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Performances and Genetic Correlations between Age at First Egg and Egg Quality Traits of Reciprocal Crossbreds of Hilly and Fayoumi Chickens

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Abstract The selection index is the best method to select the best individual to be a parent to the next generation and is important for the improvement of a trait. It’s a weighted linear function of each trait's selection criteria and breeding values. For estimating the breeding value for a trait heritability, genetic, and phenotypic correlations of the trait are necessary. And the genotypic and phenotypic correlations have great importance in indirect selection. Furthermore, the crossbred produced by the reciprocal crossing of Hilly and Fayoumi (Fay) has not been evaluated elsewhere. Therefore, the aim of this study was to evaluate the Hilly, Fay and their reciprocal crossbred chickens under both intensive and semi-intensive production systems and estimate the genetic correlation between age at first egg and egg quality traits from July 2017 to June 2020. The Hilly and Fay chickens were collected and quarantined for 15 days. Then each genotype was transferred into the rearing shed for random mating at a ratio of 1:8 (male: female). Egg production, egg weight, and survivability of the base and reciprocal crossbreds were recorded from the start of laying up to 365 days. Eggs were hatched by an electric incubator, and the hatched chicks were weighed and their fortnightly live weight up to mature age was taken and recorded. The fertility and hatchability of different genotypes were recorded accordingly. Egg quality traits and daily feed intake were observed and recorded. The breeding values and genetic correlations of each trait were estimated using AIREML software following an individual animal model. Results show the mature live weight of Hilly chickens was higher than Fay and other reciprocal crossbreds. In the case of crossbreds, Fay male × Hilly female crossbreds showed less survivability than Hilly male × Fay female crossbreds. Higher-weighed eggs were observed in Hilly than in other chicken genotypes. A significant difference between genotypes and production systems was also observed for the external and internal egg quality traits. The genotypic correlations between age at sexual maturity and egg weight were found positive, however, some traits showed negative correlations. This studied genetic correlation can be used in selection indices for selecting the best individual for the genetic improvement of these traits.

Keywords Chicken, Reciprocal Cross, Genetic Evaluation, Egg Quality Traits, Correlation

1. Introduction

Animals are evaluated phenotypically or genotypically by observing their performance. On the other hand, genetic evaluation can be done by estimating the breeding values and/or genotyping of the whole genome of an animal. However, the estimation of breeding values (BVs) using phenotypic trait values is a widely used method. A number of methods such as the least square method (LSM), maximum likelihood (ML), and best linear unbiased prediction (BLUP) were used to estimate the prediction of BVs of the traits. However, among these predictors, the BLUP is the most accepted and widely used method for the estimation of BVs [1], which precise the values by reducing the error. Genetic evaluation studies have been used to select cock and hens for the genetic improvement of poultry. For a selection of the best individual, an effective approach is the selection index method [2], which is a weighted linear function of selection criteria and breeding values for each trait in the breeding objective with weight reflecting their relative importance. It is vital to estimate the breeding values and economic values, of the traits in the breeding objective. Which requires estimating the heritability, genetic, and phenotypic correlations of the studied traits. Genetic and phenotypic correlations have great importance in intermediary or indirect selection when changes in one trait are induced through selection for another trait where a genetic correlation exists [3]. The genetic merit of an animal has been undertaken based on different models (for example, the sire model / individual animal model).

Studies found that Fayoumi is a good egg producer, scavenger, and more disease-resistant chicken among the available exotic in Bangladesh [4]. On the other hand, among the native chickens, the Hilly chickens are unique because they are well-adapted, have relatively higher disease resistance, have broodiness, the potential superiority of egg and body weight gain, and have higher survivability in comparison to others [5-8].

Both the Hilly and Fayoumi chickens carry the native gene and they are adaptive in the local environment, a combination of these two types produced a suitable adaptive heterozygote. To meet up the demand for native chicken a reciprocal crossing between Hilly and Fayoumi chicken was undertaken. In Bangladesh few studies (for example Khan et al. [4, 8]; Faruque et al. [9] have been performed to evaluate these chickens both genotypically and phenotypically. However, no detailed information is available on genetic evaluation and correlations among different traits of these crossbred chickens. Therefore, the present study was undertaken with the objectives (i) to study the production performance of reciprocal crossbreds of Hilly and Fayoumi; and (ii) to calculate the genetic correlation of the different traits of reciprocal crossbreds.

2. Materials and Methods

The research was conducted at the poultry shed at the Chattogram Veterinary and Animal Sciences University (CVASU) and the rural areas of the Chittagong Hill Tract (CHT) region of Bangladesh from July 2017 to June 2020 following the animal ethics rule and the ethical committee approval of CVASU (Memo No. CVASU/Dir (R&E) EC/2021/273(4), Date 22/09/2021).

Animal Selection, Breeding, and Performance Study

The base population has been created of 10 cockerels and 40 pullets of Reddish-Brown (RB) Hilly chickens collected/purchased considering the phenotypic features and body confirmations according to Khan et al. (2004) from the rural areas of Chittagong Hill Tract (CHT) and 10 cockerel and 40 pullets of Fayoumi (Fay) was collected from the government poultry farm, of Chattogram, Bangladesh. Then the collected chickens were kept quarantined for 15 days. In pen 1, Hilly male × Fay female and in pen 2 Fay male × Hilly female chickens were allowed for random mating at a ratio of male: female (1:8) to produce crossbreds. The chickens were vaccinated against Newcastle diseases (ND), killed ND vaccine. The Hilly male × Fay female, and Fay male × Hilly female crossbreds were reared under an intensive and semi-intensive management system. The best cocks and hens were chosen for the production of offspring based on the independent culling level method of section. All the genotypes were replicated thrice in each production system and each batch consists of 225 chickens (25 males and 200 females) in each production system. Egg production, egg weight and mortality of the base population and reciprocal crosses crossbred were recorded from the start of laying up to 365 days of laying on a daily basis and calculated the hen day egg production in each chicken population. The eggs were collected twice daily and stored at room temperature for 7 days. These stored eggs were used for hatching using an electric incubator. The hatched-out chicks were weighed and their subsequent live weight up to the age at sexual maturity was kept and recorded in both sexes. The mature live weight of the reciprocal crossbreds (Hilly male × Fay female, Fay male × Hilly female) was recorded. The fertility and hatchability of the crossbred's population were recorded accordingly. The mortality of two crossbreds was observed and recorded for calculating the survivability rate. For calculating the age and weight at sexual maturity, the age and weight of each chicken based on genotype and production system were recorded at the time of first laying. All the chickens were fed with the same formulated ration in both systems. Feed intake data of Hilly and Fay and their crossbred chickens were recorded on a weekly basis, for calculating the daily average feed intake of chickens. The average daily feed intake was calculated by recording the daily feed supply and also estimating the leftover feed in the feeding tray, deducing the amount of leftover feed from supplied feed to get the approximate average daily feed intake.

Management

Intensive system: chickens are reared in confined and supplied they balanced ration, all healthcare and proper management; and semi-intensive system: chickens are kept partially in confinement and supplemented balanced ration, and all health care, they are also allowed to scavenge in the homestead or in the fence during day time. For rearing the chickens under an intensive and semi-scavenging system all the equipment was cleaned, disinfected and fumigated. Footbath and other biosafety measures were taken properly. In the laying house, one feeder for every six birds (1:6) and one waterer for every 8 birds (1:8) were placed in equal intervals. Adlibitum fresh water and formulated ration with the ingredients of broken corn, wheat, rice polish, soybean meal, protein concentrate, concentrate, vitamin-mineral premix, soybean oil, common salt, and the nutrient composition of the ration was 2950 kcal/kg for chicks, 2800 kcal/kg for the grower and 2660 kcal/kg for layer, protein 20%, 17% and 16%, Calcium 1, 0.75 and 3.50%, phosphorus 0.5, 0.5 and 0.70% respectively was supplied twice daily. Standard vaccination schedule (BCRDV, RDV, ND, fowl Cholera) was followed, and other farm operations like debeaking and deworming were also carried out as per the appropriate procedure. Supplements such as Vitamin C, glucose, and salt were supplied with water as needed. The chicks were brooded using an electric brooder and proper brooding temperature was maintained. During summer the brooding period was provided three weeks and during winter it was 6 weeks. The lighting management for chicks was 24 h, for growers 20 weeks, and during the laying period, it was 16 h.

External and Internal Quality of Eggs

Ninety eggs from each variety of chicken from each replicated crossbred population were collected. The collected eggs were cleaned and weighed using a digital electronic balance (Model: DWA-224, Dawer Scales India Private Limited) and data was recorded. Egg width and egg length were measured using Vernier slide calipers (Mitutoyo Corp, Japan). The egg shape index was calculated using this recorded data following Yakuba et al. [10],

$$\text{Shape index} = \text{Egg width}/\ \text{Egg length} \times 100$$

Eggs shell surface area was also determined as,

$$\text{Surface area} = 3.9782 \times \text{egg weight (g)}\ 0.7056\ [11]$$

The thickness of the eggshell was determined using a micrometer screw gauge (Mitotoyo Corp, Japan). The accuracy of shell thickness dimensions was ensured by measuring shell samples at the broad end, the mid-portion and the narrow end of each egg. Each egg was broken and the yolk and the albumen were weighed and separated carefully. The albumen and yolk height were determined using a spherometer (RAC Expots, Haryana, India); the albumen height was measured in the middle of the thick albumen equidistant from the outer edge of the albumen and the yolk using Vernier slide calipers (Mitutoyo Corp, Japan). Both albumen and yolk ratios of each egg were determined as:

$$\text{Albumin or Yolk Ratio} = \text{Albumin or yolk height}/\ \text{Albumin of yolk width}$$

To correct for the difference in egg weight, the albumen height was converted into Haugh units [12], Haugh unit = 100 log (H + 7.6 - $1.7^{W0.37}$), where, H =Observed height of the albumen in millimeters and W = Weight of egg in grams.

Estimation of Breeding Values (EBVs) Using BLUP

Estimated breeding values (EBVs) and genetic correlations of different traits were obtained from univariate and multivariate analysis by AIREML based on Restricted Maximum Likelihood (REML) and using the Average Information (AI) matrix as the second derivative in a quasi-Newton procedure.

The individual animal model of analysis was presented as:

$$Y_{ij} = F_i + a_j + e_{ij}$$

Where Y_{ij} is the traits yield; Fi is the vector of fixed effects due to the age of the birds, aj is a matrix relating to the breeding value of chickens, distributed with mean 0 and variance σ^2a, the genetic variance for the observed traits; and e is the vector of error terms, assumed NID (0, σ_e^2).

In matrix notation, the above equation of the animal model becomes:

$$Y = Xb + Zu + e$$

Where Y is the vector of all observations; b is the vector of fixed effects; u is the vector of breeding values of the chickens; and e is a vector of residual effects.

X and Z are design matrices connecting to the fixed and random effects, respectively.

Statistical Analysis

The least-square means of the different recorded parameters on the basis of the chicken genotype and production system using PROC GLM and PROC MIXED of SAS [13] (2010) followed by completely randomized design (CRD) and randomized block design (RBD) for base and crossbreds, respectively population. Mean differences were compared using the least significant difference (lsd) test at the 5% level of significance.

3. Results and Discussion

Performance of the Chickens

The production performance of the Hilly and Fayoumi (Fay) and their reciprocal crossbreds under intensive and semi-intensive production systems are presented in Table 1. The production traits between Hilly and Fayoumi (Fay) chickens differed under an intensive production system differed significantly (P<0.05), and Fay chickens were better than Hilly and it was observed due to breed differences as Fay is a recognized breed and Hilly is a high egg and meat producing native genotype of Bangladesh. Similar results were obtained elsewhere [4, 8]. The annual hen house egg production of crossbred varied from 99 to

116 no /chicken and the egg production of Hill male × Fay female and Fay male × Hilly female significantly differed within the production system and the Hilly male × Fay female genotype differed between production systems. Fertility, (74 to 78%), hatchability (77 to 81%), age at sexual maturity (157 to 169 days for males (cockerel), and 146 to 172 days for females (pullet)), and live weight at sexual maturity for males 1374.44 to 1860.54 g and for females 1288.29 to 1520.22 g, respectively, and mature live weight of males (cock) was 1750.46 to 2110.75 kg and females (a hen) were 1300.49 to 1570.89 g regardless of genotype and production system (Table 1). These values differed significantly ($P<0.05$) between production systems and genotypes. All the genotypes showed higher values for most of the traits under intensive conditions than the semi-intensive conditions, which might be due to the supply of an adequate amount of feed and comparatively better management in an intensive system than in the semi-intensive system. The production system has influenced chicken's performance, showed by Noor et al. [14], Sanka and Mbaga [15], and Khan et al. [7]. Similarly, traits also differed between genotypes, and this statement was supported by Khan et al. [7, 8] and Soro et al. [16]. For both productive and reproductive performances, the Hilly × Fay (F_1) genotype showed better than the average of the parental genotype and other crosses. This might happen due to the heterozygosity of the crossbred and the highest heterosis was observed in the F_1 generation in a single cross.

Table 1. **P**erformance of different genotype chickens under intensive and semi-intensive production systems

Traits	**Genotypes**					
	Base Population in intensive system		**Intensive system**		**Semi-intensive system**	
	Hilly	**Fayoumi**	**Hilly × Fay**	**Fay × Hilly**	**Hilly × Fay**	**Fay × Hilly**
Phenotypic traits						
Egg production (no.)	88^{α} ±1.27	146^{β} ±3.41	116^{by} ±5.21	102.7^{ax} ±1.43	106^{bx} ±1.32	99^{ax} ±1.55
Fertility (%)	77 ±1.48	78 ±1.92	78.87^{by} ± 1.27	74.9^{ax} ±1.32	75.2^{x} ±1.72	74.2^{x} ±1.51
Hatchability (%)	77 ±1.83	81 ±1.75	79.1 ±0.09	78.1 ±1.07	78.7 ±1.11	78.5 ±1.91
Age at sexual maturity of male (days)	168^{β} ±2.99	157^{α} ±3.17	165.9^{y} ±5.43	167.8^{y} ±2.61	160.1^{ax} ±2.42	167.8^{by} ±2.11
Age at sexual maturity of female (days)	172^{β} ±4.68	146^{α} ±4.91	169.4^{y} ±6.74	165.6^{xy} ±2.20	163.6^{x} ±2.15	165.6^{xy} ±2.06
Wight at sexual maturity of male (g)	1860.54^{β} ±9.2	1700.6^{α} ±12.3	1432.1^{by} ±13.87	1374.4^{ax} ±8.59	1474.4^{x} ±7.17	1374.4^{x} ±8.18
Wight at sexual maturity of male (g)	1520.2^{β} ±7.85	1350.5^{α} ±11.2	1337.6^{y} ±13.52	1334.2^{by} ±7.88	1320.3^{by} ±7.03	1288.2^{ax} ±8.28
Live weight of mature male (g)	2110.7^{β} ±25.6	1750.4^{α} ±13.7	1977.7^{bz} ±37.62	1780.9^{ax} ±11.54	1890.2^{by} ±17.24	1765.2^{ax} ±14.51
Live weight of mature female (g)	1570.8^{β} ±15.7	1350^{α} ±14.93	1389.3^{by} ±23.37	1330.4^{ax} ±28.11	1391.4^{by} ±22.10	1300.4^{ax} ±20.75
Feed Intake of male (g/day)	120^{β} ±0.32	106^{α} ±0.09	112.2^{bz} ±0.36	108.4^{az} ±0.05	90.4^{ax} ±0.08	93.4^{by} ±0.04
Feed intake of female g/day)	108^{β} ±0.42	100^{α} ±0.75	102.2^{z} ±0.65	101.0^{z} ±0.20	86.0^{by} ±0.21	82.0^{ax} ±0.27
Survivability of males up to one year	86^{β} ±1.16	76^{α} ±1.25	88^{y} ±1.97	85^{y} ±0.84	91^{bz} ±1.56	79^{ax} ±1.21
Survivability of females up to one year	88^{β} ±0.78	78^{α} ±1.34	90^{y} ±1.65	89^{y} ±1.29	83^{x} ±1.32	79^{x} ±1.88

Legends: g, Gram; mm, Millimeter

Means with different superscripts differed significantly at $p<0.05$

These findings agree with the findings of Munisi et al. [17], who observed that the live weight of F_1 (Black Australorp male × broiler stocks female) was significantly higher than the F_2 generation and backcross population. Furthermore, in the current study, the chicken's mature live weight and weight at sexual maturity of pure Hilly was higher than other studied genotypes under both production systems that have been similar to Khan et al. [7]. The survivability of male and female chickens significantly differed between production systems and genotypes (Table 1). Comparatively higher survivability of different chicken genotypes and sexes was observed in intensive production conditions than in semi-intensive conditions up to one year of age and this might be due to that, under the semi-intensive conditions extra loss of the chicken may happen due to predators. This finding was similar to the findings of Khan et al. [7, 8] and Soro et al. [16].

On the other hand, the feed intake of chickens also differed between the production systems and genotypes (Table 1). Under the intensive conditions, the chickens were fully fed by supplying a balanced ration and their average feed intake was comparatively higher irrespective of genotypes than the chickens of semi-intensive production systems. Under semi-intensive conditions, the chickens were supplemented with the supplied balanced ration and the extra amount of feed they took from their surroundings.

Eggs Quality Traits of Chickens

The highest egg weight was observed for Hilly × Fay (F_1) genotype under intensive management and the lowest was for the Fay × Hilly (F_1 under the semi-intensive production system (Table 2). In addition, varying genotypes have a significant ($p<0.05$) effect on production systems for egg weight. A similar value of egg weight of Hilly and its crossbred was observed by other researchers [7, 8, 18]. The variation in egg weight might be the differences in genetics, feeding and management of chickens, and these factors were also reported by other researchers [15, 18]. Noor et al. [14] and Khan et al. [4, 8] reported a similar value on eggshell thickness to the current study (0.082 to 0.21 mm) irrespectively of genotypes and production system but Iqeobi et al. [20] reported a slightly higher value on eggshell thickness than the present study. An effect of genotype has been observed for the shape index between the production system and genotype. The highest value (78 ±2.25) was reported for the Hilly × Fay (F_1) in intensive management and the lowest (75 ±2.31) was observed for the Fay × Hilly genotype under the other production system. The shape index value was similar to Khan et al. [21]. The variation in the shape index may be due to the variation in the breed and management of birds. The effect of genotypes on albumin and yolk weight and albumin and yolk height did not differ between genotypes and production systems (Table 2). The Haugh unit (82.11 to 83.75) of this study varied between the production systems but did not differ between the genotype. The values of albumin and yolk weight and height and Haugh unit observed in the current study agreed with the study of Khan et al. [21] and differed with Noor et al. [14], this variation may be due to the genotype differences of chickens.

Table 2. External and Internal quality of eggs in different genotypes

Traits	Genotypes					
	Base population		Intensive system		Semi-Intensive system	
	Hilly	Fayoumi	Hilly male × Fay female	Fay male × Hilly female	Hilly male × Fay feale	Fay male × Hilly female
Egg weight (g)	48.10 ±0.84	44.79 ±1.14	46.99^{x} ±0.54	43.9 ±0.67	45.76^{y} ±1.16	42.9 ±0.65
Egg shell weight (g)	5.43 ± 0.13	3.73 ±0.14	3.89 ±0.25	3.78^{b} ±0.14	4.15 ±0.42	3.68^{b} ±0.13
Egg shell thickness (mm)	0.21 ±0.01	0.13^{b} ±0.03	0.0824a ±0.01	0.083^{b} ±0.043	0.11^{b} ±0.001	0.093^{b} ±0.02
Shape Index	78.26 ±2.67	75 ±1.21	78 ±2.25	76 ±1.52	77 ±1.45	75 ±2.31
Internal quality						
Yolk index	39 ±1.15	38^{a} ±1.06	41^{b} ±1.01	37^{a} ±1.02	39^{a} ±2.04	38^{a} ±1.01
Yolk weight (g)	16.10 ±0.32	12.74^{a} ±0. 27	15.83^{b} ±0.92	14.58^{a} ±0.39	15.38^{a} ±0. 39	14.58^{a} ±0.39
Yolk height (mm)	10.13 ±0.22	9.87 ±0.16	10.078 ±0.17	9.89 ±0.15	10.17 ±0.15	9.739 ±0.17
Albumin weight (g)	25.57 ±0.52	19.18a ±0.46	21.91b ±0.16	19.75^{a} ±0.58	20.49^{a} ±0.54	19.67^{a} ±0.52
Albumin height (mm)	5.82^{a} ±0.01	5.24^{b} ±0.03	5.77^{a} ±0.02	5.84^{b} ±0.07	5.91^{b} ±0.06	5.75^{b} ±0.04
Haugh Unit	76.97 ±0.79	76.87 ±0.53	82.22 ±0.28	82.91 ±0.66	83.75 ±0.65	82.11 ±0.52

Legends: g, Gram; mm, Millimeter

Means with different superscripts differed significantly at $p<0.05$

Table 3. Genetic correlation between age of first egg and egg quality traits

Production system	Genotype	Parameters	AFE	EW	YH	YW	ALW	ESW	ST	SI	HU
Intensive	Fay male × Hilly female	AFE	1								
		EW	0.41	1							
		YH	-0.45^{a}	0.23	1						
		YW	-0.13	0.21	0.43	1					
		ALW	-0.41^{a}	0.32	0.13	0.20	1				
		ESW	-0.20	0.36	-0.23	-0.19	0.27	1			
		ST	0.27^{b}	0.03	-0.12^{b}	-0.17	-0.19	0.22	1		
		SI	-0.02	0.12	-0.20	-0.15	-0.27	-0.25	0.25	1	
		HU	0.45^{b}	0.38	-0.22	-0.33	0.24	0.12	0.32	-0.03	1
	Hilly male × Fay female	AFE	1								
		EW	0.43	1							
		YH	-0.27^{b}	0.20	1						
		YW	-0.12	0.19	0.46	1					
		ALW	-0.24^{b}	0.37	0.19	0.17	1				
		ESW	-0.19	0.41	-0.13	-0.25	-0.25	1			
		ST	0.02^{a}	0.06	-0.25^{a}	-0.22	0.10	-0.12	1		
		SI	-0.28	0.15	-0.21	-0.28	-0.20	-0.23	-0.19	1	
		HU	0.23^{a}	0.36	-0.12	-0.23	-0.16	-0.25	-0.27	-0.20	1
Semi-intensive	Fay male × Hilly female	AFE	1								
		EW	0.44	1							
		YH	-0.48^{a}	0.21	1						
		YW	-0.12	0.26	0.43	1					
		ALW	-0.40^{a}	0.39	0.13	0.18	1				
		ESW	-0.21	0.42	-0.23	-0.19	0.27	1			
		ST	0.24^{b}	0.05	-0.11^{b}	-0.17	-0.19	0.20	1		
		SI	-0.02	0.18	-0.21	-0.15	-0.27	-0.28	0.22	1	
		HU	0.45^{b}	0.43	-0.23	-0.34	0.24	0.11	0.34	-0.03	1
	Hilly male × Fay female	AFE	1								
		EW	0.41	1							
		YH	-0.25^{b}	0.31	1						
		YW	-0.10	0.27	0.46	1					
		ALW	-0.22^{b}	0.36	0.19	0.17	1				
		ESW	-0.20	0.30	-0.13	-0.24	-0.25	1			
		ST	0.02^{a}	0.04	-0.25^{a}	-0.22	0.10	-0.12	1		
		SI	-0.01	0.19	-0.19	-0.30	-0.20	-0.23	-0.18	1	
		HU	0.33^{ab}	0.35	-0.14	-0.21	-0.16	-0.24	-0.27	-0.17	1

Legends: AFE = Age of first egg; EW= Egg weight; YH = Yolk height; YW = Yolk weight; ALW = Albumin weight; ESW = Egg shell weight; ST = Shell Thickness; SI = Shape index; HU = Haugh unit.

Means with different superscripts differed significantly at $p<0.05$

The genetic correlation between the egg quality traits with age at sexual maturity is presented in Table 3. The correlation between age of sexual maturity and other egg quality traits was significantly varied between genotypes and the production systems. The correlation values of all egg quality traits with age at first eggs were negative except for egg weight, shell thickness, and Haugh unit for all genotypes and production systems (Table 3). The correlation of age at the first egg with average egg weight was positive for all traits, which indicated that birds that sexually matured earlier produced smaller weighted eggs for all genotypes that are supported by the Fayoumi breed study by Kgwatalala et al. [22] and Gebreselassie et al. [23], they explained that mean egg weight was strongly influenced by the age at which a flock of hens reaches sexual maturity and where egg weight was highly correlated with age at sexual maturity irrespective of breed. The correlation between yolk height with yolk weight and albumin weight was positive and a positive correlation between yolk weight and albumin weight were also obtained, and yolk height and weight were negatively correlated with all other traits for the genotypes and production systems. The albumin weight and eggshell weight and Haugh unit and eggshell weight with shell thickness showed positive correlation and the Haugh unit and shape index were negatively correlated. On the other hand, the correlation between the Haught unit and shape index was showed negative. In the present experiment, the correlations of egg weight with albumin weight and yolk weight showed higher relationships similar to those obtained by Zhang et al. [24] and Okonkwo, [25]. Farooq et al. [26] and Zita et al. [27] mentioned a positive but non-significant correlation between egg weight and eggshell thickness in this study. Negative and no significant correlation coefficient was found between age at first egg and shell thickness, shape index in Hilly♀ × Fay♂ crossbred. In the case of Hilly♂ × Fay♀ correlation coefficient between age at first egg and other quality, traits are found negative where age at first egg and shape index was positively correlated. This favorable trend indicated that selection for earlier age of the first egg is likely to be associated with moderate gain in egg production. The correlation value (0.042) obtained between the egg weight and shell thickness was low compared to the 0.26 reported by Obike et al. [28]. This implies that egg weight in these flocks has a very weak association with eggshell thickness.

4. Conclusion

This study reveals that Hilly male × Fayoumi female crossbred is better in comparison to the other crossbreds in both intensive and semi-intensive production systems. Correlations between studied traits show a significant relationship with one another and can be used in the selection methods for selecting the best individual for genetic improvement. The crossbred (Hilly male × Fayoumi female) may be useful to develop a dual-purpose chicken. However, it is recommended that before making a final decision further study with a larger population is needed.

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