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# Canonical Analysis for Assessment of Genetic Diversity of Three Indigenous Chicken Ecotypes in North Gondar Zone, Ethiopia

Research Article

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## ABSTRACT

Rapid exploratory field survey, to identify indigenous chicken ecotypes was conducted in north Gondar zone of Ethiopia. Chicken ecotypes including *Necked neck, Gasgie* and *Gugut* from Quara, Alefa and Tache Armacheho districts were identified, respectively. Morphological variations among the three study populations and nine measurable traits were evaluated. General linear model, canonical discriminate and stepwise analyses were applied for assessing variability among the study populations. *Necked neck* and *Gasgie* ecotypes were heavier and had wider linear traits than the rest, while most of the study traits for the *Gugut* ecotype were the lowest. The most important variables for discriminating between the three populations were shank length, keel length, wingspan and beak length with canonical discriminant function score of 0.897, 0.752, 0.449 and 0.433, respectively. The greatest distance value was between *Gasgie* and *Necked neck* ecotype while the least one was between *Gugut* and *Necked neck*. The discriminate analysis therefore classified the three populations to be distinct clusters. The morphological traits studied have proved to be useful in genetic characterization of indigenous chickens and can thus be useful in developing strategies for conservation of the genetic diversity.

KEY WORDS discriminant analysis, local birds, morphological traits, variance estimation.

## INTRODUCTION

Chicken genetic resources have widespread distribution and huge population size in Ethiopia (Halima, 2007). They contribute important socio economical roles for poverty alleviation by generating additional cash incomes (Kondombo, 2005; Salam, 2005). Due to this impact, almost all rural and many peri-urban families keep small flocks of scavenging chickens (Jens *et al.* 2004). In Ethiopia chicken populations were estimated about 49.3 million of which 97.3, 0.38 and 2.32% were indigenous, crossbred and exotic breeds, respectively (CSA, 2011). Indigenous chickens show great phenotypic variability which is important for adapting various tropical environment conditions (Tadelle and Alemu, 1997). In Ethiopia, most chicken populations are non descriptive type. However, they showed a great variation in their production environment which might be due to their widespread distribution and adaptive response to different ecological conditions (Tadelle *et al.* 2003; Halima, 2007; Fisseha *et al.* 2010). Such poultry species contributed important socio-economic roles for food securities, generating additional cash incomes and religious/cultural reasons (Salam, 2005). FAO (2011) stated that characterization is identifying distinct animal genetic resource of breeds (standardized animals), ecotypes (descriptive term applied to local races), topotype (individual animals collected at the type locality), variety (number of things of the same general class that are distinct in character or quality) and describing their phenotypic uniqueness and risk status in their production environment. Phenotypic variability is the observable and measurable physical nature of animals caused by genetic and environmental components (Besbes, 2009; FAO, 2010; FAO, 2011). Variations are measured with univariate analyses by considering individual variable for substantial overlapping of results to occur. Univariate statistical techniques such as analysis of variance may not sufficient to explain how populations differ when all measured variables are considered jointly. In canonical discriminant analysis technique all variables are considered simultaneously in differentiation of populations. Canonical discriminant analysis can separate effect within and among populations by maximizing discrimination when tested against the variation within a given population (Riggs, 1973). Therefore, the objective of the study was to assess the genetic diversity and differentiation of three indigenous chicken ecotypes using canonical discriminant analysis in north Gondar zone, Ethiopia.

## MATERIALS AND METHODS

### The study area

This study was conducted in the three districts of north Gondar Administrative zone, Amhara regional state, in Ethiopia, namely: Quara, Alefa and Tache Armacheho (Figure 1). The zone had 2929628 (1486040 males and 1443588 females) with 654803 households of human populations within the total land coverage of 459446300 ha having the animal population of 3205 149 chickens, 2446359 cattle, 757210 sheep, 1147203 goats, 327450 equines and 117644 beehives within the altitude ranging from 528-4620 metres above sea level in the rainfall of 600-1772 mm with the temperature range from 44.5 to -10 ˚C (CSA, 2007). Quara district is located in the western part of north Gondar zone between latitudes 11 ˚47' and 12 ˚21 N and longitudes 35 ˚16' and 35 ˚47 E. It is 1123 km far from Addis Ababa and 324 km from Gondar town and its elevation ranges from 528 and 654 meters above sea level. Its annual temperature ranges between 25 and 44 ˚C and annual rainfall between 600 and 1000 mm (CSA, 2011). Human population of the district was about 105995 with total area of 858, 588 ha. The livestock populations was 173863 cattle, 3845 sheep, 146209 goats, 172121 poultry, 6532 donkey, 141 mule, 654 camels and 12485 bee colonies (QADO, 2010). Alefa district is located at 162 km in southwest of Gondar town and 909 km from Addis Ababa with the annual temperature ranging from 25 and 30 ˚C and annual rainfall between 900 and 1400 mm. Total human population of the district was 154940 with 189054 ha of land with the livestock population of 268695 cattle, 27421 sheep, 86992 goats, 964432 chickens, 18952 beehives, 1122 mule, 19445 donkey, 18 horse and 6 camels (AADO, 2011). Tache Armacheho district is also found at 814 km northwest of Addis Ababa and 65 km northwest of Gondar town with the altitude between 600 and 2000 meters above sea level and annual temperature ranging from 25 and 42 ˚C. Its annual rainfall ranges between 800 and 1800 mm (CSA, 2011). Total human population of the district was 88701 with the total area of 268512 ha and the livestock population was 321539 cattle, 123585 goats, 149 sheep, 133332 chickens, 11273 donkeys, 471 mule, 9328 beehive and 92 camels (TADO, 2011).

### Data collection

The rapid exploratory field survey and observation was conducted before collection of the main data in order to know and strengthening the primary information on concentration and distribution of each local chicken ecotype. Based on the preliminary survey, the distribution of dominant chicken ecotypes and their specific locations were identified using district livestock experts and key informants. Following this survey, a multi-stage and purposive sampling approach was employed to select three representative districts based on the population of chicken ecotypes. A semi-structured questionnaire, focus group discussion, trait characterization and body measurements were employed to collected necessary information. For the morphological and biometrical measurements, a total of 450 mature birds (150 males and 300 females) were measured. Linear traits including body weight (kg), body length, wing span, shank length and circumference, keel, length, beak length, comp length and width were measured using spring balance in kg and mason's tapes in cm, in the nearest two digits.

### Data analysis

The Linear traits from 450 adult birds were analyzed using the general linear model of (SAS, 2002) version 9. PROC CANDISC procedure was used to perform the uni - and multivariate analysis to derive canonical variables. The classified ecotypes and the nine linear traits were used to separate canonical variables. Stepwise discriminant analysis using PROC STEPDISC was employed to determine the best combination of variables that would differentiate the study ecotypes.

## RESULTS AND DISCUSSION

### Quantitative traits of chickens

In case of measurable traits about ten persons were involved for measurements. Table 1 presents the least square means of the linear traits of the three chicken ecotypes studied. Significant (P<0.05) differences were recorded between the study ecotypes in all the study traits.

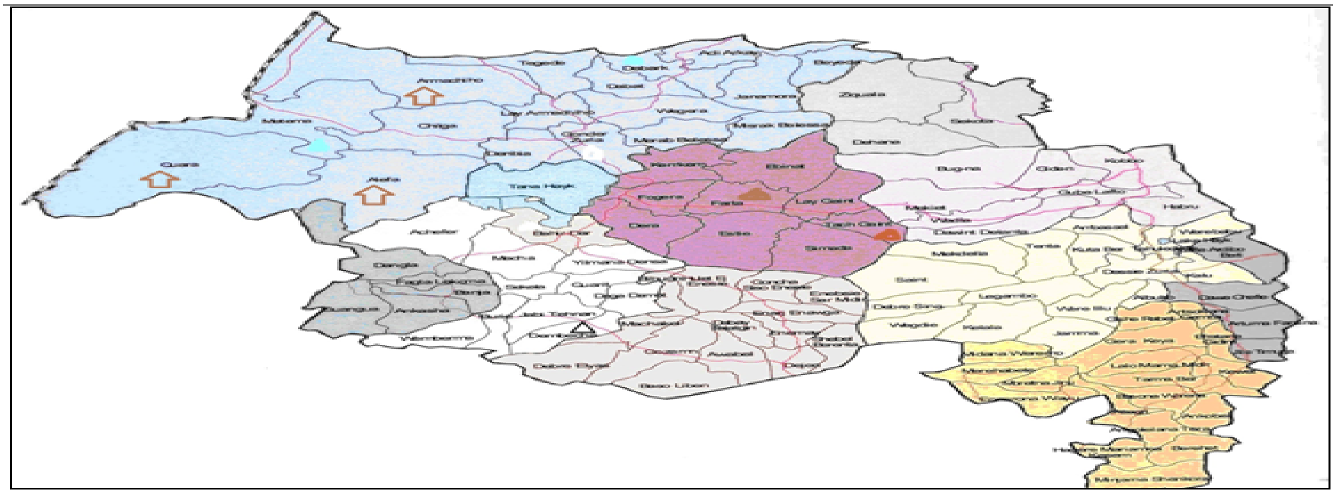

**Figure 1** Map of Amhara regional state, showing the study districts (indicated by arrows)

**Table 1** Least square means (±SE) of body weight (kg) and linear body measurements (cm) of the three indigenous chicken ecotypes, summarised by districts

| Parameters | Sex | Districts / major ecotypes | | | CV (%) | P-value | Over-all mean | Grand mean |
|---|---|---|---|---|---|---|---|---|
| | | Quara / *Necked neck* (Ehapa) | Alefa / *Gasgie* | Tache armacheh / *Gugut* type | | | | |
| SS | M | 50 | 50 | 50 | - | - | 150 | 450 |
| | F | 100 | 100 | 100 | - | - | 300 | |
| Ws | M | 38.70±2.6$^{a}$ | 39.61±0.42$^{a}$ | 35.97±0.23$^{b}$ | 6.51 | 0.0001$^{**}$ | 38.1±0.24$^{a}$ | 37.04±0.13 |
| | F | 37.17±2.36$^{a}$ | 37.36±0.26$^{a}$ | 35.03±0.18$^{b}$ | 6.19 | 0.0001$^{**}$ | 36.52±0.14$^{b}$ | |
| SL | M | 9.61±10.03$^{a}$ | 7.25±0.10$^{b}$ | 7.37±0.73$^{b}$ | 10.05 | 0.0001$^{**}$ | 8.08±0.11$^{a}$ | 7.79±0.15 |
| | F | 9.043±1.10$^{a}$ | 6.80±0.06$^{c}$ | 7.08±0.05$^{b}$ | 9.10 | 0.0001$^{**}$ | 7.64±0.07$^{b}$ | |
| BL | M | 38.12±2.14$^{a}$ | 36.10±0.34$^{a}$ | 35.2±0.09$^{b}$ | 9.49 | 0.0002$^{**}$ | 36.77±0.03$^{a}$ | 35.79±0.09 |
| | F | 36.90±2.61$^{a}$ | 34.60±0.26$^{b}$ | 34.37±0.21$^{b}$ | 6.93 | 0.0001$^{**}$ | 35.29±0.16$^{b}$ | |
| CL | M | 3.25±0.87$^{a}$ | 3.16±0.12$^{a}$ | 3.08± 0.09$^{a}$ | 26.24 | 0.59$^{n}$ | 3.16±0.07$^{a}$ | 2.76±0.09 |
| | F | 2.99±3.68$^{a}$ | 2.28±0.07$^{b}$ | 2.40±0.06$^{ab}$ | 45.61 | 0.04$^{*}$ | 2.55±0.13$^{b}$ | |
| CW | M | 2.11±0.82$^{a}$ | 1.93±0.13$^{a}$ | 2.19±0.05$^{a}$ | 38.36 | 0.25$^{ns}$ | 2.08±0.07$^{a}$ | 1.68±0.04 |
| | F | 1.78±0.85$^{a}$ | 1.07±0.06$^{b}$ | 1.59±0.06$^{a}$ | 45.55 | 0.0001$^{**}$ | 1.48±0.04$^{b}$ | |
| BL | M | 2.42±0.45$^{a}$ | 2.00±0.02$^{b}$ | 1.85±0.10$^{c}$ | 14.12 | 0.0001$^{**}$ | 2.09±0.03$^{a}$ | 2.03±0.02 |
| | F | 2.28±0.60$^{a}$ | 1.93±0.0$^{b}$ | 1.78±0.02$^{c}$ | 18.67 | 0.0001$^{**}$ | 1.99±0.02$^{b}$ | |
| SC | M | 3.58±0.50$^{b}$ | 3.25±0.07$^{b}$ | 3.85±0.03$^{a}$ | 20.78 | 0.0001$^{**}$ | 4.81±0.18$^{a}$ | 3.78±0.07 |
| | F | 3.31±0.59$^{a}$ | 3.11±0.03$^{b}$ | 3.38±0.07$^{a}$ | 17.23 | 0.003$^{**}$ | 3.27±0.03$^{b}$ | |
| KL | M | 9.11±1.02$^{a}$ | 9.55±0.15$^{a}$ | 7.62±0.23$^{b}$ | 16.81 | 0.0001$^{**}$ | 7.51±0.24$^{b}$ | 8.24±0.09 |
| | F | 8.56±0.87$^{b}$ | 9.27±0.08$^{a}$ | 7.98±0.07$^{c}$ | 9.08 | 0.0001$^{**}$ | 8.60±0.05$^{a}$ | |
| Wt | M | 1.78±0.31$^{a}$ | 1.71±0.05$^{a}$ | 1.40±0.04$^{b}$ | 18.15 | 0.0001$^{**}$ | 1.63±0.03$^{a}$ | 1.46±0.00 |
| | F | 1.52±0.26$^{a}$ | 1.36±0.03$^{b}$ | 1.23±0.02$^{c}$ | 17.50 | 0.0001$^{**}$ | 1.37±0.02$^{b}$ | |

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SS: sample size; M: male; F: female; Ws: wingspan; SL: shank length; BL: body length; CL: comb length; CW: comb width; KL: keel length; BL: beak length; SC: shank circumstance (cm) and Wt: weight (kg).
$^{*}$ (P<0.05) and $^{**}$ (P<0.05).
NA: not available.

The *Necked neck* and *Gasgie* ecotypes were heavier and had longer measurable traits than the rest ecotypes, while the *Gugut* ecotype had lower least square means for most linear traits except the shank circumference. The mean body weight (1.78±0.31 kg) of male birds under *Necked neck* was significantly (P<0.01) heavier than that of *Gugut* (1.40±0.04 kg). However, the earlier average body weight was not significantly (P>0.05) different from that of *Gasgie* cocks (1.71±0.05 kg).

Furthermore, the *Necked neck* cocks and hens had significantly (P<0.05) taller shank lengths of 9.61 ± 1.03 and 9.043 ± 1.10 (cm), respectively than those of the other ecotypes.

However, the *Gugut* cocks and hens had bigger shank circumference of 3.85 ± 0.03 and 3.38 ± 0.07 (cm) than those of *Necked neck* (3.58±0.50 and 3.1±0.59 cm) and *Gasgie* (3.25±0.07 and 3.11±0.03 cm) for male and female birds, respectively.

The average comp lengths were not significantly (P>0.05) different from *Necked neck* chicken ecotypes for males (3.25±0.87 cm) and females (2.99±3.68 cm). The *Necked neck* and *Gasgie* cocks had the longest beaks of 2.42 ± 0.45 and 2.00 ± 0.02 cm, respectively while the shortest beaks were recorded on *Gugut* cocks (1.85±0.10 cm). Both the male and female chickens had no significant (P>0.05) variations on beak lengths within ecotypes.

**Multivariate analysis**

*Discriminant analysis* The results on discriminate analysis of the study chicken ecotypes using nine linear traits are presented in Table 2.

**Table 2** Linear discriminate function coefficients for each chicken ecotype population

| Variable | Ecotypes | | |
|---|---|---|---|
| | *Necked neck* | *Gasgie* | *Gugut* |
| Sample size | 150 | *150* | *150* |
| Wingspan | 5.19 | 5.62 | 5.07 |
| Shank length | 9.41 | 5.53 | 6.41 |
| Body length | 3.08 | 2.95 | 3.10 |
| Comb length | -2.02 | -1.97 | 1.79 |
| Comb width | -7.65 | -7.67 | -6.26 |
| Beak length | 8.08 | 6.88 | 4.23 |
| Shank circumstance | 8.15 | 9.23 | 9.23 |
| Keel length | 8.54 | 9.63 | 8.52 |
| Body weight | -32.17 | -33.20 | -35.37 |
| (Constant) | -224.13 | -213.73 | -190.82 |

The results from each group at class level were significantly (P<0.05) different such that some variables showed significant variations from one group to another. Discriminate analysis model was used to prove variations among the sampled populations. Discriminate functions have relatively higher trait coefficients which functions are termed as discriminate trait functions.

In this result the hit ratio was ranged from 85.33- 94.00% in case of *Necked neck* and *Gasgie* chicken population, respectively (Table 2).

Among the three chicken ecotypes, *Necked neck* has the least heat ratio of classification whereas *Gasgie* had the highest.

Discriminate function was classified by using all the data and functions in the form of classification matrix of all chicken populations were developed. Whereas, the error count estimation for each observation was 14.70%, 12.00% and 6.00% for *Necked neck*, *Gugut* and *Gasgie* chicken ecotype, respectively with average heat ratio of 89.10%. Moreover, the benchmark that we were used to characterize a discriminate model was accurately achieved by chance alone and expected hit ratio was 41.70%. This means that the performance of these classification functions was very strong with very high hit ratios.

This high heat ratio showed that identified populations are distinct or more homogenous on the respective quantitative traits as well as the discrete predictions of traditional characterized groups of chickens were unique from their specific location, Table 3.

**Table 3** Classification result number of observations (left figure) and percent classified into ecotype (right figure) for the sample, populations Hit ratio

| | Ecotypes | Discrete predicted group membership | | | Total |
|---|---|---|---|---|---|
| | | *Necked neck* (150[1]) | *Gasgie* (150[1]) | *Gugut* (150[1]) | |
| Original count | *Necked neck* | 128 (85.3%) | 11 (7.3%) | 11 (7.3%) | 150 |
| | *Gasgie* | 3 (2.0%) | 141 (94.0%) | 6. (4.0%) | 150 |
| Total | *Gugut* | 4 (2.7%) | 14 (9.3%) | 132 (88.0%) | 150 |
| | 3 | 135 (30%) | 166 (36.9%) | 149 (33.1%) | 450 (100%) |

[1] Sample size.

**Canonical discriminate analysis**

Canonical discriminate analysis measures the strength of the overall relationship between the linear composite of the predictor set of variables. The first canonical variable or fisher linear discriminant function was explained about 66.7% from the total variation of the three grouped populations where as 33.3% of the variation is explained by canonical variable 2. Therefore, the two canonical varieties were extracted on a total of 100% variations. The most important variables for discriminating between the three populations were shank length and beak length with canonical discriminant function score of 0.897 and 0.433, respectively while keel length and wingspan had higher weighing in loaded high in Can2 with the canonical discriminant function value of 0.752 and 0.449, respectively. In this analysis the predictor is the canonical variants and the criterion is the ecotype.

The significant canonical correlation between the ecotype and the first canonical variate (rc=0.816) and the second canonical variate (rc=0.706), indicate that the canonical variate explain the differentiation of the ecotypes, though the first Can1 was more into explaining the most of the variation than Can2, Table 4. The result of the stepwise discriminant analysis is presented in Table 5. Most important variable for discriminating between the ecotypes was the shank length with the partial $R^2$ of 38%. It was closely followed by keel length and body height with partial $R^2$ as 23.5% and 20.6%, respectively. Canonical discriminant functions evaluated group means to discriminant distributions and graphic representations of the homogeneity of the three chicken ecotypes and were normally distributed from Centroids of their multivariate means (Group Centroids).

Due to smaller error count and short genetic distance between *Gasgie* and *Gugut*, there was no clearly separation despite their variation to be highly significant, (Figure 2).

**Table 4** Total sample standardized canonical coefficient, canonical correlation and total variation explained by each functions

| Variable | Canonical verity / structure matrix | |
|---|---|---|
| | Can1 ( Function one) | Can2 ( Function two) |
| Variation % | 66.7 | 33.3 |
| Canonical correlation | 0.816 | 0.706 |
| Shank length | 0.897 | -0.171 |
| Beak length | 0.433 | 0.156 |
| Bodyweight | 0.265 | 0.253 |
| Body length | 0.233 | 0.203 |
| Comb length | 0.158 | 0.077 |
| Keel length | 0.195 | 0.752 |
| Shank circumstance | -0.160 | -0.488 |
| Wingspan | 0.141 | 0.449 |
| Comb width | 0.129 | -0.240 |

**Table 5** Summary of discriminate stepwise selection among three ecotypes

| Step | Traits | Partial $R^2$ | Wilk λ | F-statistics | Significant |
|---|---|---|---|---|---|
| 1 | Shank length | 0.380 | 0.380 | 364.808 | 0.0001 |
| 2 | Keel length | 0.235 | 0.235 | 236.644 | 0.0001 |
| 3 | Wingspan | 0.206 | 0.206 | 178.622 | 0.0001 |
| 4 | Beak length | 0.192 | 0.192 | 142.034 | 0.0001 |
| 5 | Comb width | 0.181 | 0.181 | 119.783 | 0.0001 |
| 6 | Shank circumstance | 0.173 | 0.173 | 103.514 | 0.0001 |
| 7 | Body weight | 0.168 | 0.168 | 90.841 | 0.0001 |

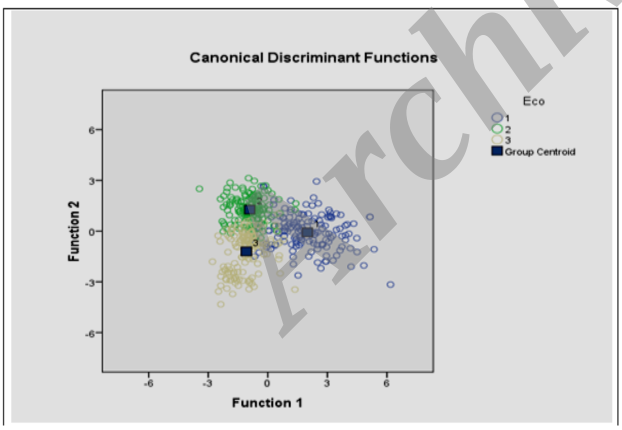


**Figure 2** Discriminate groups of ecotypes (1-3) eco1= *Necked neck*, eco2= *Gasgie*, eco3= *Gugut* and Variables of wingspan, shank length, body length, comb length, comb width, beak length, shank circumstance, keel length and body weight

Stepwise discriminate analysis was the most important techniques for discriminating the investigated ecotypes. These analyzed variables included the shank length, keel length with the partial $R^2$ value of 0.38 and 0.235, respectively and closely followed by wingspan and comp width with partial $R^2$ value of 0.206 and 0.192, respectively.

Discriminating power of traits among the ecotypes was varied. The variation in morphological traits between chicken ecotypes observed in the present study is inconsistent with what Scott and Reynolds (1984) and Ogah *et al.* (2009) reported on Mexican and Nigeria duck, respectively. The first canonical variable or fisher linear discriminant function explained 66.7% of the total variation and Can2 explained 33.3% of the total variation.

The two canonical varieties explained 100% of the total variation. Can1 had higher discriminant power than Can2 because Can1 showed higher distinction of variate between ecotypes than Can2.

Canonical discriminant analysis measures the strength of the overall relationship between the linear composite of the predictor and criterion set of variables.

The variation in morphometric traits might be an adaptation to the various ecosystems in which they are found (Hauser *et al*. 1995).

The phenotype is based on quantitative and qualitative characteristics by combining the genotypic basis and its interaction with the environment (Loos, 1993). The pairwise distances between the study ecotypes were very highly significant (P<0.001) and higher than what Rosario *et al.* (2008) observed between sexes in commercial chicken using performance traits and studying diversity of six weeks old indigenous commercial layer and broiler chickens (Al-Atiyat, 2009). This study show considerable genetic variability and homogenous appearance among the three chicken populations.

## CONCLUSION

The three indigenous chicken populations were characterized based on quantitative traits and they showed distinct characteristics. The multivariate analysis gave a powerful evidence on the uniqueness of ecotypes from the common chicken ecotypes. Significant morphological variations among the three ecotypes of *Necked neck* and *Gasgie* showed higher variability than the *Gugut*. In most cases shank length, keel length, wingspan and beak length were the most important traits to discriminate among the populations. *Necked neck* and *Gugut* ecotypes were the closest while higher distance was between *Necked neck* and *Gugut* with *Gasgie* ecotypes. Qualitatively, *Necked neck* chicken ecotype was easily identified by its complete absence of feather at neck and chest. Further research is needed to investigate other performance characteristics and variability at molecular levels that will further clarify the genetic similarity and diversity among the ecotypes.

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