[a]	0.89 ±1.37[a]	0.96±1.76
Crossbred chickens				
hen/layers	0.21±0.60[a]	0.14±0.43[a]	0.13±0.39[a]	0.15±0.46
cock (>20 weeks)	0.12±0.32[a]	0.10±0.30[a]	0.01±0.11[b]	0.07±0.25
Cockerel (8-20 weeks)	0.15±0.59[a]	0.18±0.65[a]	0.11±0.35[a]	0.15±0.53
Pullet (8-20 weeks)	0.30±0.72[a]	0.27±0.63[a]	0.23±0.43[a]	0.26±0.58
Chicks (0-8 weeks)	0.91±1.07[ab]	0.79±0.94[b]	1.08±0.91[a]	0.94±0.97
Total	1.69±2.64[a]	1.49±2.43[a]	1.56±1.65[a]	1.57±2.19
Total chickens				
hen/layers	4.73±2.88[b]	5.52±3.09[b]	7.13±4.02[a]	6.00±3.60
cock (>20 weeks)	1.02±0.73[a]	1.02±0.71[a]	0.86±0.79[a]	0.95±0.75
Cockerel (8-20 weeks)	2.43±1.79[b]	2.73±2.12[b]	3.09±1.92[a]	2.81±1.97
Pullet (8-20 weeks)	5.14±2.86[b]	5.82±2.96[b]	7.06±4.20[a]	6.17±3.59
Chicks (0-8 weeks)	9.22±4.72[b]	8.78±4.65[b]	10.11±5.26[a]	9.44±4.95
Total	21.63±8.32[b]	22.89±9.51[b]	27.16±12.14[a]	24.35±10.69

Values with different letters with same row are significantly different ($p<0.05$)

3.5. Inbreeding and Effective Population Size

The survey result revealed that the effective population size (Ne) of the chicken flock under farmers' management conditions in the lowland agro-ecology was 480.26, which was higher than in the highland (315.86) and midland (449.34) agro-ecologies (Table 6). However, the rate of change of the inbreeding coefficient (ΔF) of the lowland chicken population was 0.104%, which was lesser than that of the midland (0.111%) and highland (0.16%), since there was a collection of breeding chickens of various origins and thus a wider chance of mating among unrelated chickens in the lowland, which is the investment zone of the study area. The effective population size (Ne) and the rate of change of the inbreeding coefficient (ΔF) of a chicken flock under farmers' extensive management were 1263.69 and 0.04%, respectively, in the study area, which indicated that the population was not at risk of the consequences of the rate of inbreeding. This result was comparable with the findings of Yakubu *et al*. [44], who reported that the effective population size (Ne) and the rate of inbreeding (ΔF) for the Nigerian indigenous turkey flock considering the existing flock size and management practice were 396 and 0.13%, respectively. However, it was much higher than the effective population sizes of (3.9 and 15.35) and the rate of change in breeding coefficients of local chickens (12.82% and 5.25%), respectively, reported by Bogale [45] and Abdelqader *et al*. [46] in the Fogera district of Ethiopia and in the rural areas of the northern districts of Jordan. In Ghana, Hagan *et al*. [47] also reported that the effective population size of the local chickens in the Coastal Savannah, Rain Forest, and Guinea Savannah were found to be 13.3, 11.3 and 12.9, and 0.038 (3.8%), respectively, which were lesser than the result of the current study, and they obtained similar levels of inbreeding coefficients in three of Ghana's agro-ecologies: Coastal (0.038 or 3.8%), Forest (0.044 or 4.4%), and Guinea (0.039 or 3.9%), which were higher than the result obtained in this study. The effective population size (Ne) of local chickens in all agro-ecologies was within the minimum acceptable level of 100–1000 under the conservation rule [48], and the rate of inbreeding coefficient (ΔF) was lower than the maximum acceptable level of 0.063 [49]. This indicates the existence of genetic variability among local chicken ecotypes and within individuals of each local chicken ecotype. Sustainable and environmentally friendly breeding and conservation programs should be designed and implemented, accompanied by training of chicken owners on how inbreeding is avoided through management and its negative impact on reproductive fitness and performance of animals (inbreeding depression).

Table 6. *Inbreeding and effective population size.*

Parameter	Agro-ecological zones							
	Highland		Midland		Lowland		Overall	
	Hens	Cock	Hens	Cock	Hens	Cock	Hens	Cock
Minimum	1	0	1	0	1	0	1	0
Maximum	14	4	15	4	22	4	22	4
Mean ±SD	4.73±2.9	1.02±0.7	5.52±3.1	1.02±0.7	7.13±4.0	0.86±0.8	6.0±3.6	0.95±0.8
Total	445	96	723	133	1141	137	2309	366
Ne	315.86		449.34		480.26		1263.69	
ΔF	0.00158 (0.16%)		0.00111 (0.111%)		0.00104 (0.104%)		0.000396 (0.04%)	

Note: Ne: effective population size, ΔF: inbreeding coefficient

3.6. Chicken Meat and Egg Consumption

The survey result revealed that there were no cultural or religious taboos against chicken meat and egg consumption in the study zone. Chicken meat and egg consumption are two of the main purposes of chicken production in the study area. The study also showed that chicken meat and egg consumption were high during cultural and religious festivals (Figures 1 and 2). Chicken and egg consumption was higher among large-scale farmers than among small-scale farmers in all agro ecologies during the time of festivals. Chicken and egg consumption was influenced by agroecology and farmers' status but not by agroecology and farmers' status interaction (Table 7). Chicken and egg consumption was significantly higher among large-scale farmers than among small-scale farmers. Average annual chicken consumption per household was 7.76±0.68 and 20.79±0.68 chickens for small-scale and large-scale farmers, respectively. Similarly, the average annual egg consumption was 67.52±3.13 and 182.27±3.13 eggs for small-scale and large-scale farmers, respectively. This could be attributed to differences in chicken breeding objectives among farmers. Small-scale farmers reared chickens for income generation in addition to home consumption, while large-scale farmers raised chickens primarily for home consumption in the study area. This result is higher than the values reported in southern Ethiopia [9] and in the lowland and midland agro-ecological zones of central Tigray, Ethiopia [38]. This might be due to the differences in the wealth status of farmers, alternative income sources, and market accessibility of chicken products in different areas.

The ranking indices of chicken and egg consumption prioritization among household members indicated uniform prioritization across the agro ecologies (Table 8). First, second, and third priority was given to adults, lactating women, and pregnant women, respectively, in both chicken and egg consumption in all agro ecologies. Similar to this, Mengesha *et al*. [50] reported that around 75% of the respondents from Debreguracha gave priority to adults in their consumption of poultry products among family members. Aklilu *et al*. [51] and Alem *et al*. [38] also reported that the meatiest and most nutritious parts of the carcass (gizzard, drumsticks, thigh, and breast bones) were for men, and the lower-quality parts (neck, wing, skull, thorax parts, and skin) were meant for women and children. On the contrary, Bogale [45] reported that priority in consumption of poultry products in Fogera district was given to children (1st), pregnant women (2nd), lactating women (3rd), adults (4th), and elderly people (5th).

The result also indicated uniform chicken and egg consumption preferences of households with respect to breed, egg type, plumage colour, comb type, shank type, and chicken age (Table 9). Overall, 83.4%, 79.2%, 56.9%, 75.58%, and 70.4% of the respondents preferred local breed chickens, local eggs, smooth shanks, double combs, and chickens with 6–12 months of age, respectively, for consumption (Table 9). Similar to this, Alem et al. [38] reported that most of the households in the lowland and midland agro ecologies of Central Tigray preferred local chickens for consumption. This is due to the tastiness, flavour, and aroma of local chicken meat [38, 51]. However, consumption preferences for chicken feather distribution significantly varied across the agro ecological zones. Significantly, the highest proportion of respondents preferred chicken with normal feather distribution in highland (92.6%) and midland (90%) agro-ecologies, while the least proportion of households was observed in lowland agroecology (75%). The ranking indices of consumption preferences for chicken plumage colours indicated similar consumption preferences of farmers with respect to chicken plumage colours across agro ecologies (Table 10). Generally, chickens with red (1st), greyish (2nd), and multicoloured (3rd) plumage colours were the most preferred for consumption in the study zone. According to the focus group discussion, chickens with full white and black plumage were often used for supernatural rituals to heal a sick person by having a pure white or black bird knead or gyrate over the body of the sick person, and ultimately claimed that the evil spirit would be transferred to the bird and the sick person would be healed. Most of the time, people did not purchase pure white or black birds at the market for consumption in order not to reveal themselves to an evil spirit. Farmers often purchased such birds at a high price from their neighbours when they wanted to use them for spiritual purposes. Similar findings were reported from remote areas of southern Tigray [51] and the central zone of Tigray [38].

Table 7. *Annual chicken and egg consumption of small and large-scale farmers in three agro-ecological zones of western Tigray.*

Variable	Annual Chicken Consumption			Annual Egg Consumption		
	N	Chicken/year	P-value	N	Egg/year	P-value
Overall	385	14.27		385	124.89	
Agroecology			0.000007			0.48(ns)
highland	94	13.86±0.68^b		94	125.22±3.13	
Midland	131	13.18±0.68^b		131	126.04±3.13	
Lowland	160	15.78±0.68^a		160	123.42±3.13	
Farmers			2.2x10-16			2.2x10-16
Small-scale		7.76±0.68^b		325	67.52±3.13^b	
Large-scale		20.79±0.68^a		60	182.27±3.13^a	
Agro-ecology*Farmers			0.47 (ns)			0.121 (ns)
Highland: large		20.48±0.58			182.60±3.0	
Highland: small		7.24±0.58			67.84±3.0	

Variable	Annual Chicken Consumption			Annual Egg Consumption		
	N	Chicken/year	P-value	N	Egg/year	P-value
Midland: large		19.36±0.58			181.12±2.9	
Midland: small		7.00±0.58			70.96±2.9	
Lowland: large		22.52±0.85			183.08±3.5	
Lowland: small		9.04±0.85			63.76±3.5	

NB: ns= non-significant at 0.05

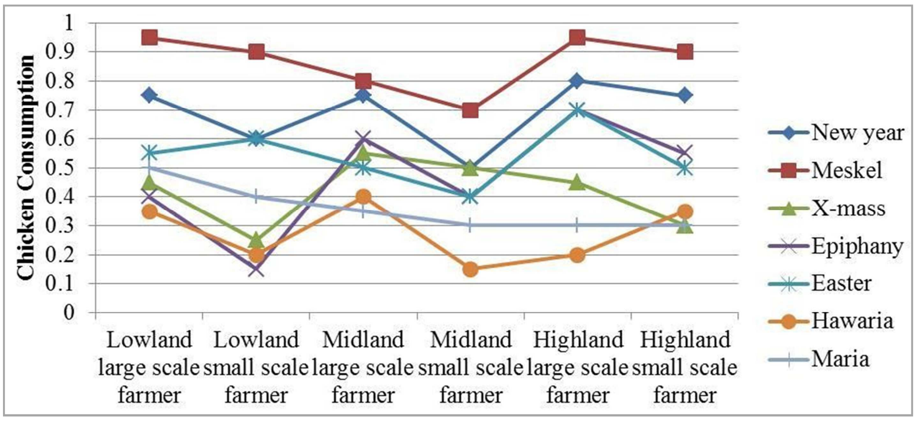

Figure 1. *Chicken consumption of the households in different festivals in the year 2019.*

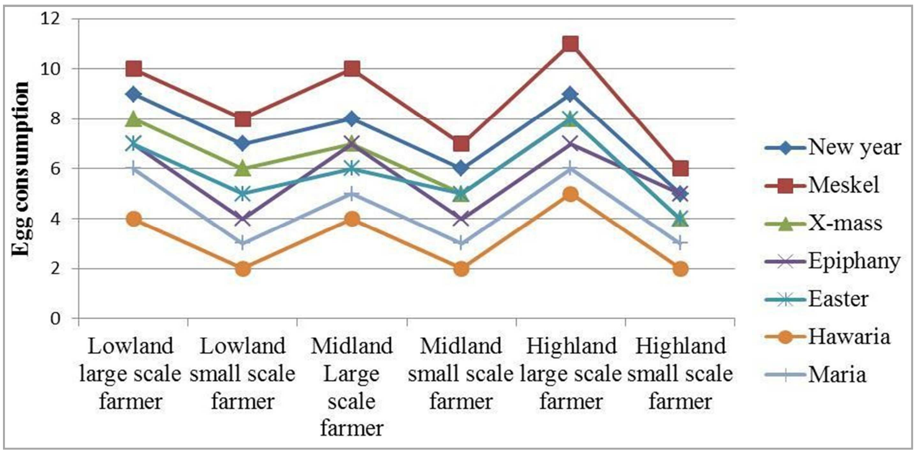

Figure 2. *Egg consumption of the households in different festivals in the year 2019.*

Table 8. *Ranking of chicken and egg consumption prioritization in the household members in western zone of Tigray.*

Household members	R1	R2	R3	R4	R5	Sum	Index
Lowland Agro-ecology							
Adults	80	68	55	47	35	966	0.340
Lactating women	42	49	53	15	0	595	0.207
Pregnant women	35	46	51	28	0	568	0.198
Women	26	20	11	29	74	375	0.132
Children	14	18	10	41	112	366	0.129
Midland Agro-ecology							
Adults	102	65	44	40	11	993	0.349
Lactating women	79	24	35	3	2	604	0.212
Pregnant women	65	26	24	26	1	554	0.195
Women	39	16	22	17	37	396	0.139
Children	11	10	22	49	40	299	0.105
Highland Agro-ecology							
Adults	60	59	35	30	3	704	0.328
Lactating women	51	31	12	6	5	432	0.201
Pregnant women	43	24	9	5	8	356	0.166
Women	37	23	15	9	10	350	0.163
Children	31	21	8	11	22	307	0.143
Western Zone of Tigray							

Household members	R1	R2	R3	R4	R5	Sum	Index
Adults	242	192	134	117	49	2663	0.339
Lactating women	172	104	100	24	7	1631	0.207
Pregnant women	143	96	84	59	9	1478	0.188
Women	102	59	48	55	121	1121	0.143
Children	56	49	40	101	174	972	0.124

R1, R2, and R3…R5=Rank 1, 2, 3…5, respectively; and Index=Sum of (5 for Rank1+4 for Rank2+…+1for Rank5) given for an individual factor divided by the sum of (5 for Rank 1+ 4 for Rank 2+…+ 1 for Rank 5) for overall variables

Table 9. *Chicken and Egg Consumption Preference of Households in Three Agro-Ecological Zones of Western Zone of Tigray (% of respondents).*

Variable	Agro-ecological zones				X^2-value	P-value
	Highland (N=94)	Midland (N=131)	Lowland (N=160)	Overall (N=385)		
Chicken breed Consumption Preference					1.672	0.433
Local breed	81 (86.2%)	111 (84.7%)	129 (80.6%)	321 (83.4%)		
Cross	8 (8.5%)	13 (9.9%)	18 (11.3%)	39 (10.1%)		
Exotic	3 (3.2%)	2 (1.5%)	5 (3.1%)	10 (2.6%)		
No breed preference*	2 (2.1%)	5 (3.8%)	8 (5%)	15 (3.9%)		
Egg consumption preference					1.934	0.380
Local chicken eggs	78 (83%)	105 (80.2%)	122 (76.3%)	305 (79.2%)		
Cross breed chicken eggs	12 (12.8%)	19 (14.5%)	25 (15.6%)	56 (14.6%)		
Exotic breed chicken eggs	2 (2.1%)	2 (1.5%)	5 (3.1%)	9 (2.3%)		
No egg preference*	2 (2.1%)	5 (3.8%)	8 (5%)	15 (3.9%)		
Consumption preference to chicken plumage colour					1.700	0.427
Yes	94 (100%)	129 (98.5%)	157 (98.1%)	380 (98.7%)		
No	0 (0%)	2 (1.5%)	3 (1.9%)	5 (1.3%)		
Consumption preference to chicken shank type					0.372	0.830
Yes	51 (54.3%)	75 (57.3%)	93 (58.1%)	219 (56.9%)		
No	43 (45.7%)	56 (42.7%)	67 (41.9%)	166 (43.1%)		
Preferred shank type					0.372	0.830
Smooth	51 (54.3%)	75 (57.3%)	93 (58.1%)	219 (56.9%)		
No chicken shank type preference*	43 (45.7%)	56 (42.7%)	67 (41.9%)	166 (43.1%)		
Consumption preference to chicken feather distribution					18.000	0.00001
Normal	87 (92.6%)	118 (90%)	120 (75%)	325 (84.42%)		
No chicken feather distribution preference*	7 (7.4%)	13 (10%)	40 (25%)	60 (15.58%)		
Consumption preference to chicken comb type					0.792	0.673
Yes	74 (78.72%)	99 (75.57%)	118 (73.75%)	291 (75.58%)		
No	20 (21.28%)	32 (24.43%)	42 (26.25%)	94 (24.42%)		
Preferred comb type					0.792	0.673
Double	74 (78.72%)	99 (75.57%)	118 (73.75%)	291 (75.58%)		
No comb type preference *	20 (21.28%)	32 (24.43%)	42 (26.25%)	94 (24.42%)		
Consumption preference to chicken age					4.626	0.099
Yes	91 (96.8%)	118 (90.1%)	143 (89.4%)	352 (91.4%)		
No	3 (3.2%)	13 (9.9%)	17 (10.6%)	33 (8.4%)		
Preferred age for consumption					3.698	0.157
6-12 th months	72 (76.6%)	86 (65.6%)	113 (70.6%)	271 (70.4%)		
>12th months	19 (20.2%)	32 (24.4%)	30 (18.8%)	81 (20%)		
Any age category*	3 (3.2%)	13 (10%)	17 (10.6%)	33 (8.6%)		

* = Preferred any chicken breed with any age category, plumage color, Shank type including rough, feather distribution including naked neck and comb type including single

Table 10. *Ranking of Consumption Preference of Chicken Plumage Colours.*

Lowland agro-ecology												
Chicken plumage colour	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**Sum**	**Index**
Red	1200	270	80	0	0	0	0	0	0	0	1550	0.141
Greyish/Gebsima	1100	225	80	63	36	0	0	0	0	0	1504	0.137
Multicolour/Ambesma	980	144	64	42	60	60	40	0	0	0	1390	0.127
white with red spots /Netch Teterma	750	198	144	70	60	25	48	24	0	0	1319	0.120
Red with white stripes/key Teterma	700	180	128	98	36	25	56	36	0	0	1259	0.115
Red brownish/Kokima	680	171	160	84	48	30	48	45	0	0	1266	0.115
Brownish/Zagrama	660	90	136	35	42	80	72	63	0	0	1178	0.107
Black with white stripes/Black Teterma	400	234	96	63	36	100	88	54	14	0	1085	0.099
White	0	0	0	0	0	0	16	30	56	118	220	0.020
Black	0	0	0	0	0	0	0	18	48	130	196	0.018

Midland agro-ecology												
Chicken plumage colour	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**Sum**	**Index**
Red	1050	162	48	14	0	0	0	0	0	0	1274	0.134
Greyish/Gebsima	900	189	80	49	18	0	0	0	0	0	1236	0.130
Multicolour/Ambesma	820	180	64	77	36	20	0	0	0	0	1197	0.126
white with red spots /Netch Teterma	800	144	80	42	60	35	8	0	0	0	1169	0.123
Red with white stripes/key Teterma	790	135	88	56	42	50	4	0	0	0	1165	0.122
Red brownish/Kokima	720	153	72	98	30	50	16	0	0	0	1139	0.119
Brownish/Zagrama	700	162	56	105	18	65	20	0	0	0	1126	0.118
Black with white stripes/Black Teterma	360	207	112	77	54	35	20	21	38	0	924	0.097
White	0	0	0	0	0	0	8	9	28	112	157	0.016
Black	0	0	0	0	0	0	0	15	16	118	149	0.016

R1, R2, andR3…R10=Rank 1, 2, 3…10, respectively; and Index=Sum of (10 for Rank1+9 for Rank2+…+1for Rank10) given for an individual factor divided by the sum of (10 for Rank 1+ 9 for Rank 2+…+ 1 for Rank 10) for overall factors.

***Table 10.** Continued.*

Highland agro-ecology												
Chicken plumage colour	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**Sum**	**Index**
Red	700	144	56	7	0	0	0	0	0	0	907	0.136
Greyish/Gebsima	620	126	48	63	18	0	0	0	0	0	875	0.131
Multicolour/Ambesma	590	153	24	63	30	5	0	0	0	0	865	0.129
white with red spots /Netch Teterma	540	144	24	49	24	35	12	0	0	0	828	0.124
Red with white stripes/key Teterma	500	135	32	56	30	40	16	0	0	0	809	0.121
Red brownish/Kokima	460	153	56	63	24	25	24	0	0	0	805	0.120
Brownish/Zagrama	330	162	64	49	54	55	32	0	0	0	746	0.112
Black with white stripes/Black Teterma	190	153	64	49	24	30	28	15	42	0	595	0.089
White	0	0	0	0	0	0	12	27	20	72	131	0.020
Black	0	0	0	0	0	0	4	15	26	75	120	0.018

Western zone of Tigray												
Chicken plumage colour	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**Sum**	**Index**
Red	2950	576	184	21	0	0	0	0	0	0	3731	0.137
Greyish/Gebsima	2620	540	208	175	72	0	0	0	0	0	3615	0.133
Multicolour/Ambesma	2390	477	152	182	126	85	40	0	0	0	3452	0.127
white with red spots /Netch Teterma	2090	486	248	161	144	95	68	24	0	0	3316	0.122
Red with white stripes/key Teterma	1990	450	248	210	108	115	76	36	0	0	3233	0.119
Red brownish/Kokima	1860	477	288	245	102	105	88	45	0	0	3210	0.118
Brownish/Zagrama	1690	414	256	189	114	200	124	63	0	0	3050	0.112
Black with white stripes/Black Teterma	950	594	272	189	114	165	136	90	94	0	2604	0.096
White	0	0	0	0	0	0	36	66	104	302	508	0.019
Black	0	0	0	0	0	0	4	48	90	323	465	0.017

R1, R2, and R3…R10=Rank 1, 2, 3…10, respectively; and Index=Sum of (10 for Rank1+9 for Rank2+…+1for Rank10) given for an individual factor divided by the sum of (10 for Rank 1+ 9 for Rank 2+…+ 1 for Rank 10) for overall factors.

3.7. Sources of Foundation and Replacement Stock

There was a significant difference in sources of chicken foundation stock among the agro ecologies of the study area (Table 11). The major sources of chicken parent stock are market purchased (73.5%), and family (inherited) agricultural offices, and gifts, which account for the remaining percentages. This implies that most of the farmers started chicken production with the foundation chickens purchased from the market, which were followed by those inherited from parents, the agricultural office, and gifts. This result is in line with the findings of Letebrhan *et al*. [52] and Fitsum *et al*. [29], who reported that market purchased and family (inherited) were the main sources of chicken foundation stock in the Gantaafeshum district of Eastern Tigray and both lowland and midland agro ecologies of the Central Zone of Tigray, respectively. Tadelle *et al*. [53] and Salo *et al*. [54] also reported that purchase was the source of foundation stock in five different agro-ecological regions of Ethiopia and in the Lemo district of Hadiya zone, respectively. Similarly, Moreda *et al*. [55] reported that purchase (91.9%), hatching (4.4%), and being inherited from parents or relatives (3.7%) are the main sources of the initial chicken stock in the southwest and south parts of Ethiopia. There were significant ($P<0.05$) differences in the sources of breeding females and males as replacement stock among the three agro-ecological zones of the study area. Hatching was the main source of breeding males, while hatching and purchase were the main sources of breeding females as replacement stocks. About 53% of breeding females in the studied households originated from both hatching at home and purchasing them from the market, while the remaining originated from sole hatching at home (31.9%), sole purchase (10.1%), and Extension office (4.9%) in the form of a poultry household package. Likewise, 57.7% of the breeding males in the studied households originated from sole hatching at home, while 20% of the interviewed households used neighbour breeding cocks. This result corroborated the findings of Tadelle *et al*. [53], who reported that hatching and purchase were the main sources of breeding females in five different agro-ecological regions of Ethiopia. Moreda *et al*. [55] also reported that hatching (63.9%), purchase (31.1%), and gift (5.1%) are the sources of replacement breeding stocks in four districts of the southwest and south parts of Ethiopia.

Table 11. *Sources of Foundation and Replacement Stock of Chickens in Three Agro- ecological zones of Western Tigray.*

Sources	Highland (94)	Midland (131)	lowland (160)	Overall (385)	x2 value	p-value
Sources of Foundation Stock						
Market/purchased	78 (83.0%)	97 (74.0%)	108 (67.5%)	283 (73.5%)	17.49	0.0001
Family/Inherited	9 (9.6%)	12 (9.2%)	27 (16.9%)	48 (12.5%)		
Agricultural office	5 (5.3%)	17 (13.0%)	21 (13.1%)	43 (11.2%)		
Gift	2 (2.1%)	5 (3.8%)	4 (2.5%)	11 (2.9%)		
Total	94 (24%)	131 (34%)	160 (42%)			
Sources of Present Breeding Females						
Hatching	24 (25.5%)	39 (29.8%)	60 (37.5%)	123 (31.9%)	16.8	0.0002
Purchase	10 (10.6%)	18 (13.7%)	11 (6.9%)	39 (10.1%)		
Hatching & Purchase	57 (60.6%)	67 (51.1%)	80 (50.0%)	204 (53.0%)		
Agricultural office	3 (3.2%)	7 (5.4%)	9 (5.6%)	19 (4.9%)		
Total	94 (24%)	131 (34%)	160 (42%)	385 (100%)		
Sources of Present Breeding Males						
Hatching	50 (53.2%)	85 (64.9%)	87 (54.4%)	222 (57.7%)	15.98	0.0005
Purchase	4 (4.3%)	9 (6.9%)	13 (8.1%)	26 (6.8%)		
Hatching & Purchase	13 (13.8%)	8 (6.1%)	15 (9.4%)	36 (9.4%)		
Agricultural office	8 (8.5%)	5 (3.8%)	11 (6.9%)	24 (6.2%)		
No breeding male, use neighbor males	19 (20.2%)	24 (18.3%)	34 (21.3%)	77 (20.0%)		
Total	94 (24%)	131 (34%)	160 (42%)	385 (100%)		

Numbers in bracket are referred to number of respondents interviewed

3.8. Ownership and Gender Roles in Poultry Production

Every family member participated in taking care of chickens, even if their degrees of responsibility varied among family members. The responsibility share of family members in providing feed and water, cleaning chicken houses, selling chickens and eggs, and purchasing drugs (treatments) was not different among the agro ecologies (Table 12). There was significant variation in the responsibility sharing among family members with regard to poultry house/shelter construction across agro ecologies. Overall, the result of the survey revealed that 59.5% of the respondents constructed poultry shelter, while 40.5% of them did not construct chicken shelter. Sole women and sole men (28.6%) had an equal share of responsibilities with respect to chicken shelter construction, while 1.3% of chicken shelters were constructed in common with different divisions of activity where men are involved in the arrangement of wood and finalization of houses with mud, which is the responsibility of women. The male children had the least responsibility in the chicken shelter construction in the study area. Men had higher responsibility in chicken shelter construction in lowland agroecology (41.9%) than in highlands (22.3%) and midland (16.8%) agro ecologies, while women had greater responsibility in the midland (38.9%) than in the highlands (34%) and lowland (16.9%) agro ecologies. However, contrasting results have been reported from lowland and midland agro-ecological zones of central Tigray, as reported by Alem *et al*. [38], who revealed men's highest responsibilities in chicken house construction (100%) in male-headed households. The same author also reported that chicken houses were constructed by women (52.4%, 51.9%). followed by the eldest male youth (33.3%, 29.6%) and paid labourers (14.3%, 18.5%) in female-headed households in the lowland and midland agro-ecological zones of central Tigray, respectively.

Samson & Endalew [56] also reported that men (57.5%) had the highest share of chicken house construction, followed by children, who accounted for 30% of the total in the mid-Rift valley of Oromia. Men were mainly involved in chicken shelter construction in Fogera. Wereda (63.9%) [45], and in the Bure district of Amhara regional state (97.5%) [57]. Mengesha *et al*. [50] reported that men (65.3%) took the highest share of chicken house construction, followed by women (19.6%) and children (15.1%) in the Jamma. district of the South Wollo Zone of Ethiopia. Overall, both women and female children (56.6%) accounted for the largest share in offering feed and water for chickens, followed by women (42.1%), female children (0.5%), female children and men (0.5%), and men and male children (0.3%). This result was close to the ones reported by Bogale [45], that women (59.72%) were mainly involved in providing feed and water for chickens in the Fogera district of Amhara, regional state. Nevertheless, it was less than the results reported from Bure district (80.7%) [45], the Jamma district of South Wollo (84.5%) [50], the Metema district (feeding (73.3%) and watering (72.2%) [58]; and the lowland and midland agro-ecologies of Central Tigray (67.5% and 65.5%, and 77.7% and 77.5%) in male- and female-headed households, respectively [38]. Likewise, both women and female children and sole women had the first and second major responsibilities of cleaning the chicken house (56.9% and

41.8%), selling chickens (54.5% and 43.1%), and selling eggs (54.5% and 42.9%), respectively, in the study area. The responsibility share of women for cleaning chicken houses obtained in this study was lower than the results reported from other districts: 62.5 percent from Fogera district [45], 91 percent from Jimma zone's Gomma district [59], 69.33 percent from Amhara regional state's Metema district [58], 82.5% from Jamma district of South Wollo [50], and it was, however, higher than the 38.6 percent reported from Bure district [57].

The survey indicated that women and female children, as well as sole women, took the highest share of responsibility in selling chickens (54.5% and 43.1%, respectively) and eggs (54.5% and 42.9%, respectively). Similarly, previous findings also revealed that selling chickens (56.95% and 82.95%) and selling eggs (63.89% and 54.6%) were practiced by women in Fogera [45] and Bure [57] districts of Amhara regional states, respectively. In this study, it was noted that men (79.7%) had the highest share of responsibilities for purchasing drugs or treatment for chickens, followed by women (16.6%), male children (1.6%), and women and female children together (0.5%). This result was in line with the results reported from male-headed households in the Central Zone of Tigray, which show that between 62.5% and 80% of the purchasing of drugs was accomplished by men in lowland and midland agro ecologies, respectively [38]. Similarly, Fisseha [57] reported that men (89.5%) had the highest and greatest share of responsibilities for treating chickens (by purchasing drugs or other treatments) in Bure district of Amhara regional state.

The analysis of the decision-making of household members indicated that the proportions of household members with respect to making decisions about selling eggs, home consumption, and purchasing eggs did not differ across the agro ecologies ($p > 0.05$) (Table 13). However, the decision-making share of the household members for chicken selling and home consumption, chicken purchasing and giving chicken products as gifts were significantly different among the three agro ecologies ($p \le 0.05$). In general, 99% of the total households interviewed had practiced both selling eggs and chickens, but the remaining 1% of the respondents had not. The result of the study revealed that women had the greatest share of the decision-making power to decide on eggs for selling (97.4%), eggs for home consumption (98.7%), and chickens for selling (93.5%), the purchase of eggs (98.7%), and the purchase of chickens in the study area. On the other hand, decisions on chickens for home consumption (76.1%) and offering chicken product as a gift (76.4%) were accomplished by men and women in common, while men had the major decision role for purchasing drugs or treatment (70.6%). It implies that women had the greatest share of the decision-making process in poultry product utilization as compared to men. Understanding the labour and ownership profiles as well as gender roles has a bearing effect on the success of designing and implementing sustainable poultry breeding programs. This result was similar to the reports of Alem *et al*. [38], who confirmed that women in female-headed households were responsible for decision-making on selling eggs (80% and 70%), selling chickens (82.5 and 72.5%), home consumption of eggs (77.5% and 70%), consumption of chickens (100% and 97.5%), purchase of drugs (100% and 100%), and purchase of chickens (100% and 100%) in the lowland and midland agroecology of central Tigray, respectively. The same author also reported that men had the major decision role in purchasing drugs and treatments in both lowland (77.5%) and midland (82.5%), while home consumption of chickens (62.5%) and 97.5%) was accomplished by the common decisions of both men and women in midland and lowland agro ecologies of central zones in male-headed households.

Table 12. *Labour division of household members in poultry management in the three agro-ecological zones of western Tigray.*

Activities	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Shelter construction					6.91 (*)	0.032
Men	21 (22.3)	22 (16.8)	67 (41.9)	110 (28.6)		
Women	32 (34)	51 (38.9)	27 (16.9)	110 (28.6)		
Men & women (arrangement of wood by men, & finalization of house with mud by women)	1 (1.1)	3 (2.3)	1 (0.6)	5 (1.3)		
Male children	-	2 (1.5)	2 (1.2)	4 (1)		
No shelter	40 (42.6)	53 (40.5)	63 (39.4)	156 (40.5)		
Providing feed & water					7.78 (*)	0.020
Women	40 (42.6)	44 (33.6)	78 (48.8)	162 (42.1)		
Female children	-	-	2 (1.2)	2 (0.5)		
Women & female children	54 (57.4)	85 (64.9)	79 (49.4)	218 (56.6)		
Men & female children	-	2 (1.5)	-	2 (0.5)		
Men & male children	-	-	1 (0.6)	1 (0.3)		
Cleaning chicken house					5.22 (ns)	0.074
Women	40 (42.6)	44 (33.6)	77 (48.1)	161 (41.8)		
Men	-	1 (0.8)	-	1 (0.3)		
Female children	-	1 (0.8)	2 (1.2)	3 (0.8)		
Women & female children	54 (57.4)	85 (64.9)	80 (50)	219 (56.9)		
Men & male children	-	-	1 (0.6)	1 (0.3)		
Selling chicken					7.45 (*)	0.024

Activities	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Women	40 (42.6)	45 (34.4)	81 (50.6)	168 (43.1)		
Female children	-	1 (0.8)	2 (1.2)	3 (0.8)		
Women & female children	54 (57.4)	82 (62.6)	74 (46.2)	210 (54.5)		
Men &male children	-	-	1 (0.6)	1 (0.3)		
No sell	-	3 (2.3)	2 (1.2)	5 (1.3)		
Selling eggs					6.93 (*)	0.031
Men	-	1 (0.8)	1 (0.6)	2 (0.5)		
Women	40 (42.6)	45 (34.4)	80 (50)	165 (42.9)		
Female children	-	1 (0.8)	2 (1.2)	3 (0.8)		
Women and female children	54 (57.4)	82 (62.6)	74 (46.2)	210 (54.5)		
men and male children	-	-	1 (0.6)	1 (0.3)		
No sell	-	2 (1.5)	2 (1.2)	4 (1)		
Purchasing drugs / treatment					2.35 (ns)	0.309
Men	73 (77.7)	110 (84)	124 (77.5)	307 (79.7)		
Women	17 (18.1)	17 (13)	30 (18.8)	64 (16.6)		
Male children	2 (2.1)	2 (1.5)	2 (1.2)	6 (1.6)		
Women and female children	1 (1.1)	-	1 (0.6)	2 (0.5)		
No purchase	1 (1.1)	2 (1.5)	3 (1.9)	6 (1.6)		
Men	73 (77.7)	110 (84)	124 (77.5)	307 (79.7)		

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed.

Table 13. *Decision -making share of household members in poultry product utilization in three agro-ecological zones of western Tigray.*

Activities	Agro- ecological zones				X^2-test	p-value
	High land n (%)	Mid land n (%)	Low land n (%)	Total n (%)		
Egg selling					1.45 (ns)	0.484
Men	-	2 (1.5)	3 (1.9)	5 (1.3)		
Women	94 (100)	126 (96.2)	155 (96.9)	375 (97.4)		
Men and women	-	1 (0.8)	-	1 (0.3)		
No sell	-	2 (1.5)	2 (1.2)	4 (1)		
Chicken selling					2.05 (ns)	0.359
Men	-	2 (1.5)	12 (7.5)	14 (3.6)		
Women	94 (100)	126 (96.2)	140 (87.5)	360 (93.5)		
Men and women	-	1 (0.8)	6 (3.8)	7 (1.8)		
No sell	-	2 (1.5)	2 (1.2)	4 (1)		
Eggs for home consumption					1.70 (ns)	0.427
Men	-	2 (1.5)	3 (1.9)	5 (1.3)		
Women	94 (100)	129 (98.5)	157 (98.1)	380 (98.7)		
Chicken for home consumption					21.59 (*)	0.000
Men	-	2 (1.5)	19 (11.9)	21 (5.5)		
Women	14 (14.9)	20 (15.3)	37 (23.1)	71 (18.4)		
Men and women	80 (85.1)	109 (83.2)	104 (65)	293 (76.1)		
Purchase of drugs / treatment					8.75 (*)	0.013
Men	65 (69.1)	103 (78.6)	104 (65)	272 (70.6)		
Women	15 (16)	16 (12.2)	37 (23.1)	68 (17.7)		
Men and women	-	-	3 (1.9)	3 (0.8)		
No purchase	14 (14.9)	12 (9.2)	16 (10)	42 (10.9)		
Purchase of eggs					1.70 (ns)	0.427
Men	-	2 (1.5)	3 (1.9)	5 (1.3)		
Women	94 (100)	129 (98.5)	157 (98.1)	380 (98.7)		
Purchase of chicken					4.37 (ns)	0.112
Men	-	2 (1.5)	3 (1.9)	5 (1.3)		
Women	94 (100)	128 (97.7)	148 (92.5)	370 (96.1)		
Men and women	-	1 (0.8)	9 (5.6)	10 (2.6)		
Chicken products as gifted					22.12 (*)	0.000
Men	-	2 (1.5)	17 (10.6)	19 (4.9)		
Women	14 (14.9)	19 (14.5)	39 (24.4)	72 (18.7)		
Men and women	80 (85.1)	110 (84)	104 (65)	294 (76.4)		

* (p<0.05) & ns (p>0.05) at p (0.05) and n=number households interviewed.

4. Conclusion

Chicken flock sizes per household vary significantly among the three agroecologies. The average number of indigenous, exotic, and crossbred chickens per household was 22.83±83, 0.96±1.76, and 1.57±2.19 chickens, respectively. The effective population size and rate of change of the inbreeding coefficient were 1263.69 and 0.04%, respectively, indicating that the population was not at risk of the consequences of inbreeding. Chicken and egg consumption is influenced by cultural and religious festivals, farmers' status, agroecology, breed, plumage color, shank type, comb type, feather distribution, and age. Across all agroecologies, the average annual chicken and egg consumption per household was higher among large-scale farmers than among small-scale farmers. The average annual chicken and egg consumption per household for small-scale and large-scale farmers was 7.76±0.68 chickens and 67.52±3.13 eggs, and 20.79±0.68 chickens and 182.27±3.13 eggs, respectively. The ranking indices of consumption preferences for plumage colors indicated uniform preferences for chicken plumage colors across the agroecologies. Red (1st), greyish (2nd), and multicolored (3rd) plumage colors were the most preferred for consumption, while chickens with full white and black colors were used for spiritual purposes in the study zone. Every family member participated in taking care of chickens, although the degree of responsibility varied among family members. Husbands and wives were involved in the decision-making process for chicken product utilization, but their degree of involvement varied across the agroecologies. Information on flock composition, factors affecting chicken product consumption, ownership, and gender roles are prerequisites for the design and implementation of successful chicken breeding strategies.

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Authors have declared that no competing exists.

Conflicts of Interest

The authors declare no conflicts of interest.

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