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Genetic analysis of growth and egg production traits of IWI strain of WLH in current generation after long term selection

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Abstract
White leghorn chicken is a promising egg producing breed in the country and undergoing continuous genetic improvement program for higher egg production. It is prudent to periodically assess the growth and production status and their genetic and phenotypic parameters, which are population specific and are crucial for any improvement program and formulation of breeding strategies. Therefore, this study was undertaken to evaluate an annual (64 weeks) egg production strain, IWI of WLH, which was undergoing selection for higher annual egg production for more than 35 generations until 2013 and maintained through rotational breeding thereafter. The population was maintained at institute farm, ICAR-CARI Izatnagar Bareilly and used as dam line to produce one of the popular crosses, namely CARIPRIYA. Data was collected on different growth and layer economic traits on 121 pullets from single hatch and analyzed to determine various estimates. The least square means of layer economic traits, viz., age at sexual maturity (ASM), egg weight at 28th week (EW28), 40th week (EW40) and at 64th week (EW64) of age, egg Production up to 40th (EP40) and 64th week (EP64) of age were estimated as 144.12±1.85 days, 48.17±0.36 g, 50.11±0.43 g, 55.65±0.53g, 109.21±1.92 and 228.17±3.02 eggs, respectively. Their heritability estimates were 0.40±0.43, 0.06±0.39, 0.43±0.44, 0.72±0.46, 0.20±0.41 and 0.22±0.41, respectively. The least square means of body weights at 16 (BW16), 40 (BW40) and 64 (BW64) weeks of age were 964.17±15.70 g, 1312.61±19.97 g and 1378.14±19.17 g, respectively. Their heritability estimates were 0.79±0.46, 0.73±0.46 and 0.30±0.42, respectively. The study revealed that the layer economic traits in IWI strain of WLH were maintained over past generations through rotational breeding. The population can be exploited in genetic improvement program, as and when needed, and also in developing improved layer crosses.

Keywords: Growth traits, annual egg production strain, heritability, layer traits, LS means, WLH

1. Introduction
One of India's most developed sectors of the livestock business, the well-organized Indian poultry industry today formed via the gradual transformation of changes in backyard chicken rearing. Although India came in third place overall for egg production, just 90 eggs are available per person annually, compared to 180 eggs suggested by the ICMR (Borah and Halim, 2014) [3], demonstrating that the layer industry still has a tremendous amount of room to grow.

The genetic development of different breeds of chickens, which aids in advancing both the commercial and backyard poultry sectors in rural areas, is significantly influenced by ICAR-CARI and some private enterprises. WLH and its developed strains are well established highest egg producing breed in our diverse environmental condition and mostly preferred by large flock owners and organized industrialists. The situation of the Indian poultry business has altered significantly over the previous three to four decades as a result of strains created by WLH by various participants.

White leghorn chicken is a promising egg producing breed in the country and undergoing continuous genetic improvement program for higher egg production. It is prudent to periodically assess the status of growth and production status and their genetic and phenotypic parameters, which are population specific and are crucial for any improvement program and formulation of breeding strategies. The IWI strain of WLH is mainly used as dam line to produce one of the popular crosses, namely CARIPRIYA. Therefore, this study was undertaken to evaluate an annual (64 weeks) egg production strain, IWI of WLH, which was undergoing selection for higher annual egg production for more than 35 generations until 2013 and maintained through rotational breeding thereafter.

2. Materials and Methods

The data recorded on growth traits of 95 birds of 24 sires from 9 hatch of IWI strain of WLH maintained at institute farm, ICAR-CARI Izatnagar Bareilly and traits were considered such as Body Weight at 16, 40, 64 weeks of age and different layer economic traits such as Egg Weight at 28, 40, 64 week of age, and Egg Production at 40 and 64 weeks of age in IWI (121) female line of WLH chickens. The data was normalized and the statistical analysis was done by using mixed model least squares analysis of variance and maximum likelihood program (Harvey, 1990) [6]. The statistical model used for the analysis was as follows,

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

Where

Y_{ijk} =Value of a trait measured on k^{th} individual belonging to i^{th} sire and j^{th} hatch.

μ = Population mean

S_i = Random effect of i^{th} sire

H_j = fixed effect of hatch

e_{ijk} = Random error associated with mean zero and variance σ^2e.

The Genetic and phenotypic parameters of growth and layer traits were assessed by using paternal half-sib correlation method.

3. Results and Discussion

The different growth and layer traits were evaluated and table 1, 2 and 3 represents genetic and phenotypic parameters of various traits in IWI female line of WLH chicken for the same

3.1 The descriptive statistics of various growth and layer traits

Average Least square mean for Age at sexual Maturity (ASM) in WLH IWI strain was 144.12 1.85 days. The results of this study's investigation of the WLH strain are consistent with those of Jayalaxmi *et al.,* (2010) [7]. However, Ahmad *et al.,* (2007) [1], Paleja *et al.,* (2008) [10], and Churchil *et al.,* (2019) [5] reported slightly higher ASM estimates besides Veermani *et al.,* (2008) [17] and Narayanankutty *et al.,* (2008) [9] reported significantly lower ASM estimates than current findings.

Table 1: Least square analysis of variance of various traits in IWI female line of WLH chicken

Source of variation		Mean sum of squares								
	Df	ASM	BW16	BW40	BW64	EW28	EW40	EW64	EP40	EP64
Sire	23	272.07	18560.32*	30221.48*	29619.34	11.02	14.63	21.28*	302.93	749.07
Hatch	8	380.48	21678.65*	59660.46**	74745.57**	34.49**	6.67	39.17**	418.47	963.63
Error/ Remainder	63	194.76	9887.69	16854.38	22961.94	10.46	10.27	11.93	254.45	620.50

df = Degrees of freedom; **p*≤0.05, ***p*≤0.01

Table 2: Least square mean ± standard error of various traits in IWI female line of WLH chicken.

Factors			Least squares mean ± SE								
		n	ASM (d)	BW16 (g)	BW40 (g)	BW 64 (g)	EW28 (g)	EW40 (g)	EW64 (g)	EP40 (no.)	EP 64 (no.)
Overall		95	144.12± 1.85	964.17±15.70	1312.61±19.97	1378.14±19.17	48.17±0.36	50.71±0.43	55.65±0.53	109.21±1.92	228.17±3.02
Hatch	1	11	144.47 ± 5.29	944.08±38.63	1296.09±50.22	1281.64±57.10	51.57±1.20	52.56±1.22	51.49±1.33	107.69±5.98	226.34±9.35
	2	12	130.55±4.79	960.59±35.19	1249.43±45.71	1284.26±51.68	47.97±1.08	50.33±1.10	54.35±1.21	123.10±5.40	248.70±8.45
	3	15	143.73±4.36	955.47±32.23	1312.90±41.83	1375.02±46.99	48.90±0.98	49.65±1.00	54.12±1.11	110.98±4.91	239.19±7.67
	4	9	147.21±5.47	922.42±39.90	1408.32±51.89	1462.62±59.10	49.95±1.24	51.59±1.26	57.97±1.38	114.24±6.19	235.10±9.67
	5	6	157.30±6.78	1078.57±49.06	1489.14±63.89	1476.25±73.39	50.33±1.55	51.60±1.55	59.96±1.70	99.20±7.70	220.55±12.03
	6	6	152.37±6.64	978.06±48.06	1414.44±62.56	1607.80±71.81	47.25±1.52	50.15±1.52	56.47±1.66	100.33±7.53	211.96±11.77
	7	14	139.69±4.61	994.50±33.93	1189.62±44.05	1328.04±49.68	47.39±1.04	50.73±1.06	56.92±1.17	112.735±5.19	228.48±8.12
	8	10	138.41±5.22	981.42±38.20	1208.62±49.66	1383.67±56.42	45.94±1.19	49.9±1.20	55.27±1.32	111.59±5.91	225.14±9.23
	9	12	143.37±5.0	862.42±36.68	1244.90±47.67	1303.92±54.03	44.20±1.13	49.85±1.15	54.27±1.27	103.01±5.65	218.06±8.84

N= Number of observations

Average least square mean For BW16, BW40 and BW64 was 964.17±15.70, 1312.61±19.97 and 1378.14±19.17 grams respectively. Nagasri *et al.*, (2022) [8] reported higher BW at 16 and 40 week of age in IWK strains of WLH. Churchil *et al.*, (2019) [5] showed greater BW in two WLH strains at 16^{th} and 40^{th} weeks of age. According to Jayalaxmi *et al.,* (2010) [7], body weight was lower at 16 weeks but greater at 40^{th} and 64^{th} weeks of age. As per Chaudhari *et al*., (2009) [4], BW was somewhat greater at 16^{th} weeks but slightly lower at 40^{th} weeks. Veermani *et al*., (2008) [17] and Narayanankutty *et al*., (2008) [9] found considerably greater BW at 16^{th}, 40^{th}, and 64^{th} weeks. Higher BW was reported in the 36^{th} week by Ahmad *et al*., (2007) [1].

The average observed least square means for EW28, EW40, EW64 EP40 and EP64 were 48.17±0.36, 50.71±0.43, 55.65±0.53, 109.21±1.92 and 228.17±3.02 gm respectively. Churchil *et al.*, (2019) [5] reported higher EN or EP at all ages for IWN and IWP strains of WLH. Jayalaxmi *et al.*, (2010) [7] reported slightly higher Egg Weights at 28^{th}, 40^{th} and 64^{th} weeks age and lower EP40 and EP64. A study by Chaudhari *et al.*, (2009) [5] showed slightly higher BW at 16^{th} week but slightly lower BW at 40th week of age. Veermani *et al.*, (2008) [17] reported higher values EW28, EW40, EP40, and EP64. and Narayanankutty *et al.*, (2008) [9] reported higher values EW28, EW40, and EP40, except for EP64.

3.2 Least square analysis of variance of various growth and layer traits

According to the least square analysis of variance of different traits in IWI the influence of sire was found to be significant on BW16, BW40, EW64 hatch was found to be significant effect on BW16, BW40, BW64 EW28 and EW64 .

3.3 Genetic analysis of different growth and layer traits

3.3.1 Genetic correlation

The genetic correlation between ASM and BW16 and BW40 was substantially negative, whereas the correlation with BW64 was very weakly positive. The genetic correlation between ASM and EW28, EW40, and EW64 was moderate to highly positive. In contrary to the present study Shridevi *et al*., (2021) [15], Churchil *et al.*, (2019) [5] reported negative correlation between ASM and all growth and egg traits. However, there was a modest to moderate genetic correlation between EP40 and EP64 and ASM. Early and late age BW had a strong correlation, and the correlation among BW16, BW40, and BW64 with EW ranged from strongly negative to mildly positive. However, there was a very high positive genetic correlation between BW16, BW40, and EP40, EP64, but a very strong negative correlation for BW64. It was discovered that there is a mild to extremely high positive genetic correlation between EW28 and EW64. Genetically, the EW and EP were substantially inversely associated, and EP40 and demonstrated very strong positive genetic correlation. However genetic correlation between other traits were in accordance with present study.

3.3.2 Phenotypic correlation

Phenotypic correlation of ASM was weakly negative with BW16 and EP64 and very weakly positive for BW40, BW64 contrary with the findings reported by Barot *et al.,* (2008) [2] However, ASM was found to be weakly positive with EW at different ages. This indicated that late maturing birds would be expected to lay heavier eggs and selection for high egg weight tends to delay sexual maturity. Similar results have been reported by Barot *et al.,* (2008) [2] Sethi *et al.* (2003) [11], Sharma *et al.* (2003) [13] and Singh *et al.* (2004) [14]. The phenotypic correlations between growth traits were positive and varied from moderate to high. Similar findings have also been reported by Sharma and Verma (2001) [12] Vasu *et al.* (2004) [16] and Barot *et al.,* (2008) [2]. Phenotypic correlation of BW with EW28, EW40, and EW64 was weakly positive and was weakly negative to weakly positive with EW at different ages. However, it was weakly positive with EP40 and EP64. The phenotypic correlation between EW40 and EW 64 showed moderate to high positive correlation but weak negative correlation with EP40 and EP64. The EP40 and EP64 showed strong positive correlation.

Table 3: Heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) of various traits in IWI female line of WLH chicken.

	ASM	BW16	BW40	BW64	EW28	EW40	EW64	EP40	EP6
AS	0.40±0	-	-	0.05±0	0.38±1	0.79±0	0.70±0	-	-
BW	-0.33	0.79±0	1.09±0	0.69±0	0.30±1	-	0.26±0	0.70±0.	0.87
BW	0.07	0.51	0.73±0	1.02±0	-	-	0.17±0	0.72±1.	0.73
BW	0.07	0.39	0.83	0.30±0	0.06±2	-	0.02±0	-	-
EW	0.17	0.09	0.16	0.14	0.06±0	0.26±1	2.19±6	-	-
EW	0.27	-0.01	0.19	0.15	0.72	0.43±0	1.06±0	-	-
EW	0.16	-0.03	0.17	0.21	0.38	0.53	0.72±0	-	-
EP4	-0.55	0.22	0.06	0.09	-0.27	-0.27	-0.18	0.20±0.	1.05
EP6	-0.37	0.16	0.06	0.09	-0.19	-0.24	-0.19	0.88	0.22

3.3.3 Heritability

In the female IWI line, the heritability of ASM was moderate to medium. For egg weight at different ages, EW28, EW40, and EW64, the estimates for heritability ranged from quite low to high. For BW16, BW40, and BW64, the estimates for heritability were vary from low to high. Estimates for EP (Egg Production) was found to be low. The table no.3 indicates heritabilities ± standard errors and phenotypic and genetic correlations among the related traits.

Estimates of ASM heritabilities discovered in the study agreed with estimates of Churchil *et al.,* (2019) [5] in the IWN strain of WLH. However, Jayalaxmi *et al.,* (2010) [7] in the IWK strain and Churchil *et al.,* (2019) [5] in the IWP strain of WLH found very low heritability values. BW and EW heritabilities estimates According to earlier studies by researchers including Jayalaxmi *et al.,* (2010) [7], Chaudhari *et al.,* (2009) [4] and Churchil *et al.* (2019) [5] in the IWN and IWP strain of WLH). However, Nagasri *et al.,* (2022) [8] revealed that the heritability of BW at various ages was significantly lower. Heritabilities values of EP reported in this investigation were consistent with Jayalaxmi *et al.,* (2010) [7], Churchil *et al.,* (2019) [5], Chaudhari *et al.,* (2009) [4], and Veermani *et al.,* (2008) [17].

Heritabilities of ASM in accordance with Churchil *et al.,* (2019) [5] in IWN strain of WLH. However Jayalaxmi *et al.,* (2010) [7] in IWK strain and Churchil *et al.,* (2019) [5] in IWP strain of WLH reported very low heritability estimates. Heritabilities estimates of BW and EW In accordance with other outcomes of researchers like Churchil *et al.,* (2019) [5] in IWN and IWP strain of WLH, Jayalaxmi *et al.,* (2010) [7] and Chaudhari *et al.,* (2009) [4]. However Nagasri *et al*., (2022) [8] reported Significantly lower heritability for BW at different ages. Heritabilities values of EP observed in present study were in accordance with Jayalaxmi *et al.,* (2010) [7], Churchil *et al.* (2019) [5], Chaudhari *et al.,* (2009) [4] and Veermani *et al*., (2008) [17].

4. Conclusion

White leghorn chicken is a promising egg producing breed in the country and undergoing continuous genetic improvement program for higher egg production. The present study of genetic analysis of growth and egg production traits concluded that moderate to high heritability estimates of various traits in IWI strain of WLH provide scope for improvement in the flock using different means of selection in future. High and positive genetic correlations found among body weights and layer economic traits can be exploited in developing models for genetic improvement in production performance breed.

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