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Estimation of phenotypic correlations between growth & reproductive traits in layer chicken

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Abstract
The 450 crossbred layer chickens used in this present study were selected from three genetic groups namely Desi cross1, Desi cross 2 and Punjab Red. The following economic parameters that were recorded during the period from 2020–2021 are Body weight (g) at first egg production, Age at sexual maturity (days), Weight of first egg (g), Egg production (no.) at 40th week, Egg weight (g) at 40th week (g), Egg production (no.) at 52nd week, Egg weight (g) at 52nd week. Weekly body weight (g) from 0 day to 20th week and 40th week. The estimation of phenotypic correlation was carried out using the WOMBAT software programme. Highly significant phenotypic correlations were found between BW 1 week, EP 40 week and FEW, BW 2 week and EW 40 week, BW 3 week and FEW, BW 10 week and EP 52 week, and BW 14 week and BW 40 week.

Keywords: Layer chickens, genetic varieties, phenotypic correlation, significant, traits

1. Introduction
India as one of the largest producer of eggs and poultry meat, highly dependent on quality of eggs and protein contents in eggs and chicken products. Compiling thorough assessment and recording of the data points using accurate measurement techniques and sufficient sample data set, it has been intended to give the farmer not a perfect but closer to an ideal genotype and hence, genetical techniques should be applied to improve quality of these stocks. In layer chickens, there are numerous features with significant commercial value that have intricate interactions. The economic importance of laying hens' ability to reproduce justifies and promotes research into the relationship between variables linked to these traits. The reproductive traits have traditionally been the main characteristic of layer chickens. To study the phenotypic correlation, researchers concentrate on traits like body weight, age of sexual maturity, egg production, egg weight, first egg weight and many more growth and reproductive traits. The objective of this investigation was to determine the genetic parameter (phenotypic correlation) related to the three genetic groups of backyard chicks in Punjab for growth and reproductive traits at Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab. Thus correlations are of great interest to the breeder.

2. Material and Methods
2.1 Experimental Animals and Management: Parents of three distinct genetic varieties (Punjab Red, Desi Cross 1 and Desi Cross 2) of chicken were chosen. 600-day-old female chicks from all three genetic groups' parents were hatched. Through artificial insemination using the chosen male's semen, mating was accomplished. Every bird was reared using the same management techniques and according to accepted standards. Finally, 150 birds from each genetic group were selected for analysis which is used for data recording up to 52-weeks of age. Pedigree chicks were hatched at the university's hatchery unit starting from the winter season of the year 2020 for the purpose of this investigation. On the basis of the vent method, sexing of the chicks were done and day-old chicks had their wings banded for the purpose of identification. Similar feeding, environmental and management conditions were provided to all the birds involved in the present study. Different traits were measured using an electronic weighing scale. Punjab Red was produced previously and kept in the poultry research farm. Desi cross 1 and Desi Cross 2 were produced by crossing Rhode Island Red with local desi birds and Punjab Red with local desi birds of the Punjab state respectively.

2.2 Data Description

The current study was carried out from 2020-2021 at the Directorate of Livestock Farms' Poultry Research Farm in Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana. Collection of data was done from 450 egg-laying birds of three genetic groups i.e. Punjab Red, Desi cross 1, and Desi cross 2 which consists of 150 birds per genetic group. In order to observe the reproductive and growth traits of birds from three genetic groups, the following traits were chosen and recorded. The following observations were then made as follows: Weekly body weight from 0 day to 20th week and 40th week(BW; g), Body weight at sexual maturity (BWSM; g), Age at sexual maturity (ASM; days), Weight of first egg (FEW; g), Egg production upto 40th week of age (EN; no.), Egg weight at 40th week (EW; g), Egg production upto 52nd week of age (EN; no.), Egg weight at 52nd week (EW; g).

2.3 Statistical Analysis

Using all of the records that were accessible, descriptive statistics of growth and reproductive attributes data were performed in the WOMBAT software. In the genetic evaluation of economic traits, only data from hens that survived up to 52nd weeks old were used. The phenotypic correlations between the various economic traits were calculated as:

$$r_{g_{xy}} = \frac{Cov_{s_{xy}} + Cov_{e_{xy}}}{\sqrt{[\sigma^2_{s_x} \times \sigma^2_{e_x}] + [\sigma^2_{s_y} \times \sigma^2_{e_y}]}}$$

where, $Cov_{s(x,y)}$ = Sire component of phenotypic covariance between traits x and y; $Cov_{e(x,y)}$ = Error component of phenotypic covariance between traits x and y; $\sigma^2 e_x$= Error component of variance for trait x; $\sigma^2 e_y$ = Error component of variance for trait y; $\sigma^2 s_x$ = Sire component of variance for trait x; $\sigma^2 s_y$ = Sire component of variance for trait y p(x, y) and the formula proposed by Panse and Sukhatme (1967) [4] was used to compute the standard error of phenotypic correlation:

$$S.E. = \frac{1 - r^2 p(x,y)}{\sqrt{N-2}}$$

Where, $r^2_{p(x,y)}$= Phenotypic correlation between traits x and y and (N-2)= Degree of freedom. To determine the level of significance, the tabulated value and the phenotypic correlation were compared at (N-2) degrees of freedom which was given by Snedecor and Cochran (1967) [5].

3. Results and Discussion

The phenotypic correlation of 0 week body weight was positive and significant with 3week body weight, age at sexual maturity, 52 week egg production and egg weight and negative with 40 week and 52 week egg production. According to Dana *et al*. (2011) [6], 0 week body weight had a positive association with body weight at 2 and 6 weeks but only a weak positive phenotypic association with body weight at 8, 12, and 16 weeks and egg production. Bodyweight at 1 week showed positive correlation with all other economic traits except age at sexual maturity and found to be highly significant with 40 week, 52 week egg production and first egg weight. The experiment conducted by Zonuz *et al*. (2013) [7] revealed that it had very little association with body weight at the 8 week, 12 week and age at first egg. There is a positive phenotypic correlation between bodyweight at 2 week and rest of the traits and showed negative association with egg weight at 40 week and age at sexual maturity but found that it was highly significant with 40 week egg weight and significant with first egg weight and 52 week egg weight. According to Dana *et al*. (2011) [6] the findings revealed that there is a positive association between 2 week and 6, 8, and 12 and 16 weeks body weight, but exhibits a weak phenotypic correlation with egg production. The present study showed positive phenotypic correlation between 3 week body weight and body weight from 4 week to body weight at 20 and 40 week and also positive association with BWSM, EP40, EP52, EW52, FEW and highly significant with FEW but showed negative relationship with age at sexual maturity and 40 week body weight. The 4 week and 5 week bodyweight showed similar result i.e. body weight at 4 week showed positive association with BW5 to BW20 and BW40, BWSM, EP40, EP52, EW40, EW52 and FEW and also in addition, body weight at 5 week showed positive relationship with BW6 to BW20 and BW40, BWSM, EP40, EP52, EW40, EW52 and FEW. The 4 and 5 week body weight revealed negative correlation with age at sexual maturity and highly significant with first egg weight. There is a positive phenotypic correlation between bodyweight at 6 week with all others economic traits excluding age at sexual maturity. Moreover, 6week body weight was significant with 40 week egg weight and first egg weight. It was positively correlated with body weight at 8, 12, and 16 weeks, according to a study by Dana *et al*. (2011) [6], but showed weak correlation with egg production. Bodyweight at 7 weeks had positive phenotypic correlations with BW8 to BW20 and BW40, BWSM, EP40, EP52, EW40, EW52, and FEW, but negative phenotypic correlations with age at sexual maturity. The body weight at 8 week showed positive phenotypic association for BW9 to BW20 and BW40, BWSM, EP40, EP52, EW40, EW52, and FEW and negative relationship for age at sexual maturity. The bodyweight at 9 week showed positive phenotypic correlation with all the traits except age at sexual maturity. Moreover, all were significantly associated with first egg weight. In 2011, Dana *et al*. [6] revealed that body weight at 8 week was positively correlated with body weight at 12 and 16 week but found weak association with egg production and in 2013, the findings of Zonuz *et al*. [7] revealed that the 8 week body weight was positively correlated with 12 week however, low correlation was observed with FEW and ASM. Bodyweight between 10 and 20 weeks old showed negative phenotypic correlation with age at sexual maturity. Additionally, the present study showed a highly significant correlation between body weight at 10 and 14 weeks and egg production at 52 and egg weight at 40 weeks, respectively. Bodyweight at 11, 12, 13, 16, and 18 weeks was, however, significantly correlated with egg weight at 40 weeks, while body weight at 5, 12 and 15 weeks was significantly correlated with first egg weight. In 2011, Dana *et al*. [6] revealed that the 12 week body weight has strong phenotypic association with the 16 week body weight. Bodyweight at 40 weeks showed positive correlation with ASM, BWSM, EW40, and EW52 and negatively associated with first egg weight, egg production at 40 weeks, and egg weight at 52 weeks. The association between 40 week body weight and first egg weight, 52 week egg production, age at sexual maturity, and 40 week egg production was significant. The 40 and 52 week egg production, 40 week and 52 week egg weight and the bodyweight at sexual maturity were all negatively correlated with the age at sexual maturity. However, it is positively correlated with FEW and significant results were shown with 52 week egg weight, first egg weight and sexual maturity body weight. The opposite findings, however, were made by Liu *et al*. (2019) [8], who found that ASM is positively associated with both 52-week and 40-week egg production. The phenotypic connection between 40-week egg production and EP52 and EW52 was positive, whereas the correlation between 40-week egg weight and first egg weight was negative but the findings has revealed that it was significant with 40 week egg weight. Both Wolc *et al*. (2007) [9] and Liu *et al*. (2019) [8] reported results that were similar in that it was substantially positively connected with 52-week egg production. Egg weight at 40 and 52 weeks were positively correlated with egg production at 52 weeks, but first egg weight was negatively correlated. The phenotypic correlation between egg weight at week 40 and egg weight at week 52 was significant, positive, and correlated negatively with FEW, while the phenotypic correlation between egg weight at week 52 and first egg weight was significant and positive. According to a study conducted by Liu *et al*. (2018) [10], egg weight at 40 week showed low positive correlation with first egg weight. However, Yi *et al*. (2014) [11] demonstrated that the 52 egg weight is positively associated with the weight of first egg. The 40 week egg weight was significantly correlated with the phenotypic correlation of Body weight at Sexual Maturity, which was favorably correlated with the 40 week egg weight, 52 week egg weight, first egg weight, 40 week egg weight, and 40 week egg production.

4. Conclusion

We have studied correlation between phenotypic traits such as body weight (BW), age at sexual maturity (ASM), egg production (EP), egg weight (EW), first egg weight (FEW). Data has been collected from 0th day to 20th week and then at 40th week and 52nd week. These readings were taken with respect to traits mentioned above. Also, 1st week BW showed significant correlation with other economical traits. Correlation between BW from 1st week to 20th week and ASM is negative whereas correlation between all other traits were found positive. There is positive correlation between BW at 40th week and ASM whereas egg production at 40th week and 52nd week is low. Highly significant phenotypic correlations are BW at 1st week with EP at 40th week and FEW, BW at 2nd week with EW at 40th week, BW at 3rd week with FEW, BW at 10th week with EP at 52nd week, BW at 14th week and EW at 40th week. Thus, these traits observations and data readings are significant while considering a particular layer chicken at early stage for productive growth.

5. Acknowledgement

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Table 1(a): Phenotypic Correlation with standard error of various economic traits in Layer Chicken

	BW 0	BW 1	BW 2	BW 3	BW4	BW5	BW6	BW7	BW8	BW9	BW10	BW11	BW 12	BW 13
BW0	1	0.127±0.04	0.086±0.04	0.018±0.04	0.117±0.04	0.132±0.04	0.108±0.04	0.138±0.04	0.083±0.04	0.101±0.04	0.085±0.04	0.123±0.04	0.09±0.04	0.106±0.04
BW1		1	0.665±0.02	0.494±0.03	0.583±0.02	0.5±0.03	0.497±0.03	0.474±0.03	0.432±0.03	0.46±0.03	0.44±0.03	0.431±0.03	0.442±0.03	0.422±0.03
BW2			1	0.637±0.02	0.751±0.01	0.682±0.02	0.631±0.02	0.591±0.02	0.56±0.02	0.547±0.02	0.529±0.03	0.557±0.02	0.548±0.02	0.523±0.03
BW3				1	0.713±0.02	0.638±0.02	0.585±0.02	0.557±0.02	0.521±0.03	0.508±0.03	0.492±0.03	0.491±0.03	0.5±0.03	0.484±0.03
BW4					1	0.834±0.01	0.77±0.01	0.717±0.02	0.693±0.02	0.664±0.02	0.665±0.02	0.656±0.02	0.665±0.02	0.62±0.02
BW5						1	0.836±0.01	0.775±0.01	0.75±0.01	0.735±0.01	0.725±0.02	0.703±0.02	0.704±0.02	0.673±0.02
BW6							1	0.87±0.01	0.837±0.01	0.789±0.01	0.79±0.01	0.777±0.01	0.769±0.01	0.737±0.01
BW7								1	0.837±0.01	0.811±0.01	0.806±0.01	0.803±0.01	0.806±0.01	0.781±0.01
BW8									1	0.82±0.01	0.83±0.01	0.805±0.01	0.8±0.01	0.754±0.01
BW9										1	0.826±0.01	0.792±0.01	0.81±0.01	0.802±0.01
BW10											1	0.853±0.01	0.851±0.01	0.844±0.01
BW11												1	0.894±0.008	0.878±0.009
BW12													1	0.909±0.007
BW13														1

Values at the diagonal are heritability estimates and values above the diagonal are phenotypic correlations
Highly significant (P≤0.01); Significant (*P*≤0.05)

Table 1(b): Phenotypic Correlation with standard error of various economic traits in Layer Chicken

	BW14	BW15	BW16	BW17	BW18	BW19	BW20	BW40	ASM	BWSM	EP40	EP52	EW40	EW52	FEW
BW0	0.086±0.04	0.094±0.04	0.077±0.04	0.071±0.04	0.085±0.04	0.078±0.04	0.077±0.04	0.099±0.04	0.031±0.04	0.149±0.04	-0.051±0.04	-0.023±0.04	0.09±0.04	0.017±0.04	0.03±0.04
BW1	0.388±0.03	0.423±0.03	0.394±0.03	0.389±0.03	0.365±0.03	0.355±0.03	0.357±0.03	0.105±0.04	-0.08±0.04	0.353±0.04	0.008±0.04	0.004±0.04	0.017±0.04	0.068±0.04	0.008±0.04
BW2	0.511±0.03	0.516±0.03	0.508±0.03	0.494±0.03	0.474±0.03	0.469±0.03	0.469±0.03	0.078±0.04	-0.167±0.04	0.41±0.03	0.086±0.04	0.079±0.04	-0.003±0.04	0.039±0.04	-0.041±0.04
BW3	0.461±0.03	0.431±0.03	0.444±0.03	0.443±0.03	0.41±0.03	0.421±0.03	0.422±0.03	0.067±0.04	-0.137±0.04	0.401±0.03	0.072±0.04	0.065±0.04	-0.051±0.04	0.061±0.04	0.001±0.04
BW4	0.595±0.02	0.617±0.02	0.571±0.02	0.559±0.02	0.532±0.03	0.533±0.03	0.536±0.03	0.099±0.04	-0.183±0.04	0.488±0.04	0.088±0.04	0.092±0.04	0.036±0.04	0.079±0.04	0.013±0.04
BW5	0.653±0.02	0.653±0.02	0.69±0.02	0.605±0.02	0.575±0.02	0.554±0.02	0.556±0.02	0.103±0.02	-0.221±0.04	0.476±0.04	0.101±0.03	0.095±0.04	0.033±0.04	0.064±0.04	0.03±0.04
BW6	0.708±0.02	0.713±0.02	0.68±0.02	0.669±0.02	0.636±0.02	0.59±0.02	0.592±0.02	0.102±0.04	-0.267±0.03	0.493±0.03	0.158±0.04	0.145±0.04	0.026±0.04	0.078±0.04	0.025±0.04
BW7	0.733±0.019	0.725±0.02	0.708±0.02	0.694±0.02	0.65±0.02	0.608±0.02	0.61±0.02	0.115±0.04	-0.268±0.03	0.514±0.03	0.153±0.04	0.134±0.04	0.019±0.04	0.066±0.04	0.034±0.04
BW8	0.755±0.01	0.745±0.01	0.724±0.02	0.704±0.02	0.66±0.02	0.617±0.02	0.619±0.02	0.12±0.02	-0.271±0.04	0.52±0.03	0.163±0.03	0.153±0.04	0.057±0.04	0.078±0.04	0.046±0.04
BW9	0.757±0.01	0.757±0.01	0.719±0.02	0.707±0.02	0.666±0.02	0.615±0.02	0.617±0.02	0.137±0.04	-0.245±0.03	0.171±0.04	0.146±0.04	0.101±0.04	-0.002±0.04	0.08±0.04	0.024±0.04
BW10	0.801±0.01	0.818±0.01	0.762±0.01	0.747±0.01	0.713±0.02	0.688±0.02	0.691±0.02	0.116±0.04	-0.251±0.03	0.6±0.02	0.154±0.04	0.001±0.04	0.027±0.04	0.085±0.04	0.077±0.04
BW11	0.858±0.01	0.805±0.01	0.807±0.01	0.792±0.01	0.756±0.01	0.705±0.02	0.708±0.02	0.131±0.04	-0.258±0.03	0.608±0.02	0.156±0.04	0.142±0.04	0.021±0.04	0.077±0.04	0.041±0.04
BW12	0.851±0.01	0.849±0.01	0.812±0.01	0.81±0.01	0.764±0.01	0.717±0.02	0.72±0.02	0.131±0.02	-0.268±0.03	0.625±0.02	0.159±0.04	0.134±0.04	0.018±0.04	0.084±0.04	0.039±0.04
BW13	0.901±0.007	0.881±0.009	0.849±0.01	0.853±0.01	0.871±0.01	0.757±0.01	0.76±0.01	0.137±0.04	-0.272±0.03	0.663±0.02	0.19±0.04	0.156±0.04	0.025±0.04	0.078±0.04	0.057±0.04

Highly significant (P≤0.01); Significant (*P*≤0.05)

Table 1(c): Phenotypic Correlation with standard error of various economic traits in Layer Chicken

	BW14	**BW15**	**BW16**	**BW17**	**BW18**	**BW19**	**BW20**	**BW40**	**ASM**	**BWSM**	**EP40**	**EP52**	**EW40**	**EW52**	**FEW**
BW14	**1**	0.882±0.009	0.886±0.009	0.883±0.009	0.844±0.01	0.778±0.01	0.78±0.01	0.13±0.04	-0.267±0.03	0.669±0.02	0.197±0.04	0.171±0.04	0.002±0.04	0.125±0.04	0.063±0.04
BW15		**1**	0.882±0.009	0.882±0.009	0.864±0.01	0.793±0.01	0.796±0.01	0.119±0.04	-0.273±0.03	0.681±0.02	0.182±0.04	0.144±0.04	0.053±0.04	0.106±0.04	0.026±0.04
BW16			**1**	0.939±0.005	0.883±0.009	0.797±0.01	0.799±0.01	0.114±0.04	-0.29±0.03	0.676±0.02	0.205±0.04	0.179±0.04	0.032±0.04	0.105±0.04	0.06±0.04
BW17				**1**	0.916±0.006	0.808±0.01	0.811±0.01	0.118±0.04	-0.292±0.03	0.693±0.02	0.189±0.04	0.165±0.04	0.812±0.01	0.1±0.04	0.065±0.04
BW18					**1**	0.869±0.01	0.871±0.01	0.105±0.04	-0.311±0.03	0.734±0.01	0.217±0.04	0.189±0.04	0.032±0.04	0.095±0.04	0.041±0.04
BW19						**1**	0.085±0	0.086±0.04	-0.341±0.03	0.817±0.01	0.222±0.04	0.2±0.04	0.052±0.04	0.111±0.04	0.068±0.04
BW20							**1**	0.085±0.04	-0.338±0.03	0.82±0.01	0.221±0.04	0.199±0.04	0.053±0.04	0.114±0.04	0.07±0.04
BW40								**1**	0.046±0.04	0.146±0.04	-0.024±0.04	-0.021±0.04	0.064±0.04	0.074±0.04	-0.045±0.04
ASM									**1**	-0.013±0.04	-0.479±0.03	-0.431±0.03	-0.058±0.04	-0.012±0.04	0.044±0.04
BWSM										**1**	0.104±0.04	0.087±0.04	0.01±0.04	0.112±0.04	0.14±0.04
EP40											**1**	0.933±0.005	-0.016±0.04	0.007±0.04	-0.046±0.04
EP52												**1**	0.012±0.04	0.007±0.04	-0.051±0.04
EW40													**1**	0.047±0.04	-0.05±0.04
EW52														**1**	0.004±0.04
FEW															**1**

Values at the diagonal are heritability estimates and values above the diagonal are phenotypic correlations
Highly significant (P≤0.01); Significant (*P*≤0.05)

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