# PRODUCTION SYSTEM AS A KEY STRATEGY IN CONSERVATION OF CHICKEN GENETIC RESOURCES: EVIDENCE FROM SRI LANKAN INDIGENOUS CHICKEN

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***Abstract***

*Indigenous chicken genetic resource in Sri Lanka is highly diverse. This rich diversity is preserved within an array of production system which are varying in resource levels. This study attempted to relate the knowledge on genetic diversity and molecular analysis with the existing management and production standards to develop a strategy for improvement of indigenous chicken population in Sri Lanka. Accordingly, production and management information of indigenous chicken populations of five geographical regions, namely north central province, north-western province, western province, uva province and southern province were collected using a brief questionnaire along with blood samples from randomly picked households (n=132) representing different villages within each province. Six different haplogroups (A, B, C, D, E and F) were identified in the molecular analysis. The haplogroups A and B were the most frequent haplogroups in each province except WP. However, no particular pattern of distribution of haplogroups identified in the study with respect to geographical region. Different haplogroups showed the similar pattern of variation in all management and production parameters considered in this study. The plumage characteristics , i.e. feather type, colour distribution and colour patters of different haplogroups again showed no particular pattern. The overall results indicated that indigenous chickens in Sri Lanka could be a mixture of diverse genotypes distributed all over the country. The common management practices adopted in rearing indigenous chicken is the primary component that helps preserving genetic diversity, and the genetic makeup of the individuals play a more important role in adaptability than in determining the productivity and phenotypic variations among them.*

***Keywords:*** *Indigenous chicken, production and management system, genetic diversity*

## INTRODUCTION

Poultry meat and egg consumption has drastically increased during the past decade. As in the case of most countries in Asia, indigenous poultry keeping has been practiced for centuries in almost all parts in Sri Lanka. Despite the overall growth of commercial poultry industry, indigenous chickens remain as a predominant family industry in rural areas, mainly because of the balance between input and output levels under rural socio-economic conditions (Abeykoon et al., 2015; Atapattu et al., 2016). As a result of adaptation to varying environmental and management regimes, and due to low level of directional selection pressures, the indigenous poultry show high diversity at the levels of local breeds/ ecotypes or varieties. The pressures of production and economic standards prevailed in the industry for the past several decades have driven the poultry industry with intensive selection to create highly specialized chickens with uniform performance (Granevitze et al., 2009). It has been reported that the population of backyard poultry of Sri Lanka is decreasing while some breeds have already been removed or is near at extinction (Silva, 2016). This trend may lead to create a vacuum in development process of future poultry industry. In one hand, the commercial industry is currently shifting its attention more on health, product quality and animal welfare, which now require access to diverse genotypes (Blackburn, 2006).

Most of the molecular investigation and characterization studies of indigenous chicken done so far have enabled us to understand the extent and level of diversity of those populations. This is the key for developing strategies to sustainable utilization of genetic resources. However, molecular information needs to be interpreted in the context of the system (Blackburn, 2006), as the indigenous chicken are found in wide range of management and environmental regimes. Our attempt in this paper is to relate the knowledge on genetic diversity and molecular analysis with the existing management and production standards to develop a strategy for improvement of indigenous chicken population in Sri Lanka.

## MATERIALS AND METHODS

### Study locations

We carried out a two-fold investigation in five different regions in Sri Lanka; namely north central province (NCP), north western province (NWP), western province (WP), uva province (UP) and southern province (SP). One part of the study consists of molecular characterization of chicken by using Single Nucleotide Polymorphism (SNP) in mitochondrial D-loop of indigenous chicken from different geographical regions of Sri Lanka (results have been described elsewhere), and the other part of the study is to relate the molecular findings with the production and management aspects in development of sustainable utilization strategy.

### Sampling strategy

Farm information and sample collection for molecular analysis were carried out in above mentioned five regions. The sampling locations or villages within the region were selected randomly. Sampling was carried out from households scattered within the village, and only one sample was taken from one household to avoid relatives been sampled for molecular analysis. This sampling strategy enabled us to incorporate diverse information as far as possible. The total number of samples consists of 20 NCP, 18 NWP, 20 WP, 37 UP and 37 SP. In addition, blood samples, the production and management information were collected using a brief questionnaire.

The administration of questionnaire was done by a single visit to each household as there is no variation of farming conditions due to seasons. Multiple visits were also made to regional veterinary office to collect relevant information about the farming conditions of the area as a process of verification of the information collected at individual households.

### Sample analysis

The procedure adopted in mitochondrial DNA based SNP analysis have been described elsewhere (Silva et al., 2008). The output the molecular analysis was used to interpret the descriptive parameters of morphological characteristics and management practices. Descriptive statistics were used to compare morphological and management parameters with the molecular characteristics. Mean comparisons were performed using Minitab version 20.4.

## RESULTS AND DISCUSSION

### Molecular findings

The molecular findings based on the SNP analysis of indigenous chickens from five geographical regions revealed that the indigenous chickens in Sri Lanka possess a comparatively high diversity. The distribution of haplogroups in five study locations is depicted in Table 1. There were 42 haplotypes, which formed six haplogroups. Majority of haplotypes (31) were unique and occurred in a single region (Table 2). However, no pattern of distribution of haplogroups identified in the study with respect to geographical region. According to these findings it was shown that the indigenous chickens in Sri Lanka could be a mixture of diverse genotypes distributed all over the country.

### Indigenous chicken rearing system of the study location

#### Socio-economic aspects of indigenous chicken rearing in study areas

Findings of the present study confirms that the indigenous chickens contribute to important livelihood functions in the local communities, basically for economic and nutritional empowerment. These functions are remarkably same throughout the world though differ in order of priority according to the requirement of the community (Abdelqader et al., 2007). The management and production parameters reported here are comparable to those reported for indigenous chicken populations in different parts of the world.

The duration of farming ranged from 3 months to 50 years.

**Table 1: Distribution of haplogroups in five geographical regions in Sri Lanka.**

| Haplogroup | North-central province | North-western province | Western province | Uva province | Southern province | Total |
|---|---|---|---|---|---|---|
| A | 10 | 8 | 3 | 6 | 17 | 44 |
| B | 4 | 3 | 3 | 22 | 12 | 44 |
| C | 4 | 5 | 6 | 3 | 4 | 22 |
| D | 2 | 1 | 6 | 4 | 2 | 15 |
| E | 0 | 1 | 0 | 2 | 2 | 5 |
| F | 0 | 0 | 2 | 0 | 0 | 2 |
| Total | 20 | 18 | 20 | 37 | 37 | 132 |

**Table 2: Haplotype diversity within haplogroups of the Sri Lankan Indigenous chickens**

| Haplogroup | Number of haplotypes | Percentage of haplotypes exclusivity* |
|---|---|---|
| A | 20 | 45.5% |
| B | 11 | 25.0% |
| C | 3 | 13.6% |
| D | 2 | 13.3% |
| E | 5 | 100.0% |
| F | 1 | 50.0% |

*calculated according to the total number of observation

Majority of households (61.7%) indicated that they had chicken in their backyard for 2-10 years. Few households (8.3%) have been keeping poultry for more than 20 years (Table 3). Long years of practices is an indication of the sustainability of the operation in the study area. Keeping poultry is a routine work of the household, especially that of women and children, and no extra attention needs to be paid on farming. This is a common practice in developing countries ( Laenoi et al., 2015, Wong et al., 2017). According to Mahoro et al. (2017), although the majority of farm owners are men, women (78%) and children (18.6%) are responsible for management activities.

**Purpose of poultry farming**

The main objective of keeping poultry was production of egg, primarily for home consumption and hatching (Table 3). All the study sites showed the similar characteristics in indigenous poultry rearing practices. It was the scenario in almost all the regions except for NCP, where egg for sale was indicated as the main objective. Only 2% of the farmers indicated that meat and egg production was the objective of poultry farming. In most of the regions in the world, the purpose of keeping backyard chicken has been shifted to income generation activity (Mahoro et al., 2017; Snively-Martinez & Quinlan, 2019; Waktole, 2018).

**Table 3: Comparison of the management practices in different regions of Sri Lanka**

| **Management practice** | **Geographical region** | | | | | **Haplogroup†** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **NCP** | **NWP** | **WP** | **UP** | **SP** | **A** | **B** | **C** | **D** | **E‡** | **F‡** |
| Purpose (%) | | | | | | | | | | | |
| Egg for Hatching | 5 | 100 | 100 | 100 | 100 | 79.5 | 90.9 | 81.8 | 80 | 100 | 100 |
| Egg for sale | 80 | 0 | 0 | 0 | 0 | 18.2 | 6.8 | 13.6 | 20 | 0 | 0 |
| Egg and meat | 15 | 0 | 0 | 0 | 0 | 2.3 | 2.3 | 4.6 | 0 | 0 | 0 |
| Duration of farming (Given by number) | | | | | | | | | | | |
| 1 yr≥ | 4 | 3 | 2 | 4 | 5 | 6 | 6 | 3 | 1 | 1 | 0 |
| 02 - 10 yrs | 10 | 8 | 14 | 17 | 25 | 25 | 21 | 14 | 12 | 4 | 2 |
| 11 - 20 yrs | 4 | 3 | 1 | 3 | 7 | 9 | 6 | 3 | 0 | 0 | 0 |
| 20 yrs≤ | 0 | 4 | 3 | 3 | 0 | 4 | 3 | 1 | 1 | 1 | 0 |
| Replacement stock (%) | | | | | | | | | | | |
| From own farm | 90.0 | 94.4 | 100 | 100 | 100 | 95.5 | 100 | 95.5 | 100 | 100 | 100 |
| From outside | 10.0 | 5.5 | 0 | 0 | 0 | 4.5 | 0 | 4.5 | 0 | 0 | 0 |
| Feed base (%) | | | | | | | | | | | |
| Scavenging only | 35.0 | 83.3 | 55.0 | 27.0 | 83.8 | 68.2 | 45.5 | 68.2 | 40 | 60 | 100 |
| Scavenging + supplement | 65.0 | 16.6 | 45.0 | 73.0 | 16.2 | 31.8 | 54.5 | 31.2 | 60 | 40 | 0 |
| Health management (%) | 68.4 | 64.7 | 30.0 | 97.3 | 73.0 | 65.1 | 79.1 | 63.6 | 73.3 | 80 | 100 |
| No medicine | 31.6 | 35.3 | 70.0 | 2.7 | 27.0 | 34.9 | 20.9 | 36.4 | 26.7 | 20 | 0 |
| With medicine | | | | | | | | | | | |

Though the results reported in the present study clearly indicated that egg production was the primary objective and meat production was the lowest priority, the farmers response on this aspect could be highly influenced by socio-cultural ethics and religious binding of their society.

**Flock characteristics**

The flock size ranged from 3 - 50 birds and there was no pattern of variation of flock size according to the region. On average the overall flock size was 7.20 ± 2.68. There was no variation in flock size according to the season or the market forces as recorded during the survey. This could be mainly due to minimum level of contact of the households with the market. There is very short and simple market chain which comprise of direct sale either using personal contacts or a local retail shop. The previous investigations reported that flock size of backyard chicken varied not only among countries but also within the country. However, the average flock size reported in this study was lower than that of other developing countries where an average flock size ranged from 10 to 24 (Bwalya & Kalinda, 2014; Okeno et al., 2012).

The female to male ratio of the flock was ranging from 3:1 (for small flocks) to 10:1 (for large flocks). This could be justified as the scavenging system of rearing increases the chances of interaction of birds with other flocks. Male to female ratio within the flock is an important criterion for the sustainability of the operation as it is a key determinant that affects fertility (Alsobayel & Albadry, 2012), However, a less attention has been paid to this aspect by the farming community owing to the free interaction opportunities the birds were having in common feeding areas. These findings agree with Assefa et al. (2019), who reported the female to male ratio 4:1 in Ethipoia. As revealed during the survey, hen used to come inside the house or to a particular place close to the house when she is at lay. In most of the households hen is provided with a box for laying to make the egg collection easy for the family. The replacement stocks are generally obtained from the own farm (Table 3). Only 2% of the households indicated the situations of reaching outside sources for replacement stocks. This is similar to what was reported by Okeno et al. (2012) and Mahoro et al. (2017), that the majority use their own hatched chicks as the replacement stock, whereas some of the farmers purchased breeding stocks. However, the level of inbreeding in the present study appears to be low owing to the flock interaction under scavenging system. Nevertheless, the prediction of level of inbreeding is not straight forward, given the complexity of management system and absence of records.

**Housing and Feeding**

There was no special housing provided for the birds in all the cases. The birds roost on elevated places such as roof-tops or trees during night-time and spend the daytime scavenging. The total amount of feed resources that consists of household leftovers (kitchen wastes) and all the materials available in the immediate environment (cereal grains, green forage, insects, and worms) are referred to scavengeable feed resource base (SFRB) (Silva et al., 2016). Availability of feeding materials for scavenging is generally influenced by season, cropping pattern and other livelihood activities of farmers. The results of the present study agree with the findings of Abeykoon et al. (2015), who observed that the majority of indigenous chicken farmers used free range system during the day time and confined chicken at night. However, 44% of the household indicated that they use a supplementary feeding apart from scavenging which supplies around 80% of the total intake. According to the farming system, the supplementary feeding materials vary. For example, there were two types of supplementary materials found in the present study, i.e. household waste and mixture of broken rice and ground. According to Hagan et al., 2013 and Laenoi et al., 2015, majority of the households in developing countries supplementing the scavenging feeding with seasonal available supplementary feeding is a common practice. The results of the present study showed that in most of the cases supplementary feeding was a type of cereal, predominantly broken rice. Only 3.5% of the farmers used commercial layer ration to supplement the backyard feeding. These results are in agreement with the findings of Abegaz & Gemechu, (2016) and Mahoro et al. (2017), who reported that most of the time grain was the supplement feed and the rest is kitchen waste. As seen in the present study too, the scavenging system with supplementary feeding is barely fulfilling the nutritional requirement, especially in the laying birds.

## Health care

According to the survey, the reported disease occurrence was low and no routine health care practices carryout for indigenous chicken. This observation highlights the high level of adaptation of indigenous chicken to the farming system which they are a part, and to the environmental challenges exist within. Thus, disease occurrence is not indicated as a problem of indigenous chicken farming. This is a positive observation contradicting the report of Okeno et al. (2012), Mahoro et al. (2017) and Waktole, (2018), where they reported the major limiting factor of backyard poultry production is the occurrence of diseases. Majority of the households (70.5%) in the present study revealed that they do not use medicine for their flocks. Those who were using medicine indicated that they use medicine occasionally but not routinely. Similar trend was reported by Assefa et al., (2019) regarding the indigenous chicken rearing in Ethiopia. Referring to the rearing conditions in Thailand, Laenoi et al., 2015 reported that though the farmers were aware about proper vaccination programmes, most of the farmers never vaccinated their chicken. This was the trend in the study location except for the WP region, where veterinary support services seem to be effective owing to improved infrastructure facilities compared to the other regions.

## Production standards

The production information reported in this study is based on the information provided by farmers as no written records maintained at household level. The average age at start of lay was around 27.1± 2.3 weeks. However, Mahoro et al. (2017), reported a little higher value (28.2) compared to the present study. The clutch size and length (weeks) was 11.9±4.8 and 3.1±1.7, respectively, which are lower than the values reported in the literature (13-18 and 2.5-3, respectively; Assefa et al. (2019)). However, those observations were limited to an area where the management conditions were similar and less diverse. The broody characteristics and the length of broody period depend on management of the flock. The present study revealed that the farmers select one bird as a natural incubator to do incubation and brooding depending on the situation. The average length of the broody period is 4 to 8 weeks which is not comparable to the value of Assefa et al. (2019), who reported brooding period of 10 weeks in Western Ethiopia. However, the length of brooding period depends on the management strategies of the given community. Those strategies invariably influence the egg production and the profitability of the farming operation.

The weekly egg production was 5.0±1.6 during laying though the minimum reported was as low as 2 eggs. The household consumption of egg varied widely where on average it was 58% of the total egg production. This is comparable to the findings of Atapattu et al. (2016), who reported that the household egg consumption per month was 53.7% in southern part of Sri Lanka. Majority of the remaining eggs are incubated and only some are sold.

According to the farmers' estimation, the indigenous chicken egg fetches higher income than the commercial chicken egg. However, the survey results indicated that though the egg prices are high, the sale of egg was not the primary objective in backyard poultry farming. The contribution of indigenous chicken to the household economy was therefore could be under-estimated when their value is assessed only based on cash income as their contribution varies over a wide range such as help in alleviating protein malnutrition and performing a social role as one of the components in socio-economic environment. Wong et al. (2017), also reported in detail the contribution made by the backyard chicken farming in household food security and socio-economic capacity development.

**Association of molecular categorization with production**

There were five different haplogroups (A, B, C, D, E and F) identified in the molecular analysis. The frequency of occurrence of haplogroups in the total population and in different regions is given in Table 1. The haplogroups A and B were the most frequent in the population and in individual regions, except for WP where haplogroups C and D were the most frequent. Evaluation of haplogroups with respect to management and production parameters revealed that there was no difference in management and production parameters among the haplogroups (Tables 3 and 4). The age at start of lay, eggs/week, clutch size and clutch length (w) were varying in a narrow

**Table 4: Comparison of the production levels in different regions and different haplogroups of Sri Lanka†**

| | | Age at lay (w) | Eggs/week | Clutch size | Clutch length (w) |
|---|---|---|---|---|---|
| Geographical region | North-central province | 26.2 ±2.[a] | 5.0 ±1.5[a] | 9.0 ±3.9 [a] | 4.7 ±3.3[a] |
| | North-western province | 27.3± 2.3[a] | 5.8 ± 1.3[a] | 11.5 ± 2.4[a] | 3.0 ± 0.0[b] |
| | Western province | 27.8 ±2.4[a] | 4.2 ± 1.7[a] | 14.8 ± 3.3[a] | 2.9 ± 1.4[b] |
| | Uva province | 27.8 ±2.3[a] | 5.5 ± 1.2[a] | 9.7 ±3.5[a] | 3.2 ± 1.2[b] |
| | Southern province | 26.5 ±1.9[a] | 4.7 ± 2.0[a] | 14.2 ± 5.9[a] | 2.3 ± 0.5[b] |
| Haplogroup‡ | A | 27.1 ±2.3[a] | 4.8 ±1.6[a] | 11.2 ±4.2[a] | 3.0 ±1.8[a] |
| | B | 27.5±2.3[a] | 5.2 ± 1.7[a] | 11.9 ± 5.1[a] | 2.8 ± 0.9[a] |
| | C | 26.8±2.4[a] | 5.5 ± 1.7[a] | 12.2 ± 5.8[a] | 3.1 ± 1.7[a] |
| | D | 27.1±2.3[a] | 4.2 ± 1.4[a] | 12.9 ±3.9[a] | 4.1 ± 2.9[a] |
| | E | 27.2±1.1[a] | 6.0 ± 1.7[a] | 11.8 ± 4.9[a] | 2.5 ± 0.6[a] |
| | F* | 26 | 5.5 | 16 | 3 |
| | Overall | 27.1 ± 2.2 | 5.0 ±1.6 | 11.8 ± 3.8 | 3.2 ± 2.0 |

† Values followed by the same latter superscript with each category (Geographical region and haplogroup) are not significantly different at P≤0.05

‡ Detailed results have been published in Silva et al., 2022.

* Observations were < 5

range almost reflecting the variation observed among different regions.

**Association of molecular categorization with Plumage characteristics**

The distribution of three plumage characteristics namely plumage type, plumage color and color pattern within the feather were evaluated in different haplogroups. Though there was no clear pattern of distribution of any of the feather parameters among haplogroups, it was interesting to note that some haplogroups were highly diverse with respect to feather characteristics except the feather distribution of the body, i.e. full feather cover and naked-neck. Accordingly, naked-neck feather distribution was found in A,B and C haplogroups at 4.5% frequency. The

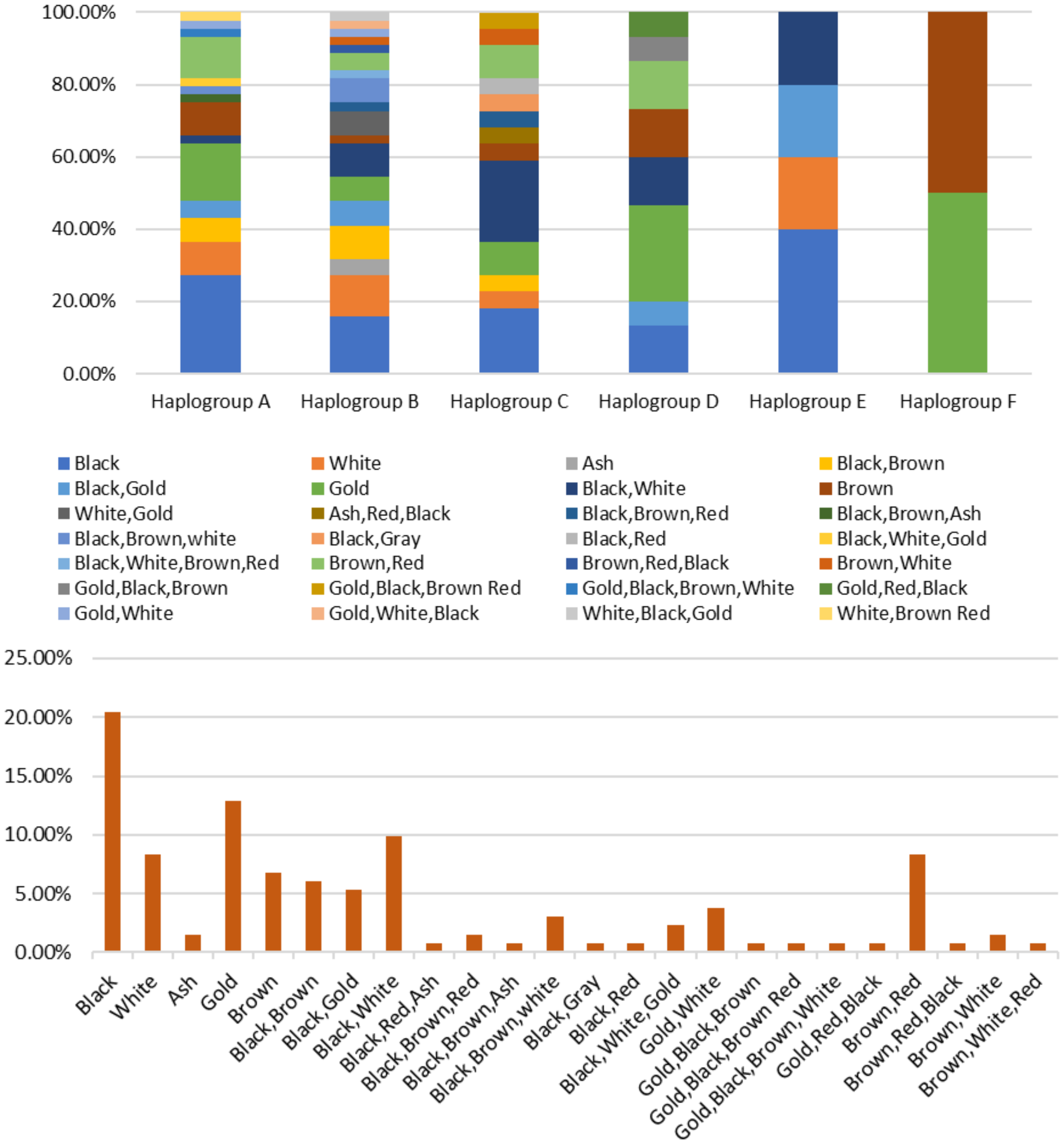


**Figure 2: Overall plumage colour combinations of all haplogroups**

other three haplogroups were represented by comparatively low numbers in the study population and it could be the reason for not appearing naked-neckness which is controlled by a single gene. Figures 1, 2 and 3 present the feather color, colour ranges and feather patterns of the six haplogroups, respectively. When the color patterns were considered, black and gold were the most frequent solid colors whereas black and white, and brown and red were the dominant combinations (Figure 2). Among the haplogroup, solid (single) colourplumage was the most frequent coloration except for haplogroup C where the two colour combinations were prominent (Table 5). Though colour diversity was high in Haplogroups A, B and C this is obviously due to the variation of the sample size. The colour pattern within the feather was randomly varying among haplogroup. Therefore, lacing, solid, mottled and barring pattern could commonly be observed among haplogroups (Figure 3).

## CONCLUSIONS

Combination of molecular investigation with the production and environmental

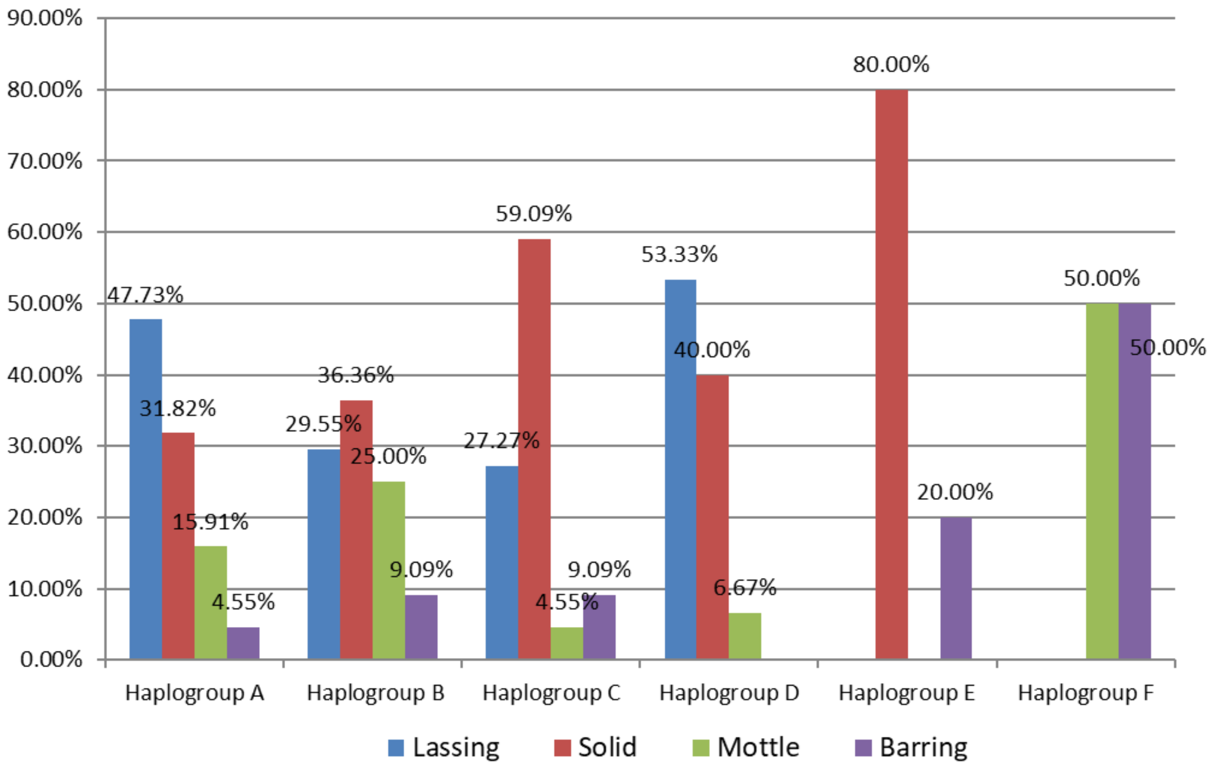


**Figure 3: Colour pattern of feathers in Haplogroups**

**Table 5: Percentage distribution range of colours in different Haplogroups**

| Colour range | Haplogroup A | Haplogroup B | Haplogroup C | Haplogroup D | Haplogroup E | Haplogroup F |
|---|---|---|---|---|---|---|
| 1colour | 61.4% | 40.9% | 36.4% | 53.3% | 60.0% | 100.0% |
| 2colours | 27.3% | 40.9% | 50.0% | 33.3% | 40.0% | 00.0% |
| >2colours | 11.4% | 18.2% | 13.6% | 13.3% | 00.0% | 00.0% |

findings is important to assess the value of contribution of individuals to the diversity and adaptability. Our findings suggest that rearing system of indigenous chicken is the primary component that helps preserving genetic diversity, and the genetic makeup of the individuals play a more important role in adaptability than in determining the productivity and phenotypic variations among them.

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