Eth. J. Anim. Prod. 5(1)- 2005: 1-12

Estimates of Crossbreeding Parameters for Egg Laying Performance of Crossbreed Chickens at Debre Zeit, Ethiopia

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Abstract

Crossbreeding parameters were estimated for egg production performance of indigenous Ethiopian and White Leghorn chicken and their crosses at Debre Zeit Agricultural Research Centre, Ethiopia. The GLM procedure of SAS (1997) was used to estimate the contribution of additive genetic and heterotic effects in the crossbreds. Results obtained on average monthly egg production indicate that individual breed additive and heterotic effects were large and significant. Breed additive effects of 5, 13, 14 and 13 eggs/chicken, and individual heterotic effects of 5, 6, 4 and 3 eggs/chicken were obtained for the first three, four to six, seven to nine and ten to twelve months of laying periods, respectively. For total egg production breed additive effects of 24, 73, 118 and 118, and individual heterotic effects of 12, 23, 46 and 45 eggs/chicken were obtained for the first three, six, nine and twelve months of laying periods, respectively. Breed additive effect for average daily egg production was estimated to be 0.44 for both first six and twelve months of laying periods and individual heterotic effect of 0.19 eggs for the first 6 months and 0.12 eggs/chickens for the first 12 months of laying periods. Maternal breed additive and heterotic effects were not significant in all cases. In general egg production performance of the crossbred chickens was largely determined by breed additive genetic effect and the contribution of the heterotic effects was small.

Keyword*:* Crossbreeding, Chicken, additive effects, heterotic effects, egg production, Ethiopia.

Introduction

Poultry production in Ethiopia shows a clear distinction between traditional, low input systems and modern, more intensive systems with a relatively improved housing, feeding, breeding, marketing and processing

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(Alemu, 1995). The traditional system of poultry production, which has come to be known as "balanced farming", is characterised by its low input and a corresponding low output (Tadelle *et al.,* 2000). In Ethiopia, the egg laying performance of indigenous chickens is reported to be low under farmers' management conditions. (Bigbee, 1965; MOA, 1980; and Kidane, 1980). However, under improved conditions, a maximum of 100 eggs per chicken per year has been reported (Teketel, 1986, Abebe, 1992 and Negussie, 1999). The major constraints that limit poultry productivity are diseases, poor feeding and management practices, and the low genetic potential of indigenous chicken (Alemu and Tadelle, 1997 and Tadelle *et al.,* 2000).

One way of improving the productivity of indigenous chickens for egg production is through crossbreeding with exotic chickens that are known for higher egg production. Such crossbreeding has widely been used as method to combine the high egg production of exotic breeds with the adaptability of indigenous breeds. Apart from the additive contribution of each breed to meet those requirements, there are also large non additive heterotic effects in egg yield and fertility traits which combine to result in high total productivity of the first generation (F_1) of these crosses (Cunningham and Syrstad, 1987). In study of genetic effect on egg production in diallel mating system of six white Leghorn strains, a marked increase in genetic variance and heterotic effect with environmental variance were observed (Laris-Erik Liljedahal (1994)

Earlier reports on the performance of crossbred chickens for egg production traits showed that crossing with 62.5% indigenous-White Leghorn proportions were found to be superior to other crossbreds (25% and 50% crosses), (DZARC, 1991; Joseph, 1995 and Mekonnen, 1998.) However, information on additive genetic and heterotic effects is lacking.

The objective of this paper was therefore, to estimate the individual and maternal additive genetic and heterotic effects for egg production traits in crossbred chickens and to predict the performance of different breed groups using estimated crossbreeding parameters.

Materials and Methods

Study area

Data used for the present study was obtained from a crossbreeding experiment conducted on indigenous Ethiopian Chickens with White Leghorn breed at Debre Zeit Agricultural Research Centre (DZARC), in central highlands of Ethiopia. The centre is located about 45 km Southeast of Addis Ababa at an altitude of about 1900 meters above see level, with an annual rainfall of 849 mm. The daily mean temperature ranges from 9 to 27 ^{0}C with an overall mean of 19.1^{0}C.

Experimental flock and breeding program

About 2000 day old White Leghorn chicks were purchased from state owned commercial poultry firm in Addis Ababa in 1992. At the same time about 150 indigenous Ethiopian Chickens were bought from Cheffe Donsa market (Central highland of Ethiopia). These were housed in deep litter system of housing and in each house they were provided with waterer and feeder. The study flock was fed on recommended starter, grower and layer rations, and both fed and water was offered *ad libtum*.

In the mating system practised in the centre, the White Leghorn males were mated with indigenous female and indigenous male with Leghorn female to produce F_1 female chickens. The reciprocal produced F_1 female chickens were mated to either pure WLH or indigenous cocks to produce 3/4 WLH and 1/4 WLH crosses, respectively. The 5/8 WLH crosses were produced by either mating 1/4 WLH females to pure White Leghorn males or by mating 3/4 WLH females to F1 males. The 5/8 WLH and 3/8 indigenous were also mated to produce the 50% White Leghorn crosses. The reciprocal crosses were produced to test the difference in performance between reciprocal crosses and indigenous chicken Data was recorded on group basis because there was no egg collection nest for individual chicken at the time of the experiment.

Data analysis

A total of 453 records from 2443 chickens were used to estimate individual and maternal additive genetic and heterotic effects on egg production traits. The General Linear Model (GLM) of SAS (1997) was used for data analysis. Chickens of different breed groups were hatched over five years (1992-1996) and two seasons. For evaluation of the effect of seasons on egg production traits, the months of the year were grouped into two seasons: dry season covering the first part of dry season from October to December and second part of dry season from January to February. The main rainy season is from June to September and the short rainy season falls between March and April.

Some of experimental groups (batches and genotypes) had their production recorded only during the first few months of laying while others had for 12 months. Thus, the number of observations after 6 months of laying period was much smaller. To include as many breed groups and batches within breed groups as possible in the analysis, the egg laying performance over the first three, six, nine and twelve months of laying periods was considered to estimate crossbreeding parameters.

The coefficients of expected breed content and heterozygosity in birds were used as covariant to obtain estimates of the individual and maternal additive and heterotic effects using similar procedure to those of Robison *et al.,* (1980), Hirooka and Bhutyan (1995), and Kahi *et al.,* (1995). Heterozygosity with respect to genes of two breeds was calculated as the expected proportion of genes from the sire and dam. For example, the expected heterozygosity with respect to local (L) and Leghorn (WLH), H^{I}_{WLH} was calculated as $(G^{s}_{L} * G^{d}_{WLH}) + (G^{s}_{WLH} * G^{d}_{L})$ where the superscript *s* and *d* denote that the genes come from the sire and dam, respectively. Similarly expected heterozygosity with respect to two breeds were calculated for the genotype of the dam of individual and were denoted H^{M}_{WLH} as before (Akbas *et al.*, 1993). Thus the model included effects for G^{I}_{WLH}, H^{I}_{WLH}, G^{M}_{WLH}, H^{M}_{WLH} as well as the environmental effects described above except breed groups. The breed groups and coefficients for expected effects of breed content and heterotic are shown in Table 1. It is assumed that the performance of each breed was affected by individual additive genetic effect (G^{I}_{WLH}), the individual heterotic (H^{I}_{WLHL}), maternal additive genetic effect (G^{M}_{WLH}) and the maternal heterotic effect (H^{M}_{WLHL}). The effect of recombination loss was ignored in this study, because available breed group are limited for all traits and these effects cannot be separated. For evaluation of genetic parameters the following statistical model was used:

$$Y_{ijkl} = M + Y_{i} + S_{j} + P_{k} + G^{I}_{WLH}X_{1} + H^{I}X_{2} + G^{M}_{WLH}X_{3} + H^{M}X_{4} + + e_{ijkl}$$

where:

M = intercept (general level of indigenous chickens)

G^{I}_{WLH} = individual genetic effect of White Leghorn as deviation from indigenous chickens.

H^{I}_{WLHL} = individual heterotic effect.

G^{M}_{WLH} = maternal additive genetic effect of White Leghorn as deviation from indigenous chickens.

H^{M}_{WLHL} = maternal heterotic effect.

X_{1} = proportion of genes from White Leghorn.

X_2 = proportion of maximum individual heterotic.
X_3 = proportion of genes from White Leghorn in dam. X_4 =
proportion of maximum maternal heterotic.
Y_i = year of hatching
S_j = season of hatching.
P_k = year group of hatching e_{ijkl} =
random error

The proportions of White Leghorn genes, individual and maternal heterotic, effect (X_1 to X_4) was considered as continuous variables. For values of X1 to X4 of the different breed groups is presented in Table 1.

Table 1. Breed groups and coefficients for expected effects of breed groups and heterotic effect

Breed group (Sire) * (Dam)	GL	GWL	HI	GML	GMWL	HM
(L) * (L)	1	0	0	1	0	0
(WL) * (L)	0.5	0.5	1	1	0	0
(L) * (WL)	0.5	0.5	1	0	1	0
(WL) (WL*L)	0.25	0.75	0.5	0.5	0.5	1
(L) (WL* L)	0.75	0.25	0.5	0.5	0.5	1
(WL *L) (WL(WL*L)	0.375	0.625	0.5	0.25	0.75	0.5
(WL) (L(WL* L)	0.375	0.625	0.75	0.75	0.25	0.5
((WL *L) (WL(WL*L)} {(WL *L) (WL(WL*L)}	0.375	0.625	0.46875	0.25	0.75	0.5
{(WL) (L(WL* L)} {(WL) (L(WL* L)}	0.375	0.625	0.46875	0.75	0.25	0.75

L=Local; GL= proportion of genes from indigenous chicken; WL= White Leghorn; GWL= Proportion of genes from White Leghorn; HL= Individual heterotic; GM =proportion of genes from dam; HM =Maternal heterotic

Results and Discussion

Average monthly egg production

Estimates of individual and maternal additive genetic and heterotic effects on average monthly egg production of the four laying cycles (1-3, 4-6, 7-9 and 10-12 months) are presented in Table 2. Breed content effects were large and showed significant ($p < 0.01$) effect on average monthly egg production in the four laying cycles. Estimates of individual heterotic were positive and significant ($p < 0.01$) for all laying cycles. Maternal additive genetic and heterotic effects were not significant in all laying cycles. The non-significant effect of maternal heterotic may imply that recombination loss is not involved (Ahlborn-Breier and Hohenboken, 1991)

Deviation of individual breed additive effect of the White Leghorn breed from local breed were estimated to be 4.6, 13, 14 and 13 eggs per chicken per month for the first 1-3, 4-6, 7-9 and 10-12 months of laying cycles, respectively. The individual heterotic contributions were estimated to be 5, 6, 4 and 4 eggs per chicken per month the first 1-3, 4-6, 7-9 and 10-12 months of laying cycles, respectively. Heterotic effect increased with age of chickens from the 1-3 months to 4-6 months and declined from 4-6 months to 7-9 months of laying cycle and remained constant then after. The result obtained in this regard is in agreement with Joseph (1995), who reported the importance of individual heterotic and its contribution to the egg production of crosses. The declined heterotic effect at the fourth period is attributed to different factors like age and small sample size. The latter might have affected heterosis expression by excluding some of the chickens that had good production potential. This affected the average value and reduced the variation in egg production between breeds and hence reduced the heterotic expression. Both year and season of hatching had no significant effect on all traits over the four laying periods.

Table 2. Estimates of individual and maternal additive genetic and heterotic effects for average monthly egg production over the four cycles of laying periods.

Parameter	Monthly egg production (numbers)			
	First 3 months	4 to 6 months	7 to 9 months	10 to 12 months
Individual additive effect	4.6 ± 2**	13±2**	14±2**	12±1**
Individual heterotic	5.3 ±2**	6±2**	4±1**	3±1**
Maternal additive effect	2.4 ±1NS	-1±2NS	-2±1NS	-3±1*
Maternal heterotic effect	-2.0 ±1NS	1±2NS	2±1NS	2±1NS

*= $p< 0.05$; **= $p< 0.01$; NS= Not significant

Total egg production

Estimates of individual and maternal additive genetic and heterotic effects on total egg production over the four cycles of laying periods are presented in Table 3. Results obtained indicate that in all cases individual breed additive effects were significant ($p < 0.05$) and increased from the first three months to the first 9 months of laying periods and remain constant then after. It was estimated that the White Leghorn produced 24, 73, 118 and 118 eggs higher than the local chickens, over the first three, six, nine and twelve months of laying periods, respectively, indicating the large potential differences between the two parental breeds.

Individual heterotic effects on total egg production were found to be non-significant for all laying periods and estimated to be 12, 23, 46 and 45 eggs/chicken for the first 3, 6, 9 and 12 months of laying cycle, respectively. The estimated values increased with age from the first 1-3 months to 7-9 months and slightly declined then after. This is in agreement with the work of Lars-Erik Liledahl *et al.,* (1994) who reported the increased heterotic effect with age of chickens in crosses between different Leghorn strains. The decline in heterotic effect at the later period can be explained by the expected decline in egg production performance with age of chickens. Moreover, the sample sizes at later periods were smaller, which might have affected heterotic expression by excluding some of the chickens that had good production potential at earlier periods. This affects the average value and reduces the variation in egg production between breeds and hence reduces the heterotic expression.

The large standard errors obtained in this study for total egg production (Table 3) are attributed to small number of observations. However, when monthly and average daily egg productions were considered, which had more number of observations, the standard error were less than those obtained for total egg production.

Table 3. Estimates of individual and maternal additive genetic and heterotic effects for total egg production/chicken for the first three, six, nine and twelve months of laying periods

Parameter	Total egg production (Numbers)			
	Three months	Six months	Nine months	Twelve months
Individual additive effect	24±14*	72.7±32*	117.53±48.7*	117.5±57*
Individual heterotic	12±12NS	22.6±29NS	45.6±50NS	45±56NS
Maternal additive effect	6±11NS	-4.3±26NS	-14.9±40NS	-41±45NS
Maternal heterotic	-5±11NS	-9.1±28NS	18±49.6NS	-207±55NS

*= p< 0.05; **= p< 0.01; NS= Not significant

Average daily egg production

The estimated individual and maternal additive genetic and heterotic effects for average daily egg production in the first six and twelve months of laying periods are presented in Table 4. Individual breed additive and individual heterotic effects for average daily egg production over the first six and twelve months of egg production were significant ($p < 0.05$) in explaining variation in average daily egg production. The individual additive genetic effects of average daily egg production of White Leghorn breed as deviation from indigenous chickens were similar for the first six as well as 12 months of laying periods and estimated to be 0.44 ±0.01 eggs/chicken. Estimated individual heterotic effects for average daily egg production was 0.19± 0.06 and 0.12 ± 0.04 eggs/hen for the first six and twelve months of egg production, respectively. The decline in individual heterotic with age is in accordance with production curve whereby egg production decreases as chicken get older. Moreover, the decline in number of observations at latter periods might have affected heterotic expression through reducing variation between breeds.

Table 4. Estimates of individual and maternal additive genetic and heterotic effects for average daily egg production in the first six and twelve months of laying periods

	Average daily egg production (Numbers)	
Parameters	6 months	12 months
Individual additive effect	0.44 ±0.01**	0.44 ±0.05**
Individual heterotic	0.19 ±0.01**	0.12± 0.04**
Maternal additive effect	-0.05 ±0.01NS	-0.11 ±0.04NS
Maternal heterotic effect	0.42 ±0.1NS	0.06 ±0.04NS

*= p< 0.05; **= p< 0.01; NS= Not significant

Hen-day and percentage hen-housed egg production

Estimated individual and maternal additive genetic and heterotic effects for hen-day and percentage hen-housed egg production over the first six and twelve months of laying periods are presented in Table 5. Results from regression analysis showed significant (p < 0.05) effects of additive breed difference for hen-day and percentage hen housed egg production over the first six months of laying period. For hen day egg production over the first 12 months breed additive genetic difference was still significant, while there were no significant difference of additive breed difference for percentage hen-housed egg production over the first twelve months of laying period. The heterotic effects were not significant for both hen days and percentage hen housed egg production over the first six and twelve months. The individual additive genetic effect of White Leghorn breed as a deviation from local birds in terms of hen-day egg production were estimated to be 0.57± 0.02 eggs/hen for the first six months and 0.53 ± 0.03 eggs/chicken for the first twelve months of laying periods (Table 5). Individual heterotic effects for hen-day egg production were estimated to be 0.25± 0.01 for the first six months and 0.18 ± 0.01 eggs/hen for the first twelve months of egg production. For percentage hen-housed egg production individual additive genetic effects were estimated to be 38 ± 13 for the first 6 months and 26 ± 13 for the first twelve months of laying periods. Individual heterotic effects were found to be 18 ± 16 for the first 6 months and 16 ±7 for the first twelve months laying periods. Maternal breed additive and heterotic effects were not significant in all cases. Thus, non-significant maternal effect on both traits indicate that recombination losses are not involved. Moreover, in modern poultry production, there is no subsequent connection between progenies and their dam; as a result maternal effect is not important. The large standard error obtained for both traits is attributed to small number of observations as both traits were calculated on the bases of total number of chickens that were presented at the end (hen-day) and start (percentage hen-housed) of laying periods. Both year and seasons of hatching had no significant effect on hen-day and percentage hen-housed egg production.

Table 5. Individual and maternal additive genetic and heterotic effects for Hen day and percentage hen housed egg production over the first 6 and 12 months egg laying periods.

Parameters	Hen-day egg production[1] (Numbers)		Hen-housed egg production[2] (%)	
	First 6 months	First 12 months	First 6 months	First 12 months
Individual additive	0.57 ± 0.02*	0.53 ± 0.03*	38 ±13*	26 ± 13NS
Individual heterotic	0.25± 0.01NS	0.18 ± 0.01NS	18±16	16±7NS
Maternal additive	-0.05±0.02NS	0.03 ±0.02	-5±1	12±1
Maternal heterotic	0.04 ± 0.01NS	0.03 ± 0.1NS	6 ±9	8± 7NS

*= p< 0.05; **= p< 0.01; NS= Not significant

[1] Total number of egg produced divided by the sum total of hen-days, i.e, sum of laying days of all hens.

[2] In the case of percentage hen-housed egg production all the birds that initially started production are considered.

Predicted egg production

The predicted egg production potential of chickens for the first six and 12 months of laying periods with different percentage of White Leghorn blood using estimated genetic parameters from Table 3 and regression coefficients from Table 1 are presented in Table 6. The prediction showed that total egg production in the first 6 months of laying periods increased as the level of White Leghorn inheritance increases up to 50%, decreases from 50 to 75% and increases then after. However, total egg production increases as level of exotic inheritance increases except for slight drops for 62.5% WLH. This prediction is in agreement with 129 eggs per chicken for F1 crosses and 114 eggs per chicken for 3/4 crosses reported by Brannang and pearson (1990) in crossing of indigenous chicken with Yarkon chicken breeds at Assela, Ethiopia. The superiority of the F_1 over the 3/4 crosses is attributed to heterozygosity indicating the importance of heterotic effect in crossbreeding programs.

Table 6. Predicted egg production performance of chickens with different percentage of WLH inheritance

Percentage of WLH inheritance	Predicted total egg production (No)	
	First six months	First 12 months
(Local)	69.9	112
¼ WLH	88.1	107.7
½ WLH	128.8	185.8
5/8 WLH	124.5	155.8
¾ WLH	124.4	166.4
7/8 WLH	131.3	177.5
15/16 WLH	134.8	183.0
WLH	138.2	188.5

Conclusion and Recommendations

Based on the results obtained in this study, egg production performance of crossbred of White Leghorn with indigenous chickens is mainly determined by additive genetic effects and to lesser extent by individual heterotic effects. The non-significant effects of individual heterotic for total egg production, hen-days and percentage hen-housed egg production are attributed to large standard errors and small number of observations as these traits were analysed on total number of eggs, but when the number of observations increased by considering monthly egg production and average daily egg production this non-significant effect disappeared indicating the importance of heterotic effect on egg production.

In general it can be concluded that from this on-station study the opportunity exists for up-grading to higher exotic blood level if optimal feeding and routine management are provided. However, under rural low input system crossbreeding around 50% White Leghorn inheritance seems optimal for smallholder farmers as they can cope up with available feed resource and management conditions. In this regard the decline in heterotic effect after first crosses can be minimised through development and use of new breed or synthetic breeds.

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