Genetic evaluation of White Leghorn layers under reciprocal recurrent selection

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ABSTRACT

Present study revealed that crossbreds were marginally superior in most of the performance traits than the purebreds. AFE of purebreds was lower than observed for crossbreds in all generations except G_4, G_5 and G_6 generations.The EN was more during the initial three generations of study whereas it declined sharply in the fourth and sixth generations. No definite trend was observed for the difference in EW of two reciprocal crosses in all the generations under study. EN was found to be more important than EW in determining the EM. Differences in the mean over the generations may be accounted for by the effect of selection and environmental factors.Heritability estimates for BW_{20}, BW_{40} and AFE were moderate to high, but EN was low heritable. Heritabilities of EM, EM/BW_{20} and EM/AFE were moderate indicating that some form of family selection may be effective for their improvement. Standard errors of heritability estimates were small suggesting that a reasonably high degree of reliance can be placed on these estimates. Large standard errors of heritabilities of traits of crossbreds than the purebreds might be due to smaller population size in comparison to purebred strains. Body weight, age at first egg and egg number were negatively correlated with each other both at genetic and phenotypic levels. Egg weight was positively correlated with body weights at phenotypic level both in purebreds and crossbreds but negatively genetically correlated in purebreds and reverse was observed in crossbreds. Most of the phenotypic correlations were highly significant both in purebreds and crossbreds. It might be concluded that heavier birds lay large sized eggs but higher weight during laying period is not a desirable proposition. Results suggest the use of RRS selection schemes for further improvement of egg production and its component traits of hybrid layer.

Key words : Genetic evaluation, egg production, hybrid layer, RSS

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INTRODUCTION

The primary objective of a poultry breeder is to alter gene frequencies and distribution by employing various mating systems/selection methods to improve different traits of economic importance that will maximize the efficiency of production and increase profitability. There are different methods of selection, each with several variants. RRS Reciprocal Recurrent Selection method of selection increases the frequency of both additive and non-additive genes, hence improve pure-line as well as cross-line performance. The main reason for this is that crossbreds often exhibit heterosis that indicates the existence of non- additive effects and the two populations under reciprocal recurrent selection do not have identical gene frequency which causes the covariance between them to be small or negative. Reciprocal recurrent selection leads to a high performance for lowly heritable and heterotic traits. Crossbreeding is a standard practice in poultry breeding programs as a way of exploiting heterosis. Furthermore, the goal of breeding is not to maximize heterosis, but to maximize overall profitability in the commercial cross, the parents and the pure lines. Considering cross-bred and pure-bred performance as two separate, but correlated traits offers an elegant way to take environmental effects into account.

Instead of describing theory of RRS kindly give objective of your study and also give some reference in introduction part which are related with earlier studies).

MATERIALS AND METHODS

Data pertaining to the present study were collected from records spreading over nine generations i.e. 1994-95 to 2002-03 for the performance traits of both strains (which both strains is not clear, pl give name and in one line details of strains)and their crosses. The chicks of all the four genetic groups (H×H, C×C, H×C and C×H) were brooded and reared hatch-wise. The progenies were produced in different hatches at weekly intervals during the month of April and May each year. All the chicks were pedigreed, wing-banded at the time of hatching and reared hatch-wise using standard managemental practices. Cockerels were separated from the pullets at eight weeks of age. At 20 weeks of age, the body weights were recorded and pullets were housed in layer houses. Trap-nest records of each pullet were maintained to record the age at first egg and egg production upto 40 weeks of age. During 40th week, three eggs from each pullet were weighed and averages of these were considered as egg weight of the pullet. At 40 weeks of age, body weights of hens were also recorded. Standard managemental practices were followed during the course of present study. The performance traits viz. body weight at 20 (BW_{20}) and 40 weeks age (BW_{40}), age at first egg (AFE), egg number upto 40 weeks age (EN) and egg weight during 40 weeks of age (EW) were recorded on individual purebred and crossbred pullets. Genetic and phenotypic parameters of the traits of purebred and crossbred were estimated from sire component of variances and covariances. The performance traits viz BW_{20} and $BW_{40,}$ AFE, EN and EW were recorded on individual purebred and crossbred pullet. Egg mass upto 40 weeks of age (EM), ratio of egg mass to body weight at 20 weeks age (EM/ $BW_{20)}$ and ratio of egg mass to age at first egg (EM/AFE) were calculated for individual pullet. Generation wise, genetic and phenotypic variances and covariances among the traits, least square means, heritabilities and correlations among traits of purebreds and crossbreds were estimated using Mixed Model Least Squares Maximum Likelihood Computer Programme of Harvey (1987).

RESULTS AND DISCUSSION

Generation wise least squares means alongwith standard error for body weight at 20 and 40 weeks (g) , age at first egg (days) and egg number of different genetic groups are given in Table 1. The results depicted that crossbred pullets were significantly heavier at 20 weeks of age than the purebred pullets in G_1 and G_8 but statistically non significant in G_4 generations only. At 40 weeks of age, crossbred pullets were heavier than purebred pullets in all generations except G_2, G_3 and G_9 generations. BW_{20} for purebreds ranged from 1202.53±2.89 to 1316.81±3.94g and the crossbreds ranged from 1202.21±12.11 to 1311.33±7.19g. The corresponding figures for BW_{40} were 1406.36±10.25 to 1667.04±5.59g and 1460.37±7.74 to 1713.25±7.41g, respectively. Sakunthala (2001) and Singh (2001) reported similar body weights at both ages in purebred strains confirming the present results. The results on crossbreds, body weights at both ages are in agreement with those of Singh (2001). On the contrary, Brah *et al*. (2002) reported lower BW_{20} and BW_{40} weeks age in purebred and crossbred groups while Yahaya *et al*. (2009) reported higher values for these traits (BW_{20} andBW_{40}) than observed in this study.

Average AFE of purebred pullets was significantly lower than observed for the crossbred pullets in all generations except G_4, G_5 and G_6 generations. AFE of purebred and crossbred pullets ranged from 135.04±0.24 to 162.11±0.68 days and 143.78±0.85 to 163.44±0.79 days, respectively (Table 1). Lower AFE in G_6 generation compared to other generations might be due to indirect selection as the criterion of selection was EN to fixed age (280 days).Similar findings to the present results have also been reported earlier in literature (Sakunthala , 2001 and Singh, 2001). Higher values for this trait in purebreds and crossbreds were reported by Yahaya *et al* (2009).

The average EN ranged from 55.28±0.63 to 81.48±0.75 and 57.02±1.04 to 81.25±0.71 in purebreds and crossbreds, respectively (Table 1). Difference in the performance of two reciprocal crosses suggests that a particular strain should be used as male line and the other as female line for producing a commercial hybrid layer. Brah *et al*. (2002) reported higher EN upto 40 weeks of age for purebreds than the crossbreds which is contrary to the present results. However, Yahaya *et al* (2009) and Momoh *et al* (2010) reported higher egg production in crossbreds than purebreds and are in agreement to the present study.

The egg production declined during fourth and sixth generation. The main reason of this decline may be due to Gumboro outbreak during……. Year? in this population causing death of high producing birds. Another possible reason might be that while selecting the pullets, emphasis on egg weight was also given in later generations thus causing decline in egg production because of negative genetic correlation between these two traits.

Average EW was significantly higher for the crossbreds than the purebreds in generations G_1 and G_2 only and significantly lower in G_3, G_6 and G_7. In the remaining generations the EW of purebreds and crossbreds were similar. The averages for EW in purebreds ranged from 49.15±0.18 g to 53.70±0.18 g and 48.06±0.32 g to 53.21±0.22 g in crossbreds over the generations (Table 2) which is in close conformity with the findings of Singh (2001),Brah *et al*. (2002) and Momoh *et al* (2010). Yahaya *et al*. (2009) reported superiority of crossbreds over purebreds in two generations of RRS.

Average EM was higher in crossbreds than the purebreds in the generation G_1 and significant in G_3, G_5, G_8 and G_9 generations. The averages for EM ranged from 2936.65±33.06 g to 4213.35±31.26 g and 2887.89±60.74 g to 4080.74±35.93 g in purebreds and crossbreds, respectively (Table 2). Momoh *et al* (2010) reported lower values than the present study for this trait in purebreds but higher values in crossbreds. Highest EN (Table 1) and EM (Table 2) in generation G_2 indicated that EN is more important than EW in determining the EM.

Ratio of EM/BW_{20} ranged from 2.23±0.03 to 3.44±0.03 in purebreds and 2.21±0.05 to 3.37±0.03 in crossbreds, respectively (Table 2). The ratio was higher for the crossbreds in generations G_1 and significant in G_3, G_5, and G_9 only and lower in rest of the generations. Ratio of EM/AFE ranged from 20.01±0.31 to 31.30±0.25 in purebreds and 20.27±0.52 to 26.77±0.26 in crossbreds (Table 2). Crossbreds were superior to purebreds in generations G_4, G_5 and G_7 for this trait. From the above results, it may be concluded that in general crossbreds were slightly superior to the purebreds for most of the performance traits. Differences in generation means for different traits may be accounted for by the effect of both selection and environmental factors.

Heritability : Heritabilities estimated from sire component of variance pooled over generations along with their standard errors for performance traits of purebred and crossbreds are presented in Table 3.

The results showed that heritability estimates for BW_{20} and BW_{40} age was medium for the purebreds (0.391±0.043, 0.352±0.054) and high for crossbreds (0.418±0.034, 0.444±0.089). The present results are in confirmation with the findings of Shakunthala (2001) for purebreds at 20 weeks age. The reported estimates of heritability of crossbred in present study are lower for both traits than those of Singh (2001) but higher than reported by Yahaya *et al* (2009).

Medium heritability of BW_{20} and BW_{40} has also been reported earlier (Chatterjee *et al*, 2008). The results of present study indicated that BW_{40} for crossbreds is highly heritable. The higher heritability of crosses over pures for these traits is caused by higher genetic variation and lower environmental variation. Higher heritability estimates in crosses than in pures were also reported by Yahaya *et al* (2009) whereas Pirchner (1976) observed only slight differences in heritabilities between crosses and pures. The excess of sire component heritability in crosses over the pures for body weight (as reported in literature) showed that body weights are influenced by non-additive genetic effects. Thus, the magnitude of heritability of a particular cross was more dependent on the male-parent than that of female-parent strain.

The pooled estimates of heritability for AFE were found to be 0.427±0.099 and 0.565±0.106 in purebreds and crossbreds respectively. Higher

Table1. Generation wise least squares means along with standard error for body weight at 20 and 40 weeks (g), age at first egg (days) and egg number of different genetic groups

	Purebreds				Crossbreds			
Generations	**20wk (gm)**	**40wk (gm)**	**AFE (days)**	**EN**	**20wk (gm)**	**40wk (gm)**	**AFE (days)**	**EN**
1.	1202.53a±2.89	1593.21a±3.86	147.20a±0.27	75.04a±0.45	1217.06b±3.71	1599.08a±4.21 (478)	154.08b±0.34	76.59a±0.98 (328)
2.	1223.93a±3.14	1561.37a±3.58	135.04b±0.24	81.48a±0.75	1212.67a±5.58	1550.77a±4.75 (628)	153.20a±0.46	78.76b±0.68 (300)
3.	1275.25a±4.15	1646.34a±4.51	138.88b±0.40	65.60b±0.74	1202.21b±12.11	1597.06b±11.55 (358)	146.86a±1.12	72.35a±1.84 (68)
4.	1230.61a±4.28	1553.13b±4.97	151.16a±0.47	58.96a±0.66	1239.63a±5.73	1582.94a±8.33 (294)	143.82b±0.48	58.32a±0.93 (136)
5.	1295.25a±2.75	1617.33a±4.47	159.70a±0.33	76.74b±0.51	1289.33a±3.72	1625.00a±5.85 (472)	154.35b±0.51	81.25a±0.71 (240)
6.	1316.81a±3.94	1667.04b±5.59	145.87a±0.54	55.28a±0.63	1311.33a±7.19	1713.25a±7.41 (285)	143.78a±0.85	57.02a±1.07 (83)
7.	1311.02a±3.67	1541.57a±4.99	145.17b±0.36	65.68a±0.55	1242.70b±3.37	1555.75a±8.22 (362)	149.14a±0.56	62.86b±0.91 (174)
8.	1225.91b±10.34	1406.36b±10.25	142.96b±0.66	61.06b±1.06	1290.75a±11.56	1479.79a±10.19 (110)	159.00a±0.62	64.84a±0.90 (146)
9.	1222.28a±4.51	1479.70a±6.31	162.11a±0.68	66.33b±0.88	1212.48a±5.64	1460.37a±7.74 (267)	163.44a±0.79	72.51a±0.92 (246)
Overall	1255.74a±1.51	1575.93a±1.98	145.22b±0.22	72.03b±0.30	1237.36b±2.36	1561.49b±2.91 (3254)	149.82a±0.30	73.86a±0.36 (1721)

Figures in parentheses are the number of observations.
Means bearing different superscripts (among genetic groups and crosses separately) differ significantly (P<0.05)

Table 2. Generation wise least squares means along with standard error for egg weight (gm), egg mass (gm), ratio of egg mass to body weight at 20 weeks age and ratio of egg mass to age at first egg of different genetic groups

	Purebreds				Crossbreds			
Generations	**20wk (gm)**	**40wk (gm)**	**AFE (days)**	**EN**	**20wk (gm)**	**40wk (gm)**	**AFE (days)**	**EN**
1.	51.32a±0.12	3898.07a±31.28	3.27a±0.03	26.50a±0.25	52.68b±0.14	4056.62a±38.22 (478)	3.33a±0.03	26.34a±0.30 (328)
2.	50.92b±0.10	4213.35a±31.26	3.44a±0.03	31.30a±0.25	51.86a±0.08	4072.85b±31.02 (628)	3.37a±0.03	26.77b±0.26 (300)
3.	50.42a±0.17	3274.87b±30.14	2.57b±0.02	23.76a±0.26	48.06b±0.32	3465.28a±83.88 (358)	2.89a±0.07	23.75a±0.64 (68)
4.	53.70a±0.18	3165.74a±37.15	2.58a±0.03	21.04a±0.27	53.21a±0.22	3106.04a±52.36 (294)	2.51a±0.04	21.65a±0.39 (136)
5.	50.83a±0.14	3897.16b±26.96	3.01b±0.02	24.49b±0.19	50.32b±0.21	4080.74a±35.93 (472)	3.17a±0.03	26.55a±0.27 (240)
6.	52.88a±0.14	2936.65a±33.06	2.23a±0.03	20.37a±0.29	50.54b±0.23	2887.89a±60.74 (285)	2.21a±0.05	20.27a±0.52 (83)
7.	52.79a±0.13	3465.04a±29.04	2.65a±0.02	24.05a±0.25	51.12b±0.19	3209.02b±46.24 (362)	2.59a±0.04	21.60b±0.34 (174)
8.	50.68a±0.30	3101.93b±57.47	2.54a±0.05	21.81a±0.44	50.01a±0.27	3249.63a±45.05 (110)	2.53a±0.04	20.53b±0.32 (146)
9.	49.15a±0.18	3271.54b±43.55	2.68b±0.04	20.01b±0.31	49.07a±0.20	3554.11a±45.73 (267)	2.94a±0.04	22.02a±0.35 (246)
Overall	51.43a±0.06	3688.27b±14.49	2.95b±0.01	25.78a±0.12	51.00b±0.08	3764.77a±19.41 (3254)	3.06a±0.02	25.47a±0.16 (1721)

Figures in parentheses are the number of observations.
Means bearing different superscripts (among genetic groups and crosses separately) differ significantly (P<0.05)

estimates of heritability in crossbreds than in purebreds were reported by Singh (2001). The findings of this study resembles with the reports of Chatterjee et al. (2000, 2008) for purebreds. The pooled heritability estimates over generations were lower for purebreds (0.255±0.054) than the crossbreds (0.324±0.090). Singh (2001) and Ravikumar (2003) reported heritability of part year egg production ranging from 0.02±0.17 to 0.35±0.23 which are in agreement with the present results.

The higher pooled heritability estimates in crossbreds than in the purebreds were reported by Singh (2001). Contrary to the present results, higher heritability estimates in purebreds than in crossbreds have been reported by various workers (Chaudhary et al., 1997). The heritability obtained in the present study as well as reported by earlier workers indicates that egg number is low to moderate heritable and can be improved by following some form of combined selection. The lower heritability estimates are indicative of increased role of various environmental influences. The low magnitude of heritability estimates of EN in purebreds as compared to other traits indicates two possibilities. Firstly, it could be because of the fact that egg production, being a fitness trait, its heritability estimates were low. Secondly, continued selection for egg production practiced during the last two decades could have been responsible for a gradual reduction in the genetic variation in this trait.

Heritability estimates for EW were higher in crossbreds than purebreds suggesting that this stock had more additive genetic variance for further utilization through selection. The heritability estimates were 0.286±0.060 and 0.369±0.061 in purebreds and crossbreds respectively. The estimates obtained by Besbes and Gibson (1999) were higher than those observed in the present study. On the contrary, lower heritability estimates were reported by Chaudhry et al. (1997) both in purebreds and crossbreds. The higher estimates of heritability in crosses than in purebreds have also been reported earlier (Singh, 2001).

The heritability estimates for EM were 0.276±0.058 and 0.408±0.083 in purebreds and crossbreds respectively. These estimates are lower than reported by Thangaraju and Ulaganathan (1990) (0.809±0.183 in Forsgate strain and 0.683±0.166 in Meyer Strain). Medium to high heritability of this trait indicates the possibility of improvement through some form of intra-population selection.

The estimates of heritability for ratio trait (EM/BW_{20}) were also higher in crossbreds than purebreds like other performance traits. The estimates were 0.284±0.060 and 0.365±0.077 in purebreds and crossbreds, respectively. On the contrary, Thangaraju and Ulaganathan (1990) reported higher estimates of heritability for this trait (0.637±0.155 and 0.953±0.209 in Forsgate and Meyer strains, respectively). The present results suggest that this trait can be improved effectively by mass selection.

Heritability estimates of ratio trait (EM/AFE) were estimated as 0.276±0.075 and 0.363±0.076 in purebreds and crossbreds, respectively. These estimates were also higher in crossbreds than purebreds. These results are of low magnitude than those obtained by Thangaraju and Ulaganathan (1990) for purebreds (0.872±0.192 in Forsgate and 0.418±0.122 in Meyer strain).

Based on the present findings, it may be concluded that heritability estimates for BW_{20}, BW_{40} and AFE were moderate to high. The standard errors were small, suggesting that a reasonably high degree of reliance can be placed on these estimates. However, the standard errors were relatively larger in the crossbreds which may be because of small population size as compared to the purebreds. EN is low heritable and to some extent may be influenced by non-additive gene action. Heritability estimates of EM and its ratio traits were moderate indicating that some form of family selection may be effective for their improvement.

Heritability estimates of all the traits under study were higher for the crosses than the purebreds suggesting the buffering qualities of the heterozygous genotypes in relation to a changing environment. Also the additive genetic variation observed among crossbred progenies may contain

Table 3. Heritabilities (±SE) of performance traits of purebreds and crossbreds estimated from sire component of variances

Traits	Purebreds	Crossbreds
BW20	0.391±0.043	0.418±0.034
BW40	0.352±0.054	0.444±0.089
AFE	0.427±0.099	0.565±0.106
EN	0.255±0.054	0.324±0.090
EW	0.286±0.060	0.369±0.061
EM	0.276±0.058	0.408±0.083
EM/BW20	0.284±0.060	0.365±0.077
EM/AFE	0.276±0.075	0.363±0.076

Table 4. Genetic correlations along with standard error among performance traits of purebreds estimated from sire component of variances and covariances

Traits	BW40	AFE	EN	EW	EM	EM/BW20	EM/AFE
BW20	0.522±0.206	0.048±0.248	0.020±0.295	–0.158±0.245	–0.161±0.284	–0.354±0.294	–0.140±0.261
BW40	–0.550±0.194	0.346±0.243	0.004±0.248	0.320±0.236	0.197±0.247	0.408±0.205	
AFE	–0.866±0.173	0.039±0.206	–0.883±0.161	–0.855±0.158	–0.945±0.135		
EN	–0.237±0.160	0.969±0.015	0.917±0.038	0.963±0.022			
EW	0.008±0.241	0.132±0.240	0.015±0.221				
EM	0.980±0.011	0.988±0.010					
EM/BW20	0.967±0.019						

Table 5. Genetic correlations along with standard error among performance traits of crossbreds estimated from sire component of variances and covariances

Traits	BW40	AFE	EN	EW	EM	EM/BW20	EM/AFE
	0.506±0.134	0.105±0.180	0.213±0.176	0.012±0.190	0.236±0.175	0.023±0.186	0.179±0.180
BW40		–0.487±0.126	0.095±0.157	0.466±0.131	0.199±0.153	0.068±0.160	0.375±0.139
AFE			–0.205±0.151	0.440±0.137	–0.128±0.155	–0.128±0.156	–0.255±0.152
EN				–0.439±0.141	0.975±0.008	0.960±0.014	0.871±0.038
EW					0.233±0.157	0.266±0.156	0.064±0.166
EM						0.975±0.009	0.925±0.023
EM/BW20							0.903±0.031

Table 6. Phenotypic correlation along with standard error among performance traits of purebreds

Traits	BW40	AFE	EN	EW	EM	EM/BW20	EM/AFE
	0.648**±0.009	–0.119**±0.011	0.115**±0.008	0.028±0.012	0.093*±0.07	0.254**±0.00	80.027±0.009
BW40		–0.233***±0.012	0.024±0.011	0.162**±0.011	0.057±0.008	–0.118**±0.00	70.106±0.009
AFE			–0.434**±0.010	0.055±0.009	–0.450**±0.008	–0.419**±0.008	–0.656**±0.009
EN				–0.443**±0.011	0.973**±0.012	0.935**±0.008	0.943**±0.007
EW					0.232**±0.011	0.224**±0.011	0.231**±0.012
EM						0.962**±0.018	0.965**±0.019
EM/BW20							0.925**±0.015

* = P±0.05, ** = P±0.01

both the additive genetic variation found in the purebred lines plus the purebred's non-additive genetic variation which is seen as additive genetic variation in the crossbred. From the results it may also be inferred that non-additive genetic variation existed for various components of egg laying productive traits. This type of genetic variation may be exploited through some sort of crossbred selection schemes.

Genetic and phenotypic correlations : Genetic and phenotypic correlations among various traits in the present investigation were estimated by sire component of variance and covariances and are presented in Tables 4 to 7 respectively.

Correlation of body weight with other traits : Genetic correlation of BW_{20} was found to be negative with EW, EM, EM/ BW_{20} and EM/AFE in purebreds while positive with all other traits in both purebreds and crossbreds. The phenotypic correlation between BW_{20} and AFE were highly significant and negative but low in magnitude both in purebreds and crossbreds. Kumar (2001) also reported negative genetic correlation between BW_{20} and EW while several authors reported in reverse direction. Negative genetic association of BW_{20} with AFE and EN and phenotypic correlations between BW_{20} and AFE were also reported to be negative and low both in purebreds and crossbreds (Singh, 2001). Genetic and phenotypic correlations between BW_{40} and AFE were observed to be negative both in purebreds and crossbreds. On an average, magnitudes of genetic correlation between these traits were low in

Table 7. Phenotypic correlation along with standard error among performance traits of crossbreds

Traits	BW40	AFE	EN	EW	EM	EM/BW20	EM/AFE
	0.685**±0.008	–0.212**±0.011	0.188**±0.009	0.050±0.011	0.111*±0.008	0.244**±0.007	0.129**±0.008
BW40		–0.264**±0.012	0.068±0.009	0.252**±0.011	0.148**±0.009	–0.109*±0.008	0.209**±0.007
AFE			–0.101*±0.008	0.142**±0.009	–0.136**±0.011	–0.091*±0.008	–0.417**±0.009
EN				–0.224**±0.009	0.949**±0.017	0.894**±0.015	0.898**±0.011
EW					0.086±0.007	0.060±0.008	0.116**±0.007
EM						0.933**±0.018	0.954**±0.017
EM/BW20							0.881**±0.016

* = P±0.05 ** = P±0.01

crossbreds compared to purebreds. The results indicated that pullets with higher BW attained sexual maturity earlier, confirming the fact that optimum BW is also important in layer flocks too.

Genetic and phenotypic correlations of BW_{20} and BW_{40} with EN were found to be positive both in purebreds and crossbreds. Yahaya *et al.* (2009) also reported positive genetic association between BW_{20} and EN. On the basis of the present findings and reports available in the literature, it may be concluded that pullets which attain more weight before sexual maturity produce more eggs but more body weight during laying is not desirable as heavy birds are likely to produce less number of eggs.

The genetic correlation between BW_{20} and EW was negative in purebreds but positive in crossbreds but of low magnitude. However, phenotypic correlations of BW_{20} and BW_{40} with EW were positive in purebreds as well as in crossbreds. From these results, it may be concluded that heavier birds are likely to lay large sized eggs.

Correlation of age at first egg with other traits : The genetic and phenotypic correlations between AFE and EN were found to be negative for both purebreds (-0.866±0.173 and -0.434±0.010) and crossbreds (-0.205±0.151 and -0.101±0.008). Most of the phenotypic correlations of AFE with other traits were highly significant (P±0.01) both in purebreds and crossbreds. Similar estimates between these traits have also reported by Singh (2001), Khalil *et al* (2004) and Anees *et al* (2010). Contrary to the present findings, Singh (1994) reported positive genetic correlation between these traits. From present results it may be inferred that direct selection for high EN may lower down the age at sexual maturity concomitantly. The negative genotypic and phenotypic correlation among these traits indicated that early maturing pullets laid more eggs upto 40 weeks of age. Hence, strong negative association between these traits will be beneficial to the breeder as long as there is no adverse impact on egg weight.

The genetic and phenotypic correlation between AFE and EW were positive in both purebreds (0.039±0.206 and 0.055±0.009) and crossbreds (0.440±0.137 and 0.142±0.009). Chatterjee *et al.* (2000) reported low correlation between AFE and EW. However, negative associations between these traits were reported by Singh (2001) and Shad *et al* (2007).

The genetic as well as phenotypic correlations of AFE with EM, EM/ BW_{20} and EM/AFE were found to be negative in both purebreds and crossbreds. The estimates of correlation of AFE with other traits were higher in purebreds than in crossbreds.

Correlation of egg number with other traits : Negative genetic and phenotypic correlations between EN and EW in both purebreds (-0.237±0.160 and -0.443±0.111) and crossbreds (-0.439±0.141 and -0.224±0.009) were observed. Present results are in agreement with the findings of earlier workers (Singh, 2001; Chatterjee *et al*., 2008 and Yahaya *et al*, 2009). On the contrary, Kumar *et al*. (2001) reported positive genetic correlation between these traits. Magnitude of genetic correlation between these traits was higher in crossbreds than in purebreds. From the present results, it may be concluded that high laying pullets will produce comparatively small sized eggs and therefore, to improve simultaneously both the traits, some specialized selection programs should be practiced.

EN was highly positively correlated with EM, EM/ BW_{20} and EM/AFE, both at genetic and phenotypic levels in purebreds as well as in crossbreds.

Correlation of egg weight with other traits : Positive but low genetic and phenotypic correlation between EW and EM were observed both in purebreds and crossbreds. Similar trend was observed for the correlation between EW and EM/ BW_{20} and EM/AFE in both purebreds and crossbreds. The magnitude of genetic correlation was higher in crossbreds than the purebreds. Standard errors of genetic correlations were large indicating that estimates are extremely variable, possibly due to inadequate population sizes. Thangaraju and Ulaganathan (1990) reported negative genetic correlations of EW with EM and EM/AFE in Forsgate strain but their results of Meyer strain were similar to the present findings.

Correlation among egg mass, ratio of egg mass to body weight at 20 weeks and ratio of egg mass to age at first egg : Positive high genetic and phenotypic correlations were observed among these three traits both in purebreds and crossbreds. These results are in conformity with those reported by Thangaraju and Ulaganathan (1990).

Genetic correlations of body weights with AFE and EW were negative in purebreds but positive between BWs and EW in crossbreds. Genetic correlation between AFE and EN was negative both in purebreds and crossbreds. Genetically AFE was positively associated with EW, but negatively with EM and both ratio traits in purebreds and crossbreds. Positive but low genetic correlation of EW with EM and both ratio traits was observed both in purebreds and crossbreds. Phenotypic correlations of BWs with AFE were negative and highly significant both in purebreds and crossbreds. Positive and highly significant correlation of BW_{40} with EW was also observed. Phenotypic correlations of AFE with EN, EM and both ratio traits were negative and highly significant both in purebreds and crossbreds. Negative and highly significant phenotypic correlation was found between EN and EW both in purebreds and crossbreds. High positive correlation between EN and EM suggested that selection for EM may bring about concomitant increase both in EN and EW unlike selection for EN alone causing a decrease in EW as correlated response. Most of the correlations among all the traits under study were highly significant (P±0.01) both in purebreds and crossbreds.

REFERENCES

Anee C, Veeramani P,Narayanankutty K, Jacob BA and Riyas MA. 2010.Estimation of genetic and phenotypic parameters of economic traits in White Leghorns. *Indian J.Poult. Sci.* 45(1):14-17

Besbes B and Gibson JP. 1999.Genetic variation of egg production traits in purebred and crossbred laying hens. *Anim.Sci.* 68 (2):433-439

Brah GS, Chaudhary ML and Sandhu JS. 2002. Inheritance of changes in body weights over the laying cycle and their interrelationship with economic traits in White Leghorn. *Indian J. Poult. Sci*. 30 (3):215-220

Chatterjee RN, Mishra BS and Singh HN. 2000. Time trends in estimates of genetic parameters in White Leg horn population subjected to long-term selection. *Indian J.Ani. Sci*. 70(1):184-187

Chatterjee RN, Niranjan M and Panda AK. 2008. Inheritance of important economic traits in 3 pure lines and a control population of white leg horn. *Indian J.Ani. Sci*. 78(1):177-182

Chaudhary ML, Brah GS and Sandhu JS. 1997. Genetic inferences from comparison of pure and crossline White Leghorn. *Indian J. Poult. Sci*. 32 (3):28-32

Harvey WR. 1987. Mixed model least squares and maximum likelihood computer program. PC-1 Version

Khalil MK, Al-Homidan A H and Hermes I H. 2004. Crossbreeding components in age at first egg and egg production for crossing Saudi chickens with White Leghorn. *Livestock Research for Rural Development* 16(5):111-114

Kumar D, Singh CV and Singh RV. 2001. Estimation of genetic parameters and construction of multitrait selection indices using various economic traits in broilers.*Indian J.Poult.Sci*. 36:178-182

Momoh OM, Ani AO and Ugwuowo LC. 2010. Part-period egg production and egg quality characteristics of two ecotypes of Nigerian Local Chickens and their F_1 crosses. *International J. of Poul. Sci.* 9 (8): 744-748

Pirchner F. 1976. Genetic correlations between purebred and crossbred performance in poultry. *Anim. Breed. Abstr*.45 :420

Ravi Kumar K, Mishra SC, Mishra PK and Dehuri PK. 2003. Evaluation of response to combined selection for part year egg production to 280 days of age in layers.*Indian J.Poult. Sci*. 38.:6-12

Sakunthala Devi K. 2001. Prediction of annual egg production on the basis of part record egg production and other economic traits in White leghorn. *Indian J.Poult.Sci*.36:163-168

Shad AG, Jawaremi AN and Yeganesh HM. 2007. Animal model estimation of genetic parameters for most important economic traits in Iranian native fowls. *Pakistan J.Biol.Sci.* 10(16) :2787-2789

Singh N.2001.Maximizing genetic response through crossbred selection scheme in egg type chicken.*Ph.D.Thesis,CCSHAU,Hisser*

Singh S.1994. Studies on the optimum testing period for the improvement of annual egg production in egg type chicken. M.V.Sc.Thesis, CCSHAU,Hisar

Thangaraju Pand Ulaganathan V.1990. Simultaneous selection for egg production and egg size in White Leghorn chicken *Indian J.Poult. Sci*. 60.:1355-1359

Yahaya HK, Oni OO, Akpa GN and Adeyinka. 2009.Evaluation of layer type chickens under reciprocal recurrent selection.. *Bayero J. Pure and App. Sci*, 2(1):177 -182