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Characterization of Production and Reproduction Performances in Rhode Island Red-White Strain Chicken

Research Article

A.K. Das[1], S. Kumar[2*], A. Rahim[1] and A.K. Mishra[3]

[1] Department of Animal Genetics, Indian Veterinary Research Institute, Izatnagar, Bareilly, India
[2] Molecular Genetics Laboratory, Avian Genetics and Breeding Division, Central Avian Research Institute, Izatnagar, Bareilly, India
[3] Department of Animal Genetics Resources, National Bureau of Animal Genetic Resources, Karnal, India

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*Correspondence E-mail: sanjeev.kumar3@icar.gov.in

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ABSTRACT

This study aimed to characterize production and reproduction performances in Rhode Island Red-White strain chicken developed and maintained at the Central Avian Research Institute, Izatnagar. Three hundred and forty six fertile eggs were set in automated electric incubation and 234 chicks were investigated in three hatches. The performance data was analyzed by least squares analysis of variance. The percent differences in fertility, hatchability and mortality among different hatches were assessed by the normal deviate test. Percent fertility, total egg set and fertile egg set basis hatchability, chick mortality and least squares means of chick weight, body weights, sexual maturity, egg weights and part period egg production were estimated. The different hatch significantly (P<0.05) influenced the estimates of the fertility, total egg set basis hatchability, chick weight to housing weight, sexual maturity, egg production and mortality at younger age. The sex of the chicks also affected (P<0.05) the estimates of the body weights at eight week onwards. The significant regression effect of the chick weight was demonstrated on the body weights at first to twelfth week of age. The chick weight demonstrated a positive association with the sexual maturity and various body weight and egg weight estimates with a low to high phenotypic correlation coefficients; but a negative association with the egg production. The light weighed pullets would face delayed sexual maturity, which would again provoke lower egg weight and production. These phenomics might serve as strain characteristics of this rare strain of Rhode Island Red (RIR) chicken.

KEY WORDS body weights and layer performances, correlation, hatch and sex effect, regression effect of chick weight, RIR-White strain chicken.

INTRODUCTION

A rare white plumage colored strain of Rhode Island Red (RIR) chicken evolved at the Central Avian Research Institute (Izatnagar), was institutionally named as RIR-White strain (Das *et al.* 2014a; Das *et al.* 2014b). It is a brown egg layer strain with yellow skin and shank, single red comb and self-white pattern within feather (Das *et al.* 2014a). The pure RIR chicken has some unique characteristics of either single or rose red comb, typically dark red or brick red plumage colour, yellow skin, early sexual maturity, good brown egg color, good egg size and egg numbers, non-broodiness and good tough feather. In due course of time, breeders also developed its many strains as per their needs. In commercial egg type chicken breeding, the number of important traits has increased over time and emphasis on the traits used in the selection of breeding stocks has varied due to changes in their economic importance (Oni *et al.* 2007). The layer stock is generally selected for high egg production, heavier egg, earlier sexual maturity, higher viability, strong eggshell and optimum body size; most of these traits relate to its genetic background (Niranjan and

Kataria, 2008). Understanding of these various production and reproduction characteristics could provide significant information for planning breeding strategy with optimum performances. Moreover, relevant literature is lacking on this rare strain, though few information appeared in the literatures more recently indicating its commendable production potentiality and immune responsiveness (Das *et al.* 2014a; Das *et al.* 2014b). The best way to improve its productivity without altering any of the morphological characteristics is to undergo selection and breeding for the avowed production and reproduction traits within a given population. Such strategy needs accurate estimates of genetic and phenotypic parameters. The present investigation was carried out to characterize the production and reproduction performances in RIR-White strain chicken.

MATERIALS AND METHODS

Experimental birds and procedures

Following artificial insemination, eggs were collected for 10 days and set in the automated electric incubator (Dayal Poultry Appliances, New Delhi) for hatching the chicks of RIR-White strain chicken at the experimental layer farm of the Central Avian Research Institute, Izatnagar (India). The eggs were checked on day-18 of incubation for infertility, and on day-21 for embryonic mortality. A total of 234 numbers (87, 74 and 73 in successive three hatches) of the chicks were hatched out against 346 fertile eggs set in the incubation for this investigation. The day-old chicks were wing banded in the hatchery itself. Standard litter brooding and housing was provided with optimum management (Das, 2013; Das *et al.* 2014a; Das *et al.* 2015a). Fresh water and feed were provided *ad libitum* twice daily. Birds were fed on the institute-formulated chick mash containing crude protein (CP): 20.65%, metabolic energy (ME): 2694.64 kcal/kg, Calcium: 1.02%, available phosphorous (P): 0.45%, Lysine (Lys): 1.05% and methionine (Met): 0.41% for 0-8 weeks of age, grower mash containing CP: 16.78%, ME: 2536.00 kcal/kg, Ca: 1.15%, P: 0.40%, Lys: 0.76% and Met: 0.37% for 9-20 weeks and layer mash containing CP: 18.18%, ME: 2676.52 kcal/kg, Ca: 3.61%, P: 0.34%, Lys: 0.83% and Met: 0.36% for 20 weeks onwards (Das, 2013; Das *et al.* 2014a; Das *et al.* 2015a). The birds were vaccinated following standard vaccination schedule being followed at this institute, *viz.* vaccination with Ranikhet disease (F strain RD) and Mareck's disease (MD) vaccines at day old, infectious bursal disease (IBD) vaccine on 14-day, F strain RD booster on 28-day, IBD booster on 35-day, Fowl pox vaccine in 42-day, R_2B strain RD vaccine on 56-day, egg dropping syndrome (EDS) vaccine at 18-19 weeks and IBD killed vaccine at 20-22 weeks of ages (Das *et al.*2014a; Das *et al.* 2014b; Das *et al.* 2015a). It was routinely checked on each morning for recording mortality on the previous day followed by its wing band number recording and postmortem examination.

Traits investigated

Percent fertility and total egg set and fertile egg set basis percent hatchability were calculated. Chick weight and body weights at various weeks of age were weighed using electronic top pan digital weigh balance (capacity-0.5 g to 3 kg). The layer performances were investigated. Age at sexual maturity of a pullet was recorded for individual pullet as the number of days taken from hatching to the laying of her first egg. Egg weight was recordedas an average of egg weights for three consecutive days for each pullet in 28 and 40th week of age on electronic digital balance up to a fraction of 0.1 g. Part period egg production of each pullet was recorded daily up to 40 weeks of age in individual laying cages. Percent mortality was calculated for the birds in the stage of brooders (1-7 days and 1-6 weeks of age), growers (7-20 weeks of age) and layers (21-40 weeks of age).

Statistical analysis

Data on chick weight, various body weights and layer performance traits was analyzed by least squares analysis of variance (Harvey, 1990) incorporating sex and hatch as fixed effects and chick weight as a regressor in the linear model. Phenotypic parameters of various body weights and layer production traits were also estimated by the least squares ANOVA. Normal Deviate test at the 5% level of probability of significance were performed in assessing percent differences among different hatches.

RESULTS AND DISCUSSION

Percent fertility and hatchability

The estimates of percent fertility and hatchability on total egg set (TES) and fertile egg set (FES) basis are presented in Table 1. The highest estimates were in the first hatched followed by third and second hatch. The first hatch demonstrated significant percent different with the second hatch for percent fertility and TES basis hatchability, other inter-hatch differences being non-significant by normal deviate test. The present fertility estimates were well comparable to the available reports in RIR chicken (Malago and Baitilwake, 2009; Das *et al.* 2014b) and better than the reports in CARI-Sonali and CARI-Debendra chicken (Das *et al.* 2014b). The present TES basis hatchability estimates were in accordance with the report in RIR control and white strains (Das *et al.* 2014b) and in the reviewed range of 60 to 88% in African indigenous chickens (Mengesha, 2012); but also better as evident when compared to the reports in RIR selected strain, CARI-Sonali and CARI-Debendra chicken (Das *et al.* 2014b). The present FES basis hatchability estimates were comparable to the earlier reports in RIR strains

(CARI Annual Report, 2011; Das *et al.* 2014b), CARI-Sonali and CARI-Debendra chicken (Das *et al.* 2014b). Malago and Baitilwake (2009) reported hatchability estimate as 64.0 ± 2.16% in a RIR chicken. Difference in the estimates might be due to a different strain, line or breed investigated and different incubation system adopted.

Table 1 Percent fertility and hatchability estimates in the RIR-White strain chicken

Hatch	Percent fertility	Percent hatchability	
		Total egg set basis (TES)	Fertile egg set basis (FES)
1	84.96[a]	76.99[a]	90.63[a]
2	73.77[b]	60.66[b]	82.22[a]
3	79.28[ab]	65.77[ab]	82.95[a]

The means within the same column with at least one common letter, do not have significant difference (P>0.05).

Chick weight and body weights

The present chick weight was comparable to the reports for RIR chicks (Ashraf *et al.* 2003; Das *et al.* 2014a; Das *et al.* 2014b), PL1 and PL2 strains of White Leghorn chicks (Choudhary *et al.* 2009), CARI-Sonali and CARI-Debendra chicks (Das *et al.* 2014b); but also better than an earlier report for RIR chicks (Malago and Baitilwake, 2009). The present strain demonstrated overall lower chick weight than the RIR control (Das *et al.* 2015a) and selected lines (Das *et al.* 2015b), though the second hatch performed as like as RIR control line (Das *et al.* 2015a). The present body weights were comparable to the reports in RIR strains (Das *et al.* 2014a; Das *et al.* 2014b), RIR male and female lines (Nwagu *et al.* 2007a). The present strain demonstrated better body weights than the RIR control line (Das *et al.* 2015a), but lower than the RIR selected line (Das *et al.* 2015b). The present chicken strain had these estimates better than the reports in other chicken breeds, lines, strains and their crosses with RIR chicken as evident when compared to the available reports in White Leghorn (Ahmad and Singh, 2007; Jayalaxmi *et al.* 2010; Qadri *et al.* 2013), Gramapriya female line (Chatterjee *et al.* 2010), Kadaknath and Aseel (Chatterjee *et al.* 2007a), Giriraja (Adebambo *et al.* 2006), CARI-Sonali (CARI Annual Report, 2011; Das *et al.* 2014b), Fayoumi male × RIR female cross and its reciprocal (El-Maghraby *et al.* 1975) and crosses of RIR × indigenous lines Bare-neck / Betwil / Large Beladi (Mohammed *et al.* 2005); though few chicken lines (*i.e.* RIR selected line reported in the CARI Annual Report, 2011; Das *et al.* 2015b) or crosses (CARI-Debendra reported by Das *et al.* 2014b) were found better than this present chicken strain. The difference might be due to strain, line or breed difference and different management as well as rearing system.

The least squares analysis of variance revealed that the different hatch significantly (P<0.05) influenced the estimates of the chick weight and body weights up to the housing weight (BW20), though the body weight of 40 week aged pullets had no inter-hatch difference at a significant level. Significant hatch differences were also reported earlier in different chicken genotypes (Das *et al.* 2014b), different tester × line crosses between exotic testers (*viz.* RIR, Bovans, Fayoumi cockerels) and indigenous lines (*viz.* large Beladi, Bare-neck, Betwil hens) at various ages under Sudanese environment (Mohammed *et al.* 2005). However, Ashraf *et al.* (2003) did not find any significant hatch difference in chick weight of Lyallpur Silver Black and Rhode Island Red chicken. Nwagu *et al.* (2007b) reported that hatch effect might have contributed to the variable response in different economic traits achieved from generation to generation might also be due to varying seasons of hatching across generation when studied RIR male and female lines.

The least squares analysis also revealed that the sex of the chicks had a significant effect on the body weights from eight week onwards; the males being heavier than females throughout the ages (Table 2).

Significant sex-differentiation in body weights and the male birds being heavier than the females were also observed at sixth week onwards in RIR selected line (Das *et al.* 2015b), Libyan chicken (El-Safty, 2012) and at 12 weeks onwards in Giriraja, WLH and Nigerian improved indigenous chicken genotypes (F_1, F_2 and B-α chickens) (Adebambo *et al.* 2006).

Layer performance traits

The present findings of age at sexual maturity were close to the reports in RIR control and white strains and CARI-Debendra chicken (Das *et al.* 2014b) and much better than the reports in RIR male and female line (Nwagu *et al.* 2007a). The present chicken strain demonstrated late sexual maturity than RIR selected strain or line (CARI Annual Report, 2011; Das *et al.* 2014b), RIR control line (CARI Annual Report, 2011), White Leghorn chicken (Ahmad and Singh, 2007; Jayalaxmi *et al.* 2010; Qadri *et al.* 2013), CARI-Sonali cross (CARI Annual Report, 2011; Das *et al.* 2014b) and CARI-Debendra cross (CARI Annual Report, 2011).

The present weight estimates of the egg laid at 28 and 40th weeks of age were comparable to the corresponding reports in RIR strains (Das *et al.* 2014b), RIR control and selected line (CARI Annual Report, 2011), an IWN strain of White Leghorn chicken for egg weight at 40 week of age (Qadri *et al.* 2013); though the present strain pullets laid lighter eggs as evident when compared to the reports in RIR (Malago and Baitilwake, 2009) and its crossbreds (Malago and Baitilwake, 2009; CARI Annual Report, 2011; Das *et al.* 2014b), few strains of White Leghorn chicken (Jayalaxmi *et al.* 2010; Qadri *et al.* 2013).

Table 2 Least squares means of chick weight and various body weights in the RIR-White strain chicken

Factors		Least squares means ± standard errors										
		CW (g)	BW 1 (g)	BW 2 (g)	BW 3 (g)	BW 4 (g)	BW 6 (g)	BW 8 (g)	BW 12 (g)	BW 16 (g)	BW 20 (g)	BW 40 (g)
Overall		34.86± 0.28 (162)*	50.74± 0.92 (79)	77.27± 1.21 (144)	136.09± 3.44 (79)	180.72± 3.29 (142)	318.48± 7.46 (77)	457.06± 8.69 (120)	884.54± 14.67 (115)	1282.00± 23.56 (106)	1402.81± 24.67 (38)	1604.41± 30.37 (38)
Hatch	1	34.21± 0.37^{b} (87)	50.74± 0.92 (79)	87.69± 1.62^{a} (79)	136.09± 3.44 (79)	196.38± 4.37^{a} (79)	318.48± 7.46 (77)	526.72± 11.14^{a} (70)	1024.41± 18.95^{a} (67)	1421.08± 30.51^{a} (61)	1603.62± 33.25^{a} (21)	1630.00± 40.63^{a} (21)
	2	35.52± 0.40^{a} (75)	NE	66.85± 1.77^{b} (65)	NE	165.06± 4.83^{b} (63)	NE	387.40± 13.01^{b} (50)	744.66± 22.02^{b} (48)	1142.92± 35.41^{b} (45)	1201.99± 37.02^{b} (17)	1578.82± 45.16^{a} (17)
Sex	Male	34.91± 0.34 (102)	50.79± 1.08 (52)	78.18± 1.45 (93)	137.24± 4.02 (52)	183.63± 3.91 (92)	327.75± 8.84 (50)	480.33± 10.28^{a} (78)	946.98± 17.57^{a} (74)	1380.16± 28.13^{a} (68)	NE	NE
	Female	34.82± 0.44 (60)	50.69± 1.50 (27)	76.37± 1.95 (51)	134.94± 5.58 (27)	177.81± 5.28 (50)	309.21± 12.03 (27)	433.79± 13.90^{b} (42)	822.09± 23.35^{b} (41)	1183.83± 37.49^{b} (38)	1402.81± 24.67 (38)	1604.41± 30.37 (38)

* The figures within parenthesis denote the number of observation.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).
CW: chick weight; BW: body weight in grams at different week of age and NE: not estimated.

Saadey *et al.* (2008) reported a range of 41.9 to 45.5 g egg weights in Fayoumi, Sinai, Rhode Island Red and White Leghorn chicken. The present findings of part period egg production were in the line of earlier reports in RIR control and white strain (Das *et al.* 2014b), RIR control line (CARI Annual Report, 2011), Gramapriya female line (Chatterjee *et al.* 2010), Siani and RIR chicken (Saadey *et al.* 2008).

The present chicken strain also laid more eggs than Kadaknath, Aseel and Vanraja male line (Chatterjee *et al.* 2010), but less number of eggs than RIR selected strain or line, CARI-Sonali and CARI-Debendra crosses (CARI Annual Report, 2011; Das *et al.* 2014b), White Leghorn chicken (Ahmad and Singh, 2007; Jayalaxmi *et al.* 2010; Qadri *et al.* 2013) and Vanraja female line (Chatterjee *et al.* 2010). The attributed differences might be due to different strain, line or breed investigated and different management as well as rearing system adopted.

The different hatch had significant (P<0.05) influences on the estimates of the age at sexual maturity and egg production (Table 3) in accordance to reports in RIR male and female lines (Nwagu *et al.* 2007b).

Regression effect of chick weight on the subsequent traits

The least squares analysis of variance revealed that chick weight had significant (P<0.05) regression effect on the estimates of the body weights at first week to twelfth week of age, though it was not demonstrated on any layer performance traits. The present findings were corroborated by the findings in different genotypes where the layer performance traits could also bear regression effects of the chick weight in layer purpose chickens (Das, 2013; Das *et al.* 2014b).

The higher chick weight might be due to the higher egg weight from which it was hatched out (Ashraf *et al.* 2003) and generally tends to maintain its growth throughout the ages provided better nutrition and management.

Percent mortality

The estimated percent mortalitiy were 3.45%, 3.57%, 17.28% and 0% in the first hatch at the age groups of 0-7 days, 1-6 week, 7-20 week and 21-40 week, respectively. The corresponding estimates in the second hatch were 5.33%, 15.49%, 8.33% and 0%. Normal deviate test clarified no significance difference between the hatches throughout the periods except the period of 1-6 week wherein percent mortality was significant (P<0.05) higher in the second hatch might have due to suffocation created when kept in a small area of confinement for the purpose of taking body weights and measurements of shank length, keel length and breast angle for other experiment. For similar reason, 7-20 week's percent mortality in the first hatch was also an extreme high. Although other estimates of the percent mortality were within the range of normal mortality observed in intensive rearing (Adebambo *et al.* 2006; Malago and Baitilwake, 2009) and almost similar range of mortality in various chicken germplasm was reported earlier also (Das *et al.* 2014b).

Phenotypic correlations

The estimates of the phenotypic correlation coefficients among different performance traits are presented in Tables 4 and 5. The phenotypic correlation coefficients ranged from low (0.019) to high (0.888) in the magnitude for the chick weight and various body weights (Table 4) and from low (0.007) to medium (0.628) in magnitude for various layer performance traits (Table 5).

Table 3 Least squares means of various layer performance traits in the RIR-White strain chicken

Factors		Obs.	Least squares means ± standard errors			
			ASM (days)	EW 28 (g)	EW 40 (g)	EP40 (nos.)
Overall		38	177.30±3.03	43.84±0.61	50.48±0.49	66.15±3.04
Hatch	1	21	169.43±4.06[a]	44.61±0.82[a]	50.71±0.66[a]	74.48±4.07[a]
	2	17	185.18±4.51[b]	43.06±0.91[a]	50.25±0.74[a]	57.82±4.52[b]

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
ASM: age at sexual maturity in days; EW 28: egg weight in grams at 28th week; EW 40: egg weight in grams at 40th week and EP 40: part period egg production in numbers up to 40 weeks of age.

Table 4 Phenotypic correlations among chick weight and various body weights in the RIR-White strain chicken

Traits	CW	BW 1	BW 2	BW 3	BW 4	BW 6	BW 8	BW 12
BW1	0.275 (79)*	-	-	-	-	-	-	-
BW2	0.123 (144)	0.549 (79)	-	-	-	-	-	-
BW3	0.237 (79)	0.432 (79)	0.840 (79)	-	-	-	-	-
BW4	0.131 (142)	0.337 (79)	0.758 (142)	0.857 (79)	-	-	-	-
BW6	0.285 (77)	0.330 (77)	0.644 (77)	0.732 (77)	0.721 (77)	-	-	-
BW8	0.103 (120)	0.335 (73)	0.691 (120)	0.692 (73)	0.724 (120)	0.888 (73)	-	-
BW12	0.065 (115)	0.226 (61)	0.633 (120)	0.633 (61)	0.652 (120)	0.842 (61)	0.873 (106)	-
BW16	0.019 (106)	0.158 (61)	0.501 (106)	0.556 (61)	0.537 (106)	0.690 (61)	0.735 (106)	0.759 (106)

* The figures within parenthesis denote the number of observations.
CW: chick weight and BW: body weight at different week of age.

Table 5 Phenotypic correlations among chick weight and various layer performance traits in the RIR-White strain chicken

Traits	CW	BW 20	ASM	EW 28	BW 40	EW 40
BW 20	0.072	-	-	-	-	-
ASM	0.178	-0.363	-	-	-	-
EW 28	0.035	0.315	-0.149	-	-	-
BW 40	0.191	0.239	-0.350	0.007	-	-
EW 40	0.266	0.064	-0.077	0.375	0.288	-
EP 40	-0.247	0.255	-0.628	0.204	0.224	0.010

CW: chick weight; BW 20: body weight at 20th week of age; ASM: age at sexual maturity; EW28: egg weight at 28th week; BW40: body weight at 40th week; EW40: egg weight at 40th week and EP40: part period egg production up to 40 weeks of age.

The chick weight demonstrated more coefficient value with very younger aged body weights, and the coefficient values between the two closer parameters were more than the distant parameters for body weights (Das, 2013). The chick weight demonstrated a positive association with the sexual maturity and various body weight and egg weight estimates with a low to high phenotypic correlation coefficients; but a negative association with the egg production (Das, 2013). The negative association between the sexual maturity and body weights of the 20 and 40 week aged pullets and indicated that the light weighted (BW20) pullets would favor late sexual maturity of the birds (Sethi *et al.* 2003; Paleja *et al.* 2008; Jayalaxmi *et al.* 2010). A negative association of ASM was also reported earlier, but with younger body weights (upto 16th week of age) and its positive association with older body weights in the White Leghorn chicken (Choudhary *et al.* 2009; Qadri *et al.* 2013). The sexual maturity again demonstrated a negative association with the egg weights (Vasu *et al.* 2004; Paleja *et al.* 2008) at 28 and 40th weeks of age and egg production (Johari *et al.* 1988; Paleja *et al.* 2008; Jayalaxmi *et al.* 2010) indicating that early sexual matured pullets would lay heavier and more eggs. On the contrary, its positive association was also reported with egg weight (Barot *et al.* 2008) and egg production (Oni *et al.* 2007) in other genotypes. Pullets' body weights, egg weights and egg production demonstrated a positive association (Paleja *et al.* 2008; Agu *et al.* 2012) among themselves in the present study. 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 the White Leghorn chicken (Qadri *et al.* 2013).

CONCLUSION

It was concluded that the most of the production and reproduction traits might have hatched to hatch variations. The body weights might not be sex independent and might have a regression effect of its chick weight. The chick weight demonstrated a positive association with the sexual maturity and various body weights and egg weights, but a negative association with the egg production. The light weighted pullets would face delayed sexual maturity, which would again provoke lower egg weight and egg production. These performance statistics assessed in this study might serve as strain characteristics and documentation on the RIR-White strain, a rare strain of the Rhode Island Red chicken.

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