



## Genetic analysis of layer performances in a selected line of Rhode Island Red chicken<sup>#</sup>

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### ABSTRACT

The study aimed to estimate genetic parameters of layer performance traits in a selected line of Rhode Island Red (RIR) chicken maintained at this institute. The performance traits were recorded on 433 pedigreed pullet progenies, offsprings of 48 sires and 113 dams; and data were analyzed by least squares analysis of variance. Heritability and correlations were estimated using full-sib correlation method. The least squares means of age at first egg (AFE), body weights (BW20, BW40), egg weights (EW28, EW40) and egg production up to 40 weeks of age (EP40) were estimated. Almost all the traits were significantly affected by sires and hatch, whereas dam within sire could not affect any trait. Birds' housing weight demonstrated significant regression effect on the above traits. The heritability estimates from sire component of variance ranged from 0.003 to 0.241 in different traits. The heritability estimates from dam component and sire plus dam component ranged from 0.011 to 0.670 and 0.061 to 0.379, respectively. The ranges of genetic and phenotypic correlations among the traits were 0.130 to 0.918 and 0.015 to 0.542, respectively. The varied direction of correlations revealed that selection for earlier age at first egg would favour moderately lower body weights and egg production. Again selection for heavier EW28 would favour late AFE and lower egg production. Present findings would serve as the pre-requisites for chalking out the breeding strategies for genetic improvement of RIR chicken.

**Key words:** Genetic correlation, Heritability estimates, Layer performance traits, Phenotypic correlation, RIR chicken, Sire and hatch effect

Poultry rearing is a common and popular practice in the rural livelihoods of the developing countries because of its impact in economic empowerment of the resource poor segment of the society (King'ori 2011). The Central Avian Research Institute (CARI, India) imported fertile eggs of Rhode Island Red (RIR) chicken in 1980 from the USA, hatched out at its hatchery, and carried out genetic selection for improvement of the germplasm. The population was acclimatized and genetically improved over last 33 years covering 29 generations of selection and being maintained as a selected line. Selection was carried out for egg production upto 40 weeks of age along with some independent culling for egg weights at 28<sup>th</sup> weeks of age; this changed the genetic properties of the population (Das 2013). Selection also being carried out for long generations, factors such as inbreeding, random drift, natural selection,

changes in reproductive fitness, and genetic and physiological limits might influence the response; and if carried out more intensively, selection could fast reduce the genetic variance present in the population. The genetic change of a population due to selection could be manifested by the change in the heritability estimates. The estimates of genetic parameters could be used in the prediction of response to selection, and also as a base for the future selection and breeding strategies. Breeders desire to obtain the estimates of genetic and phenotypic parameters afresh for each population in each generation, because the estimates vary from one population to another and at different times (Barot *et al.* 2008). Therefore, the present investigation was undertaken to estimate genetic parameters of layer performance traits in the selected line of Rhode Island Red chicken.

### MATERIALS AND METHODS

*Experimental birds:* Pedigreed pullet progenies (433: 229 and 204 in successive 2 winter hatches), offsprings of 48 sires and 113 dams of a selected line of RIR chicken maintained at the experimental layer farm of this institute were investigated.

*Poultry husbandry adopted:* The day-old chicks were

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wing-banded and pedigreed by sire and dam in the hatchery itself. Standard litter brooding, housing and *ad lib.* feeding on the CARI-formulated feed were provided with optimum management (Das *et al.* 2014b). Birds were fed on chick mash with 20.65% CP, 2694.64 Kcal/kg ME, 1.02% Ca, 0.45% P, 1.05% Lys and 0.41% Met at 0–8 weeks of age; grower mash with 16.78% CP, 2536.00 Kcal/kg ME, 1.15% Ca, 0.40% P, 0.76% Lys and 0.37% Met at 9–20 weeks and layer mash with 18.18% CP, 2676.52 Kcal/kg ME, 3.61% Ca, 0.34% P, 0.83% Lys and 0.36% Met at 20 weeks onwards (Das *et al.* 2014b). Birds were vaccinated with RD and MD vaccines at day-old, IBD vaccine on 14-day, RD booster on 28–day, IBD booster on 35–day, fowl pox vaccine on 42-day, R<sub>2</sub>B vaccine on 56-day, EDS vaccine at 18–19 weeks and IBD killed vaccine at 20–22 weeks of ages (Das *et al.* 2014 a, b).

**Data recording:** Layer performances were assessed investigating the traits of body weights at 20<sup>th</sup> (BW20) and 40<sup>th</sup> (BW40) week of age, age at first egg (AFE), egg weights at 28<sup>th</sup> (EW28) and 40<sup>th</sup> (EW40) week and part period egg production up to 40 weeks of age (EP40). Body weights (g) were measured using digital weighing balance during morning at birds' empty stomach. Egg weights (g) were taken using the digital weighing balance for successive three days; records being averaged to a single record. AFE was recorded in days as of laying her first egg and EP40 in numbers was calculated from the production data sheet.

**Statistical analysis:** The performance data were analyzed by least squares analysis of variance (Harvey 1990) taking sire as random effect, hatch as fixed effect and housing weight (BW20) as regressor in the linear model; dam within sire effect being non-significant was not considered in the model to avoid df-loosing:

$$Y_{ijk} = \mu + S_i + H_j + R + e_{ijk}$$

where,  $Y_{ijk}$ , observation on  $k^{\text{th}}$  individual belonging to  $j^{\text{th}}$  sire and  $i^{\text{th}}$  hatch;  $\mu$ , population mean;  $S_i$ , random effect of  $i^{\text{th}}$  sire;  $H_j$ , fixed effect of  $j^{\text{th}}$  hatch;  $R$ , regression effect of housing weight on each subsequent performance trait; and  $e_{ijk}$ , random error associated with mean zero and variance  $\sigma^2$ .

The genetic and phenotypic parameters were estimated

using full-sib correlation method (Becker 1975) taking sire and dam within sire as random effects and hatch as fixed effect in the linear model:

$$Y_{ijkl} = \mu + S_i + D_{ij} + H_k + e_{ijkl}$$

where,  $Y_{ijkl}$ , observation on  $l^{\text{th}}$  individual belonging to  $j^{\text{th}}$  dam within  $i^{\text{th}}$  sire and  $k^{\text{th}}$  hatch;  $\mu$ , population mean;  $S_i$ , random effect of  $i^{\text{th}}$  sire;  $D_{ij}$ , random effect of  $j^{\text{th}}$  dam nested within  $i^{\text{th}}$  sire;  $H_k$ , fixed effect of  $k^{\text{th}}$  hatch; and  $e_{ijkl}$ , random error associated with mean zero and variance  $\sigma^2$ .

## RESULTS AND DISCUSSION

**Least squares means:** The estimated least squares means of birds' housing weight (BW20), age at first egg (AFE), egg weight at 28<sup>th</sup> week (EW28), body weight at 40<sup>th</sup> week (BW40), egg weight at 40<sup>th</sup> week (EW40) and part period egg production up to 40 weeks of age (EP40) are presented in Table 1. The present estimates of different layer performance traits indicated that the said chicken flock was an elite flock with better growth rate leading to earlier sexual maturity, higher egg production and egg weights as evident when compared to its control line and RIR-white strain (Das *et al.* 2013, 2014a). The present layer flock might also be comparable to some indigenous, synthetic or crossbred chicken populations such as Aseel, Kadaknath and Vanraja male line (Chatterjee *et al.* 2010) and CARI-Debendra crossbred (Das *et al.* 2014a) for its better performance. The present estimates were comparable to the previous reports in the selected and control populations of 27<sup>th</sup> generation of RIR chicken (Anonymous 2011); Fayoumi, Sinai, RIR and WLH chickens (Saadey *et al.* 2008); and RIR male and female lines (Nwagu *et al.* 2007a). The present layers also laid more eggs up to 40 weeks of age than the earlier reports in Vanraja female and Grampriya female lines (Chatterjee *et al.* 2010), but less than the report in CARI-Sonali (Das *et al.* 2014a). Better performances achieved in this chicken line was due to long term selection undergone through 29 generations for egg production up to 40 weeks of age along with some independent culling for egg weights at 28<sup>th</sup> week of age utilizing genetic variability in the population.

**Genetic and non-genetic factors:** Sire effect was significant ( $P \leq 0.05$ ,  $P \leq 0.01$ ) on almost all the performance

Table 1. The estimated least squares means of various layer performance traits in a selected line of RIR chicken

Factors	Least squares means $\pm$ standard errors					
	BW20 (g)	AFE (days)	EW28 (g)	BW40 (g)	EW40 (g)	EP40 (nos.)
Overall	1596.6 $\pm$ 11.7 (433)	150.8 $\pm$ 0.9 (433)	44.8 $\pm$ 0.2 (401)	1701.4 $\pm$ 9.6 (401)	51.5 $\pm$ 0.2 (401)	95.4 $\pm$ 1.1 (401)
Hatch						
1	1605.6 $\pm$ 14.8 <sup>a</sup> (229)	155.7 $\pm$ 1.2 <sup>b</sup> (229)	44.9 $\pm$ 0.3 <sup>a</sup> (208)	1744.2 $\pm$ 12.6 <sup>a</sup> (208)	52.4 $\pm$ 0.3 <sup>a</sup> (208)	91.8 $\pm$ 1.5 <sup>b</sup> (208)
2	1587.6 $\pm$ 15.4 <sup>a</sup> (204)	145.9 $\pm$ 1.2 <sup>a</sup> (204)	44.8 $\pm$ 0.3 <sup>a</sup> (193)	1658.7 $\pm$ 12.9 <sup>b</sup> (193)	50.6 $\pm$ 0.3 <sup>b</sup> (193)	98.9 $\pm$ 1.5 <sup>a</sup> (193)

Means within factor 'Hatch' and within a column having different superscripts differ significantly ( $P \leq 0.05$ ). Figures within parenthesis denote number of observations. BW20, body weight in grams at 20<sup>th</sup> week of age; AFE, age at first egg in days; EW28, egg weight in grams at 28<sup>th</sup> week; BW40, body weight in grams at 40<sup>th</sup> week; EW40, egg weight in grams at 40<sup>th</sup> week; EP40, part period egg production in numbers up to 40 weeks of age.

traits except body weight at 40<sup>th</sup> week of age ( $P \leq 0.06$ ), but dams within sire could not demonstrate any significant effect. Hatch effect was also significant ( $P \leq 0.001$ ) on almost all the traits except housing weight and egg weight at 28<sup>th</sup> week of age. Birds' housing weight demonstrated significant ( $P \leq 0.01$ ,  $P \leq 0.001$ ) regression effect on all the subsequent performance traits. The present significant sire and hatch effects were also reported in few performance traits in WLH chicken (Shivakumar *et al.* 2011). Nwagu *et al.* (2007b) reported that hatch might have contributed to the variable response achieved from generation to generation in different economic traits i.e. age at sexual maturity, egg weight and numbers, and body weight at 40<sup>th</sup> week of age in RIR male and female lines. Significant regression effect of housing weight was also reported earlier on layer performance traits (Das *et al.* 2014a) and thus important for selection of pullets as better layers.

#### Genetic and phenotypic parameters

**Heritability estimates:** The heritability estimates from sire component of variance ( $h^2_S$ ), dam component of variance ( $h^2_D$ ) and sire plus dam component of variance ( $h^2_{S+D}$ ) for various layer performance traits are presented in Table 2. The  $h^2$  estimates varied among the different components of variance for a particular trait. Dam effect was more important for weight related traits, and sire effect for early sexual maturity and egg production related traits; thus combined effect of sire plus dam components could not par-exceed any individual effect. That is why the estimated  $h^2_{S+D}$  got placed in the middle of the obtained  $h^2$  range i.e. in between  $h^2_S$  and  $h^2_D$ . The present intra-trait  $h^2_S < h^2_D$  indicating selective exploitation of maternal inheritance in improving the traits of body weights and egg weights of layers was in accordance to the findings in White Leghorn chicken (Ahmad and Singh 2007). Rajkumar *et*

*al.* (2011) reported, on contrary, greater  $h^2_S$  estimates than  $h^2_D$  for body weights and EW28; but, on corroboration, lower  $h^2_S$  than  $h^2_D$  for EW40 in a sex linked dwarf chicken, thus getting no specific trend. The findings of  $h^2_S > h^2_D$  indicating selective exploitation of sire inheritance in genetic improvement of the traits of age at first egg and egg production was in accordance to the earlier reports such as Ahmad and Singh (2007) obtained greater  $h^2_S$  estimates than the  $h^2_D$  for egg production and reverse for age at first egg; whereas, Rajkumar *et al.* (2011) reported higher  $h^2_S$  estimates than the  $h^2_D$  for these traits in a sex-linked dwarf chicken. The estimated  $h^2_{S+D}$  indicated the existence of genetic variability and scope for improvement through sire and dam selection in accordance to the earlier reports (Rajkumar *et al.* 2011, Jayalaxmi *et al.* 2010, Ahmad and Singh 2007, Oni *et al.* 2007).

The  $h^2_S$  estimates also ranged (inter-traits) from 0.003 (BW40) to 0.241 (AFE);  $h^2_D$  from 0.011 (EP40) to 0.670 (BW20) and  $h^2_{S+D}$  from 0.061 (EP40) to 0.379 (BW20). The  $h^2$  estimates from different components of variance were quite in the range of low to high in magnitude, indicating that possibility of selection based on the flock's own performance to improve these traits would take a long or short generations for the concerned traits. The EP40 demonstrated the least  $h^2$  estimated from dam and sire plus dam components of variance indicating more importance in selection for elite/proven sire. Again BW40 and EW28 had the least  $h^2$  estimated from sire component of variance indicating importance of dam and sire plus dam components for better weights. The present heritability estimates from sire, dam and sire plus dam components of variance were in agreement with the earlier available reports in White Leghorn chicken (Ahmad and Singh 2007, Oni *et al.* 2007, Jayalaxmi *et al.* 2010, Rajkumar *et al.* 2011). The heritability estimates from sire component of variance might also be compared to the paternal half-sib heritability estimates reported in White Leghorn chicken (Barot *et al.* 2008, Paleja *et al.* 2008, Choudhary *et al.* 2009, Qadri *et al.* 2013), and Nigerian chicken ecotype (Agu *et al.* 2012). The lower magnitude of the present heritability estimates indicated the presence of high environmental variances and the higher magnitude of the  $h^2$  estimates was indicative of a greater role of additive genetic variance than the environmental component of variance (Barot *et al.* 2008, Rajkumar *et al.* 2011). The heritability of a trait is notably a population parameter which could be affected by environmental circumstances (Falconer 1989). Thus any change in the components of variance would lead to likely change in the heritability estimates and the fact might explain the attributed differences in the estimates by different workers. Moreover, the present estimates were in the expected range. The heritability estimates could vary considerably from study to study, depending upon breed, strain, line, population sampled, environmental and management conditions, and random as well as systematic errors in the estimation procedures (Mia *et al.* 2013). The numbers of progeny, dams within sire and the entire data set from which these estimates

Table 2. The estimated heritability of various layer performance traits in a selected line of RIR chicken

Trait	Heritability estimates from different component of variance		
	$h^2_S$	$h^2_D$	$h^2_{S+D}$
BW20	0.088±0.132 (433)	0.670±0.228 (433)	0.379±0.109 (433)
AFE	0.241±0.160 (433)	0.025±0.222 (433)	0.133±0.094 (433)
EW28	0.018±0.128 (409)	0.464±0.241 (409)	0.241±0.107 (409)
BW40	0.003±0.124 (401)	0.550±0.242 (401)	0.277±0.110 (401)
EW40	0.185±0.160 (401)	0.502±0.243 (401)	0.343±0.114 (401)
EP40	0.110±0.146 (401)	0.011±0.239 (401)	0.061±0.094 (401)

Figures within parenthesis denote number of observations.  $h^2_S$ , heritability estimates from sire component of variance;  $h^2_D$ , heritability estimates from dam component of variance;  $h^2_{S+D}$ , heritability estimates from sire plus dam component of variance.

Table 3. Genotypic (above diagonal) and phenotypic (below diagonal) correlations estimated from sire plus dam components of variance between different layer performance traits in a selected line of RIR chicken

Trait	BW20	AFE	EW28	BW40	EW40	EP40
BW20		-0.385±0.443 (433)	0.157±0.268 (409)	0.677±0.176 (401)	0.584±0.229 (401)	0.369±0.519 (401)
AFE	-0.430 (433)		0.641±0.351 (409)	-0.187±0.395 (401)	0.140±0.351 (401)	-0.520±1.172 (401)
EW28	0.183 (409)	0.073 (409)		0.130±0.295 (401)	0.918± 0.165 (401)	-0.196±0.587 (401)
BW40	0.542 (401)	-0.056 (401)	0.157 (401)		0.492±0.240 (401)	0.230±0.606 (401)
EW40	0.191 (401)	0.129 (401)	0.443 (401)	0.247 (401)		0.589±0.708 (401)
EP40	0.236 (401)	-0.514 (401)	0.015 (401)	-0.045 (401)	-0.092 (401)	

Figures within parenthesis denote number of observations.

were obtained were relatively small, and could have sampling errors. However, the present heritability estimates could suggest breeders that the sire and dam selection may be utilized for further genetic improvement in most of the layer performance traits in RIR chicken.

*Genetic and phenotypic correlation:* The genetic ( $r_G$ ) and phenotypic ( $r_P$ ) correlation coefficients estimated from sire plus dam component of variance among various layer performance traits ranged from low to high in magnitude but variable in direction (Table 3). The ranges of the estimated  $r_G$  and  $r_P$  in different traits were 0.130 to 0.918 and 0.015 to 0.542, respectively. The AFE had negative  $r_G$  and  $r_P$  with BW20, BW40 and EP40, whereas EP40 had negative  $r_G$  with EW28. The EW28 had positive  $r_G$  and  $r_P$  with BW40 and EW40. The EP40 had positive  $r_G$  with BW20, BW40 and EW40; whereas its  $r_P$  was positive only with BW20 but negative with BW40 and EW40. The  $r_G$  between AFE and EW28 was positive, whereas their  $r_P$  did not reveal any definite trend. Most of the estimates were associated with higher standard errors. The genetic and phenotypic correlations indicated that selection for early sexual maturity would favour moderately lower housing weight (Choudhary *et al.* 2009, Anees *et al.* 2010, Qadri *et al.* 2013); and attain comparatively low egg production (Ahmad and Singh 2007, Oni *et al.* 2007, Paleja *et al.* 2008, Jayalaxmi *et al.* 2010, Qadri *et al.* 2013) and low body weight at 40<sup>th</sup> week of age (Choudhary *et al.* 2009, Anees *et al.* 2010, Qadri *et al.* 2013). Selection for heavier egg size tends to delay sexual maturity (Barot *et al.* 2008) and would not favour more egg production (Qadri *et al.* 2013), though Agu *et al.* (2012) reported positive association of egg number and egg size with significant high  $r_G$  value. The later egg size would depend on their earlier egg size (Qadri *et al.* 2013) and body weight (Barot *et al.* 2008, Qadri *et al.* 2013); and the egg production would be more if pullet's housing weight be heavier on contrary to the findings in the strains of White Leghorn chicken (Qadri *et al.* 2013). Though the correlation estimates from sire plus dam component of variance were compared with the earlier

estimates from the paternal half-sibs in many cases, the magnitude of the correlation coefficients might vary from the study to study but should remain its consistent direction or trend of correlations. Most of the estimates in this study were found associated with higher standard errors (Barot *et al.* 2008, Jayalaxmi *et al.* 2010, Qadri *et al.* 2013) making them less precise due to less number of progeny per dam within a sire (Falconer 1989). However, the present performance traits demonstrating a low to high range of genetic and phenotypic correlations though in variable directions, could be combined in a construct of standard selection indices and might be adopted in breeding strategy.

It was concluded that the information generated in this investigation might be important as the pre-requisites for chalking out of breeding strategies for genetic improvement of RIR chicken.

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