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Genetic analysis of body weight in a selected line of Rhode Island Red grower chicken*

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ABSTRACT

A total of 1207 pedigreed progenies of 50 sires and 177 dams of a selected line of Rhode Island Red chicken were investigated in two hatches at ICAR-Central Avian Research Institute for genetic analysis of their body weights. The genetic and non-genetic parameters of chick weight at day-old age and body weight at different ages were estimated using least squares analysis of variance. The heritability and correlation coefficients were estimated for different traits using paternal half-sibs. The mean sum of squares for sex component of variance was significant for body weights at third week of age onwards, males being heavier throughout the ages. Sire component of variance was also significant for chick weight and different body weights except the estimates at 6th and 16th week of age. Hatch component of variance was highly significant for chick weight and body weights upto 12th week of age. Regression effect of chick weight on subsequent body weights was found significant specifically for body weights from 1st week onwards to 20th week of age. The heritability estimates were 0.775±0.151 for chick weight, 0.303±0.09 to 0.44±0.142 for body weights from 1st week to 12th week of age, and 0.258 to 0.248 for body weights from 16th week to 20th week of age. The estimates at lower age could be used in selection programme based on the flock's own performance to improve those traits. The genetic and phenotypic correlation coefficients were positive and highly significant in most of the cases. The corresponding estimates ranged from 0.044 to 0.990 and 0.020 to 0.788, and these coefficients could be combined in construct of standard selection indices for optimum growth in body weight that might be adopted in future breeding strategy for this RIR chicken genotype.

Key words: Body weight, Correlation, Genetic and non-genetic parameters, Heritability, RIR chicken

A selected line of Rhode Island Red (RIR) chicken is being maintained through genetic selection for egg production by the Central Avian Research Institute, Izatnagar (India) since its inception in 1979. Being carried out for over 33 generations, the selection could result in genetic change in the population which could be manifested by the change in heritability estimates. The estimates of genetic parameters could be used for 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). Besides more egg production, optimum growth in body weight is also an important attribute to the farmers for promoting RIR in rural livelihood. Notably, the growth is an irreversible, correlated and coordinated increase in the mass of body in a definite interval of time (Kausar *et al.* 2016). It is necessary to have knowledge of factors influencing the growth of poultry birds because body growth is an important factor that contributes to the profitability in poultry production (Kausar *et al.* 2016). Therefore, the present study aimed for genetic analysis of grower body weights investigating the genetic and non-genetic parameters in a selected line of RIR chicken.

MATERIALS AND METHODS

A total of 1207 pedigreed progenies of RIR selected line chicken maintained at the experimental layer farm of ICAR-Central Avian Research Institute (CARI, Izatnagar) were investigated. Among these, 625 chicks were of 50 sires and 177 dams in first hatch and 582 chicks of 50 sires and 159 dams in second hatch. The day-old chicks were wing-banded and pedigreed by sire and dam in the hatchery itself. Standard litter brooding, housing and *ad lib.* feeding on the

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CARI-formulated feed were provided with optimum management (Das *et al.* 2014ab). The birds were fed chick mash at the age of 0–8 weeks and grower mash at 9–20 weeks (Das *et al.* 2014ab). The birds were vaccinated with RD and MD vaccines at day-old age, IBD vaccine on 14-day, RD booster on 28-day, IBD booster on 35-day, fowl pox vaccine on 42-day, R_2B vaccine on 56-day, EDS vaccine at 18–19 weeks and IBD killed vaccine at 20–22 weeks of age (Das *et al.* 2014ab).

Data generation: The day-old chick weight and body weight at different ages were measured using digital weighing balance 5 mg used upto 8^{th} week and 100 mg used 12^{th} week onwards) during morning on empty stomach.

Statistical analysis: The data were analyzed by least squares analysis of variance (Harvey 1990) taking sire as random effect, sex and hatch as fixed effects and chick weight as regressor in the linear model:

$$Y_{ijkl}=\mu + S_i + W_j + H_k + b_{ijkl} + e_{ijkl};$$

where, Y_{ijkl}, observation on l^{th} individual with j^{th} sex belonging to i^{th} sire and k^{th} hatch; μ, population mean; S_i, random effect of i^{th} sire; W_j, fixed effect of j^{th} sex; H_k, fixed effect of k^{th} hatch; b_{ijkl}, regression effect of chick weight on subsequent body weights of that particular individual; and e_{ijkl}, random error normally distributed with mean zero and variance σ^2. The genetic and phenotypic parameters were estimated using paternal half-sib correlation method (Becker 1975).

RESULTS AND DISCUSSION

The estimated least squares means±SE (no. of observations) of chick weight at day-old age in a selected line of RIR grower chicken was 37.55±0.24 g (1207), and grower body weights were 56.95±0.57 g (591), 91.08±0.77 g (1101), 154.87±1.65 g (570), 199.85±1.83 g (1059), 357.65±4.01 g (216), 572.18±7.22 g (648), 984.58±8.32 g (997) and 1460.81±11.08 g (873) for age at week- 1, 2, 3, 4, 6, 8, 12 and 16, respectively. The housing weight (at 20^{th} week of age) of pullets was 1596.58±11.67 g (433). The estimates were indicative of better growth rate of body mass as evident when compared to its control line (Das *et al.* 2017, Das *et al.* 2014a, Das 2013, Anonymous 2011) or White strain of RIR (Das *et al.* 2014ab, Das 2013) and White Leghorn strains (Jayalaxmi *et al.* 2010, Chaudhary *et al.* 2009, Paleja *et al.* 2008).

Genetic and non-genetic factors: The investigation evidenced that the male birds could demonstrate better estimates of body weights than the females almost throughout the ages. The mean sum of squares for sex component of variance were highly significant ($P<0.001$) for body weights at 3^{rd} week of age ($P<0.01$) onwards indicating significant sex-differences and counter role of sex to control the growth of body mass as a whole a genetic factor (Das *et al.* 2017). The mean sum of squares for sire component of variance were also highly significant ($P<0.001$) for chick weight and body weights at different ages ($P<0.001$ for 20^{th} week of age) indicating that body mass growth is influenced by a factor of sire-inheritance (Das *et al.* 2017, Das *et al.* 2015ab, Debnath *et al.* 2015, Das 2013). Hatch is considered as a non-genetic factor and the present results indicated highly significant ($P<0.001$) hatch-differences for different traits ($P<0.01$ for 4^{th} week of age). Significant hatch-differences were also reported earlier in RIR chicken (Das *et al.* 2017, Debnath *et al.* 2015, Das 2013). The mean sum of squares of variance for regression effect of day-old chick weight on subsequent body weights were found significant ($P<0.001$), specially for body weights from 1^{st} week onwards to 20^{th} week of age ($P<0.01$ for 6^{th} week; $P<0.05$ for 8^{th} and 16^{th} week), indicating significant chick weight effect on its subsequent growth in consistence to the earlier report (Das *et al.* 2017). It was interpreted that the body mass growth of the birds could be judged better by its day-old chick weights. Significant chick weight-regression effects on different body weights were also reported earlier when studied body weights data were pooled over different genotypes (Das *et al.* 2014a).

Heritability estimates: The heritability (h^2) estimates from paternal half-sibs for the present chick weight and different body weights are presented in Table 1. The heritability estimates were 0.775±0.151 for chick weight, 0.303±0.09 to 0.44±0.142 for body weights from 1^{st} week to 12^{th} week of age, and 0.258 to 0.248 for body weights at 16^{th} to 20^{th} week of age, indicating that possibility of selection based on the flock's own performance to improve these traits would take propagation of short generations for the concerned traits. The present estimates might be compared to the h^2 estimates from paternal half-sibs reported in RIR chicken (Das *et al.* 2017, Das *et al.* 2015ab) and White Leghorn chicken (Qadri *et al.* 2013, Chaudhary *et al.* 2009, Barot *et al.* 2008, Paleja *et al.* 2008). The lower magnitude of the present h^2 estimates indicated the presence of high environmental variances and its higher magnitude was indicative of greater role of additive genetic variance than the environmental component of variance (Rajkumar *et al.* 2011, Barot *et al.* 2008). The heritability of a trait is notably a population parameter which could be influenced 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 per sire and the entire data set from which these estimates were obtained were relatively small, and could have sampling errors. However, the present heritability estimates could suggest for the breeders that the sire selection would be utilized for further genetic improvement in the body weight traits in RIR selected line chicken.

Genetic and phenotypic correlations: The genetic (r_G)

Table 1. Estimated heritability (at diagonal), genotypic (above diagonal) and phenotypic (below diagonal) correlations of chick weight at day-old age and body weight at different ages in a selected line of RIR grower chicken

Traits	CW	BW1	BW2	BW3	BW4	BW6	BW8	BW12	BW16	BW20
CW	0.775±0.151 (1207)	0.352±0.208^{c} (591)	0.294±0.181^{c} (1101)	0.345±0.202^{c} (570)	0.475±0.152^{c} (1059)	0.248±0.652^{c} (205)	0.595±0.183^{c} (648)	0.470±0.164^{c} (997)	0.044±0.618^{ns} (196)	0.236±0.291^{c} (406)
BW1	0.305^{c} (591)	0.338±0.125 (591)	0.852±0.122^{c} (557)	0.743±0.162^{c} (557)	0.726±0.239^{c} (557)	>1 (196)	0.799±0.285^{c} (552)	0.406±0.418^{c} (196)	0.325±0.504^{c} (196)	0.411±0.435^{c} (196)
BW2	0.176^{c} (1101)	0.565^{c} (557)	0.303±0.090 (1101)	0.857±0.076^{c} (557)	0.882±0.079^{c} (1059)	0.854±0.648^{c} (205)	0.751±0.154^{c} (648)	0.650±0.157^{c} (997)	0.257±0.567^{c} (196)	0.467±0.451^{c} (406)
BW3	0.194^{c} (570)	0.440^{c} (557)	0.788^{c} (557)	0.440±0.142 (570)	0.990±0.100^{c} (557)	0.242±0.786^{c} (205)	0.732±0.193^{c} (552)	0.311±0.417^{c} (196)	0.488±0.463^{c} (196)	0.656±0.366^{c} (196)
BW4	0.196^{c} (1059)	0.310^{c} (557)	0.553^{c} (1059)	0.664^{c} (557)	0.403±0.107 (1059)	0.233±1.022^{c} (205)	0.683±0.161^{c} (648)	0.597±0.149^{c} (997)	0.439±0.537^{c} (196)	0.379±0.396^{c} (406)
BW6	0.185^{b} (205)	0.142^{a} (205)	0.500^{c} (205)	0.548^{c} (205)	0.498^{c} (205)	0.112±0.225 (205)	>1 (196)	>1 (196)	>1 (196)	>1 (196)
BW8	0.143^{c} (648)	0.156^{c} (552)	0.418^{c} (648)	0.477^{c} (552)	0.596^{c} (648)	0.440^{c} (196)	0.314±0.116 (648)	0.798±0.200^{c} (462)	0.517±0.253^{c} (196)	>1 (196)
BW12	0.169^{c} (997)	0.129^{ns} (196)	0.316^{c} (997)	0.376^{c} (196)	0.399^{c} (997)	0.327^{c} (196)	0.575^{c} (462)	0.332±0.098 (997)	0.851±0.303^{c} (196)	0.696±0.237^{c} (406)
BW16	0.164^{a} (196)	0.031^{ns} (196)	0.247^{c} (196)	0.282^{c} (196)	0.241^{c} (196)	0.192^{b} (196)	0.180^{b} (196)	0.607^{c} (196)	0.258±0.248 (196)	0.920±0.188^{c} (196)
BW20	0.199^{c} (406)	0.020^{ns} (196)	0.159^{c} (406)	0.290^{c} (196)	0.275^{c} (406)	0.145^{a} (196)	0.241^{c} (196)	0.549^{c} (406)	0.758^{c} (196)	0.248±0.142 (406)

CW, day-old chick weight in grams; BW, body weights in grams at different weeks of age; $^{a}P<0.05$, $^{b}P<0.01$, $^{c}P<0.001$; ns, non-significant.

and phenotypic (r_P) correlation coefficients estimated from paternal half-sibs for the present chick weight and different body weight traits were positive and significant ($P<0.05$, $P<0.01$ or $P<0.001$) for almost all the traits. The estimated r_G and r_P ranged from low to high in magnitude (Table 1). The ranges of the estimated r_G and r_P in different traits were 0.044 to 0.990 and 0.020 to 0.788, respectively, both with moderate to higher magnitudes for the most traits. The estimates <1 being beyond the absolute range are not under consideration. The present findings were in the line with earlier reports for different chicken genotypes (Das *et al.* 2017, Qadri *et al.* 2013, Rajkumar *et al.* 2011, Chaudhary *et al.* 2009, Barot *et al.* 2008, Paleja *et al.* 2008). In this context, few estimates were associated with higher standard errors (Qadri *et al.* 2013, Jayalaxmi *et al.* 2010, Barot *et al.* 2008) making them less precise which was due to less number of progeny per sire (Falconer 1989).

It was concluded that the estimated genetic and non-genetic parameters of chick weight and different body weights would serve as base information for academicians and in genetic improvement programme of the selected line of RIR chicken. The heritability estimates at lower age group could be used in selection programme based on the flock's own performance to improve those traits. The genotypic and phenotypic correlation coefficients could be combined in construct of standard selection indices for optimum growth in body weights that might be adopted in future breeding strategy for this chicken genotype.

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