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AIREML estimation of genetic parameters and study of factors affecting growth and fertility performance of sire line of IBL-80 broiler chicken

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ABSTRACT

The present investigation included the data of 29,879 birds pertaining to 8 generations, from 2010 to 2018 on growth line (PB1) of IBL-80 broiler. The mean estimates of growth and fertility traits were BWT0 (39.97±0.05 gms), BWT5 (1189.17±1.45 gms), BWT10 (1723.59±6.26 gms), BWT15 (2165.71±7.90 gms), BWT20 (2611.23±4.10 gms), ADG5 (32.36±0.07 gms/day), ADG10 (13.09±0.14 gms/day), ADG15 (12.38±0.13 gms/day), ADG20 (12.65±0.13 gms/day), AFE (171.80±0.21 days) and ENO40 (62.47±0.25) which indicated higher growth performance of PB1 affected its fertility performance. ADG5 had highest estimate indicating higher growth during chick stage. Least squares analysis indicated that effect of gender, month of hatch and generation were significant ($p<0.01$) for all growth and fertility traits. AIREML heritability estimates indicated appreciable additive variance in BWT0 (0.50), BWT5 (0.54) and ADG5 (0.20). Other growth and fertility traits had lower heritability which was due to stage wise selection in breeder flock. Phenotypic and genetic correlation estimate indicated negative association between growth and fertility traits.

Key words: AIREML, Growth line, Growth and fertility traits.

INTRODUCTION

During the last two decades in the livestock sector the poultry industry has shown maximum growth and improvement because of the high quality chicks developed by different government and private breeder farms. Genetic variation is considered as the primary biological resource that is exploited in poultry breeding programme. The knowledge of genetic and phenotypic parameters like mean, variance and heritability along with genetic and phenotypic correlations of important economic traits is necessary for designing a breeding programme for genetic improvement. According to the socio-economic conditions prevailing in different states, various government institutes of our country have developed broiler, layer and dual purpose poultry varieties. IBL-80 is one such coloured broiler variety which has been released at the Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana. The IBL-80 is a cross of parent lines *viz*. PB1 (growth line) and PB2 (dam Line) which have been selected for more than 45 generations since 1977 and are being maintained at the livestock farm of the institute. Continuous univariate selection leads to loss of genetic variability making the population sensitive to different environmental factors. There is also a need to understand the effect of continuous long term selection for body weight in parent poultry population on different variables. Identification of significant factors would help in taking decisions for mitigation of negative environmental effect thus optimising the performance of breeder birds. The present investigation had the objective of genetic analysis and studying the factors affecting growth and fertility performance of sire line of IBL-80 broiler chicken.

MATERIALS AND METHODS

Data were collected on 29,879 PB1 birds for growth and fertility traits pertaining to 8 generations, from 2010 to 2018 from pedigree records of PB1 (sire line) population maintained at AICRP Ludhiana centre. Regeneration of PB1 population was done every generation on the basis of growth performance till 5 weeks of age. Standard management practices were followed for chick, grower and laying stages of the breeder birds. Stage wise culling in both sexes, was practised for culling of stunted and surplus birds from the population. The birds were fed as per the AICRP schedule with *adlibitum* feeding at chick stage followed by restricted feeding starting from 5 weeks through grower stage and laying stage of the birds. Total stock was vaccinated as per the standard vaccination schedule covering diseases *viz*. Mareks, Ranikhet/New castle disease (F1, R2b and Lasota strains), Gumboro/ Infectious Bursal disease and Fowl pox. Deworming was practised every three months of age for removal of parasitic infestation.

The pedigree data of sire line (PB1) as well as data on growth and fertility performance traits were collected from 2010 to 2018. Data recorded for the study included date of

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hatch, gender, sire number, dam number, day old body weight (BWT0), 5 weeks body weight (BWT5), average daily gain up to 5 weeks (ADG5), 10 weeks body weight (BWT10), 15 weeks body weight (BWT15), age at first egg (AFE), 20 weeks body weight (BWT20) and egg production upto 40 weeks (ENO40).

To identify the effect of non-genetic factors on economic traits the statistical model used for least-squares analysis (Harvey, 1990) was $Y_{ijkl} = \mu + MH_i + S_j + G_k + e_{ijkl}$; where, Y_{ijkl} is the observation of trait of l^{th} individual, μ is the overall population mean; MH_i is the fixed effect of i^{th} month of hatch, S_j is the fixed effect of j^{th} gender of the individual, G^k is the fixed effect of k^{th} generation to which individual belongs and e_{ijkl} is the random residual error. In case of BWT and ADG traits which were generated for one generation the generation effect was not considered. Similarly, gender effect was not considered in case of AFE and ENO40.

Estimation of genetic parameters was carried out by AIREML using WOMBAT software package (Meyer, 2007). The animal model used for (co)variance component estimation by univariate analysis of traits was $Y = Xb + Zw + e$. Where, Y is the observation vector of records, X is the incidence matrix for fixed effects, Z is the incidence matrix for random effect, W = incidence matrix relating records to permanent environmental effects, a = vector of random effect, b = vector for fixed effects and e = vector of random residual effects. The residual effects were assumed to be normally independently distributed with means zero and variance $\sigma^2 e$, respectively. The above animal model was based on the following assumptions involving random and error variances *viz.* Var (a) = $A\sigma^2 a$ and Var(e) = $I\sigma^2 e$.

RESULTS AND DISCUSSION

Descriptive statistics of growth and fertility traits: As regular recording of variables BWT5, BWT20, AFE and ENO40 is carried out under the technical programme of the AICRP poultry breeding project, therefore higher number of observations were available for these traits. Data for BWT0 were collected for two generations and BWT10 and BWT15 for one generation during the period of study.

Body weight: Descriptive statistics were estimated for data on body variables recorded at 0 day, 5^{th} week, 10^{th} week, 15^{th} week and 20^{th} week of age. BWT0 was appreciable and had minimum standard deviation indicating uniformity in quality and weight of eggs used in hatching. The estimates of standard deviation increased for body weight variables recorded at higher ages (Table 1). Higher variation in the weight variables with increasing age can be attributed to changing expression pattern of the genes associated with growth, as well as changing nutrition and management of birds at different age groups. Gaya *et al.* (2006) reported the mean BWT38 and BWT42 to be 2,250.75 and 2,354.44 grams and CV estimates of the traits were 12.90 and 12.18 per cent, respectively in a male broiler line. Adeyinka *et al* (2006) studied the least-squares mean of day old weight, 2, 4, 6 and 8 weeks weight to be 37.20, 210.46, 744.33, 1351.30 and 2428.10 grams, respectively in Naked Neck broiler chickens. Venturini *et al.* (2014) reported BWT42 to be 2224.39 grams in broiler chicken parent line which was evaluated for body weight, feed conversion and carcass traits. The mean values for body weight at 6, 20 and 40 weeks of age were 1190.2±4.1 g, 2125.9±3.7 g and 3086.26±3.8 g, respectively (Mishra *et al.* 2006).

Average daily gain: The average daily gain was estimated for birds from 0 to 5 weeks (ADG5), 6 to 10 weeks (ADG10), 11 to 15 weeks (ADG15) and 16 to 20 weeks (ADG20). ADG5 was highest for the birds upto 5 weeks of age as the broiler birds have the highest growth during this period due to continual selection of the birds for increased body weight upto 5 weeks. ADG10, ADG 15 and ADG20 were similar and appreciably lower than ADG5 indicating decreased growth rate post chick stage of the PB1 bird.

Reproduction traits: AFE and ENO40 were two fertility related traits considered for the present study, the AFE of the broiler female parent averaged around 25 weeks and 40 weeks egg production was also on the lower side. The delayed AFE was the major cause contributing to lower 40 weeks egg production. The PB1 broiler are selected for 5 weeks egg production for a number of generations; which has resulted in lowering the populations fertility rate as heavier birds tend

Table 1: Descriptive statistics of different growth and fertility traits.

Trait	N	Mean	σ	CV%	Skewness	Kurtosis
BWT0	6331	39.97±0.05	3.90	9.75	0.07±0.03	-0.11±0.06
BWT5	29886	1189.17±1.45	250.82	21.10	0.04±0.01	-0.12±0.03
BWT10	2275	1723.59±6.26	298.47	17.32	0.23±0.05	-0.12±0.10
BWT15	1904	2165.71±7.90	344.53	15.91	0.26±0.06	-0.21±0.12
BWT20	12110	2611.23±4.10	450.93	17.27	0.40±0.02	0.10±0.05
ADG5	6287	32.36±0.07	5.91	18.26	-0.18±0.03	0.05±0.06
ADG10	2177	13.09±0.14	6.95	53.10	0.43±0.05	-0.20±0.11
ADG15	1885	12.38±0.13	5.63	45.47	0.62±0.06	1.02±0.11
ADG20	1782	12.65±0.13	5.40	42.68	0.34±0.06	0.18±0.12
AFE	6735	171.80±0.21	16.95	9.87	0.45±0.03	-0.10±0.06
ENO40	5482	62.47±0.25	18.89	30.24	0.55±0.03	0.08±0.07

to produce lesser eggs. The mean performance of females of male broiler line of IBI-91 were for age at sexual maturity and egg number to 280 days of age were 166.20±0.10 days, 67.65±0.20 numbers, respectively (Mishra *et al.* 2006). Padhi *et al.* (2012) studied the reproduction traits in Vanaraja male line and reported the means of ENO40 as 52.80±0.05.

Least squares analysis of factors affecting growth and fertility traits

Body weight: Gender had a highly significant effect on the growth traits; males had higher body weight across all ages which indicated the effect of male hormones responsible for higher growth of males in comparison to females (Tables 2, 3 and 4).

Significant ($p<0.01$) effect of month of hatch was observed for all the body weight variables. Chicks hatched during the month of November were heaviest with respect to BWT0 (40.54 grams) in relation to other months; which can be attributed to favourable egg size and egg weight of the hatching eggs produced during the previous month and cooler ambient temperature leading to improvement of hatching results and production of healthy chicks (Table 2). BWT5 was significantly ($p<0.01$) higher for chicks hatched during November and December (1198.19 grams and 1205.37 grams, respectively) which might be due to better feed consumption and utilization for growth and maintenance of body temperature during these months in response to low atmospheric temperature of winter months (Table 3).Chicks hatched during October had the higher BWT10 (1991.02 grams), BWT15 (2406.21 grams) and BWT20 (2711.87 grams) in comparison to other months (November, December and January) indicating that growth of broiler bird at grower stages were favourable in case of an October hatch. The estimate of BWT10, BWT15 and BWT20 were significantly ($p<0.01$) lower during other months (Tables 3 and 4).

Effect of generation was significant ($p<0.01$) for BWT0, BWT5 and BWT20 traits. Among the two generations (2016-17 and 2017-18) of data collected for BWT0, the mean weight of chicks of 2017-18 generation were significantly ($p<0.01$) higher in weight (40.55 grams) in comparison to their previous generation (39.16 grams). BWT5 and BWT20 showed inconsistent trend across generations which indicated significant variations ($p<0.01$) in management across years. However, both the traits showed improvement in later generations (Tables 2 and 3).

Average daily gain: Gender had a significant ($p<0.01$) effect on all average daily gain traits (ADG5, ADG10, ADG15 and ADG20). Average daily gain was significantly higher in males at all stages in comparison to females indicating the effect of growth promoting male hormones which are absent in females. Chicks hatched during December had significantly higher ($p<0.01$) and more uniform average daily gain across all ages (Table 5). ADG10 was significantly higher ($p<0.01$) for the chicks which hatched during December (13.95 grams) in comparison to chicks which hatched during October and November (12.03 and 10.11 grams, respectively). The growth of the poultry bird peaks around 3 to 4 weeks of age, therefore having the peak during winter might be the probable reason for higher ADG10 of October hatch. In comparison to ADG15 the ADG20 was found to be higher in gender wise as well as month wise analysis, which indicates the effect of hormones associated with puberty cause the increase of body weight of the birds towards puberty through growth in size of body tissues associated with reproduction.

Table 2: Least squares analysis of factors affecting body weight traits.

Factor	Subclass	N	BWT0
Gender	Male	2641	39.96±0.08a
	Female	3690	39.75±0.06b
Month of Hatch	Oct	2069	39.31±0.09a
	Nov	2670	40.54±0.07b
	Dec	1592	39.72±0.11b
Generation	16-17	2918	39.16±0.08a
	17-18	3413	40.55±0.07b

Table 3: Least squares analysis of factors affecting body weight traits.

Factor	Subclass	N	BWT5	N	BWT20
Gender	Male	13615	1280.33±2.16b	3449	2992.69±8.41b
	Female	16264	1112.84±1.75a	8660	2450.21±3.89a
Month of Hatch	Oct	3533	1156.77±3.32b	1219	2711.87±12.69d
	Nov	9477	1198.19±2.80c	3569	2504.99±7.73a
	Dec	12855	1205.37±2.19c	5815	2645.61±6.52c
	Jan	4014	1144.46±3.76a	1506	2602.59±9.43b
Generation	10-11	2770	1226.41±4.43e	1631	2426.42±13.09a
	11-12	4014	1144.46±3.76c	1506	2602.59±9.43de
	12-13	4732	1306.92±3.75g	1552	2550.46±13.43bc
	13-14	3559	1059.31±4.12a	1087	2640.79±13.99e
	14-15	5221	1270.19±3.54f	2100	2713.04±9.23f
	15-16	3276	1090.42±3.64b	1234	2822.19±13.55g
	16-17	2895	1134.68±3.68c	1131	2510.19±11.46b
	17-18	3412	1200.70±3.74d	1868	2591.57±10.53cd

Table 4: Least squares analysis of factors affecting body weight traits.

Factor	Subclass	N	BWT10	N	BWT15
Gender	Male	922	1920.35±8.72b	793	2405.49±10.48b
	Female	1340	1681.35±7.33a	1110	2070.43±8.96a
Month of Hatch	Oct	321	1991.02±13.94c	290	2406.21±16.47c
	Nov	972	1633.45±8.02a	794	2060.73±9.94a
	Dec	969	1778.09±8.05b	819	2246.95±9.86b

Table 5: Least squares analysis of factors affecting average daily gain traits.

Factor	Subclass	N	ADG5	N	ADG10	N	ADG15	N	ADG20
Gender	Male	2612	34.88±0.11b	876	16.48±0.21b	768	13.39±0.19b	689	14.41±0.23b
	Female	3668	30.61±0.09a	1294	13.59±0.17a	1097	11.16±0.16a	1093	12.18±0.17a
Month of Hatch	Oct	2056	31.99±0.12a	315	12.03±0.33c	287	11.94±0.31a	208	14.50±0.38b
	Nov	2654	33.02±0.11b	918	10.11±0.19a	780	11.92±0.18a	776	12.39±0.19a
	Dec	1570	33.21±0.14c	937	13.95±0.15b	798	12.98±0.18b	798	12.98±0.19a

Table 6: Least squares analysis of factors affecting fertility traits.

Factor	Subclass	N	AFE	N	EGG 40
Month of Hatch	Oct	920	178.77±0.57c	696	56.49±0.80b
	Nov	2086	173.72±0.37b	1671	57.37±0.53b
	Dec	3350	173.41±0.29b	2298	44.97±0.42a
	Jan	838	158.42±0.59a	827	69.38±0.79c
Generation	10-11	876	182.59±0.61f	780	59.07±0.71c
	11-12	838	158.42±0.44a	827	69.37±0.70d
	12-13	774	166.20±0.44b	621	67.83±0.78d
	13-14	624	179.87±0.63e	411	56.27±0.88c
	14-15	1140	169.53±0.57c	434	24.74±0.64a
	15-16	878	174.56±0.68d	695	49.84±0.73b
	16-17	1033	181.03±0.40ef	842	48.49±0.67b
	17-18	1031	168.23±0.52bc	872	58.51±0.67c

Fertility traits: Birds hatched during January had the lowest AFE (158.42 days) and highest ENO40 (69.38), favourable light intensity during grower phase allowed early sexual maturity resulting in higher egg numbers of the birds. AFE was highest for chicks hatched during October month (178.77 days) followed by those hatched in November (173.72 days) and December months (173.41 days) as grower phase of these hatches was during winter months having cold foggy weather with decreased light intensity delaying sexual maturity and reducing egg number (Table 6).

Significant effect ($p<0.01$) of generation was observed on AFE and ENO40 traits. Regression analysis of AFE and ENO40 least squares means against time (generation) revealed positive regression coefficient for AFE (0.32 days/generation) and negative (-2.30 eggs/generation) for ENO40 indicating that selection for increase body weight and changing environment across years had resulted in decline in reproduction performance of growth line (Table 6).

The significant effect of month of hatch on AFE and BWT40 traits were reported by Shivakumar *et al.* (2011) and Das *et al.* (2016). Significant effect of hatch on BWT2, 4, 6 and 8 weeks was reported by Adeyinka *et al.* (2006). Gaya *et al.* (2006) and Venturini *et al.* (2014) reported significant effect of hatch and gender on body weight variables in their study. Effect of generation on body weight variables has been found to be significant in a study where data on four generation were analysed (Larivière *et al.* 2009). Oleforuh-Okoleh (2011) analysed data of generations and reported the significant effect of generation on growth and fertility performance of Nigerian local chicken. Shim *et al.* (2012) studied the effect of gender on growth in contemporary commercial cross broilers and reported significant effect of the factor. Firozjah *et al.* (2015) reported the significant effect of generation and gender on body weight and egg production traits in Mazandaran native chickens of Iran, they used data of 20 generations for analysis. Hanusova *et al.* (2017) observed significant effect of gender on BWT5 and BWT12 in native Oravka chicken breed.

Heritability estimates: AIREML heritability estimates were high for BWT0 (0.50) and BWT5 (0.54). Estimates were found to decrease with advancing age i.e. 0.10, 0.07 and 0.03 for BWT10, BWT15 and BWT20, respectively. Similar observation was observed in average daily gain traits with highest variation observed in ADG5 (0.20) and the estimates of heritability were very low (less than 5 per cent) for ADG10, ADG15 and ADG20. Estimates of heritability for both the fertility traits AFE and ENO40 were negligible (0.005), fertility traits are known to be affected less by additive gene

Table 7: AIREML heritability estimates of growth and reproduction traits.

Trait	N	Heritability Estimate
BWT0	6314	0.50±0.03
BWT5	29879	0.54±0.02
BWT10	2262	0.10±0.03
BWT15	1903	0.07±0.03
BWT20	12109	0.03±0.02
ADG5	6280	0.20±0.03
ADG10	2170	0.05±0.03
ADG15	1864	0.002±0.018
ADG20	1781	0.04±0.02
AFE	5465	0.005±0.003
ENO40	5465	0.005±0.003

Figures in parenthesis indicate number of observations

action (Table 7). As per the broiler breeding programme stage wise disposal due to poor performance with respect to BWT5 and natural selection reduced overall variability in the grower and adult flock; which affected the overall variability of the later expressed traits thus resulting in lower additive genetic variance.

Gaya *et al.* (2006) used the MTDFREML for heritability estimation and reported the BWT38 and BWT42 to be 0.40±0.02 and 0.24±0.03, respectively. Maximum likelihood estimation indicated moderate heritability for body weight traits *viz.* BWT0, 2, 4, 6 and 8 weeks were 0.32, 0.22, 0.31, 0.24 and 0.20, respectively in naked neck broilers (Adeyinka *et al.* 2006). Venturini *et al.* (2014) used WOMBAT tool for heritability estimation in broiler chicken and observed the BWT42 to be 0.41±0.08. Larivière *et al.* (2009) estimated the BWT11 heritability in Ardennaise chicken breed in Belgium and observed moderate heritability of 0.11 and positive response in selection for body weight in four generations. Sang *et al.* (2006) reported moderate heritability estimates (around 0.40) for body weight traits and 0.24 for AFE in Korean native chicken. Positive genetic correlation, ranging from (0.31 to 0.34), between AFE and BWT traits were observed and the phenotypic correlation estimates between these traits were low and negative (-0.03 to 0.09). Mishra *et al.* (2006) estimated heritability using Paternal half sib method and reported the estimates as 0.135±0.08 for 6 week body weight, 0.074±0.07 for 20 week body weight, 0.002±0.05 for 40 week body weight, 0.139±0.08 for age at sexual maturity and 0.093±0.07 for egg number to 280 days of age. Padhi and Chatterjee (2012) reported the maximum likelihood heritability estimates for body weight at 6 weeks to be low in magnitude, body weight at 40 weeks had high estimate (0.62) and low estimates were observed for AFE (0.01) and ENO40 (0.10). In Vanaraja male line the LSML heritability were estimated to be low (0.01 to 0.10) for traits *viz.* BWT2, BWT4 and BWT6 (Padhi *et al.* 2015). Pertile *et al.* (2014) used ASREML analysis for heritability estimation and observed heritability of body weight traits at 1st week, 4th and 5th weeks of age to be high, ranging from 0.44 to 0.64. Das *et al.* (2016) reported low heritability for reproduction traits AFE (0.01) and ENO40 (0.05) in Rhode Island Red poultry using LSML estimation method.

Phenotypic and genetic correlation estimates: High positive genetic correlation (0.69) was observed between growth traits BWT5 and BWT20. Similarly genetic correlation (0.80) between AFE and ENO40 was high; such estimates of genetic correlation indicated that these traits were governed by same type of genes. Estimates of genetic correlation between growth traits and fertility traits were high negative, indicating selection for increased body weight in broiler line decreased its performance in reproduction traits. Phenotypic correlation (0.17) between BWT5 and BWT20 was positive and estimates of AFE and ENO40 with BWT5 and BWT20 were low. Estimates indicated birds having higher BWT20 reached weight of sexual maturity and therefore egg production at an earlier age. Strong negative phenotypic correlation (-0.35) between AFE and ENO40, indicated increased AFE would decrease egg production of the flock. All estimates of phenotypic correlation indicated greater degree of negative environmental covariance between the traits (Table 8).

High genetic correlation between body weight traits (BWT38 and BWT42) has been reported by various workers (Rance *et al.* 2002 and Gaya *et al.* 2006). Negative genetic correlation was observed between weight at 0 day and all other body weight traits; however similar to the present study, correlation estimates were positive between the body weight traits (Adeyinka *et al.* 2006). Positive genetic correlation, ranging from (0.31 to 0.34), between AFE and BWT traits were observed and the phenotypic correlation estimates between these traits were low and negative (-0.03 to 0.09) (Sang *et al.* 2006). Mishra *et al.* (2006) observed positive and high genetic and phenotypic correlationsamong body

Table 8: Phenotypic and genetic correlation estimates of growth and reproduction traits on pooled data.

Trait	N	BWT5	BW20	AFE	ENO40
BWT5	5440	1	0.69±0.15	-0.54±0.25	-0.94±0.99
BWT20		0.17±0.01	1	-0.98±0.31	-0.89±0.08
AFE		-0.05±0.01	-0.30±0.01	1	0.80±0.02
ENO40		0.02±0.01	0.11±0.01	-0.35±0.01	1

*Figures above diagonal are genetic correlation and below diagonalarephenotypiccorrelation estimates.

weight at differentages; egg number at 40 weeks had negative correlation with body weight at all age.Genetic correlations of BWT20 with AFE and ENO40 were negative -0.14 and -0.18, respectively and the estimates of phenotypic correlation were 0.24 and 0.05, respectively (Padhi and Chatterjee, 2012). In a study on Vanaraja male line the genetic and phenotypic correlation estimates between BWT2, BWT4 and BWT6 were positive and high (Padhi *et al*. 2015). Similarly, the estimates between body weight traits measured at 1st week, 4th and 5th weeks were positive and ranged from 0.44 to 0.64 (Pertile *et al.*, 2014). Negative genetic (-0.28) and phenotypic (-0.18) correlation estimates have been observed between body weight at first egg and total egg production (Oleforuh-Okoleh *et al*. 2011).

CONCLUSION

All the factors had significant effect on the performance traits indicating for optimum phenotypic expression of growth and fertility traits, timely hatching should be attempted to allow optimum expression all traits. Stage wise culling practised to maintain the population size had an effect on depletion of additive variance for the traits expressed at later stages of life. The study revealed that due to continuous selection on body weight traits the performance of growth line females had declined in fertility traits due to negative association between the growth and fertility traits. There is a need for developing a selection strategy giving importance to fertility traits in addition to growth performance of the individual of sire line.

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