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Genetic Analyses of Generation Means for a Cross between two Local Breeds of Chickens: II-Comparisons between F3 and Backcrosses for Egg Production Traits

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Abstract - Comparisons between F3 and Backcross combinations derived from Gimmizah x Bandarah cross were used to estimate additive and dominance effects and the average level of dominance, which control the inheritance of egg production traits. Genetic variance components were estimated using Designs II and III. Both analysis determined that large positive additive genetic variations were found for age at sexual maturity 20.4, egg number at the first 90 d. of production 149.8 and egg number at 52 weeks of age 848.7 in backcross generations compared with the same traits in F3 generation (–52.0, 14.8 and 9.9), respectively. On the other hand small positive additive genetic variances were found for body weight at maturity (0.0144) and egg weight at maturity (0.281) in backcross generations, the corresponding values in F3 generation were – 0.018 and – 9.87, respectively. These results indicate that the parents Gimmizah and Bandarah contain a high proportion of additive genes for these traits, which accumulated in backcrosses. Furthermore, the F3 generation yielded higher positive dominance variance components for age at sexual maturity 287.7 and egg weight at maturity 48.6 than the corresponding variances in backcrosses 8.3 and 8.1, respectively. Contrary, backcrosses had higher dominance variances for early egg weight 8.7, egg number at the first 90 d. of production 165.8 and egg number at 52 weeks of age 20.5 than the corresponding variances in F3 generation – 15.3, - 39.9 and – 167.6, respectively. The results of the average level of dominance (d') showed that dominance was partial to over dominance for the majority of the loci controlling egg production traits in backcrosses, while over dominance was controlling the inheritance of these traits in F3 generation. Generally, these results showed the effects of natural selection on accumulation of additive genes for age at sexual maturity and egg number traits combined with relaxation of selection for body weight in the parents Gimmizah and Bandarah.

I. Introduction

Understanding the genetic basis of phenotypic variation is essential for predicting the direction and rate of phenotypic evolution of these traits. The methods used to estimate different kinds of gene action in cross populations are commonly performed by comparisons of the mean of backcrosses, F2 and F3 generations derived from the cross of two parental lines or breeds. The parental line Gimmizah was derived from crossing Dokki4 x White Plymouth Rock (Mahmoud et al., 1982) and Bandarah parental line was derived from crossing Gimmizah x White Cornish (Mahmoud et al., 1989). While Fayoumy crossed with Barred Plymouth Rock to produce Dokki4 chicken (El-Itriby and Sayed, 1966). On such a situation Fayoumi is considered a common ancestor for the two parental lines. Several reports have been discussed the relative importance of additive and non-additive variations upon productive traits in poultry (Hill and Nordskog, 1958; Goto and Nordskog, 1959; Merritt and Gowe, 1960; Redman and Shoffner, 1961; Yao, 1961 and Wearden et al., 1965) They reported that additive variance was the single most important source of genetic variations for most productive traits, but non-additive genetic variance may be important for some other traits. Comstock and Robinson (1948 &1952) presented and discussed three mating designs and the associated experimental procedures for estimating genetic variances of quantitative characters. These designs (I, II and III) utilize the covariances among full and half sibs for estimating the genetic parameters. However, only two genetic parameters, additive genetic variance and dominance variance, can be estimated from these designs. The aim of this study is to compare F3 with backcross generations of Gimmizah x Bandarah cross to estimate additive and dominance effects and the average level of dominance, which control the inheritance of egg production traits, what may help for developing the effective improvement programs.

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II. Materials and Methods

The present experiment had been carried out at El-Sabahiah Research Station, Animal Production Research Institute, Agriculture Research Center.

a) Experimental Stock

The parental lines in this experiment were derived from crossing Dokki4 x White Plymouth Rock to produce Gimmizah (Mahmoud et al., 1982) then crossing Gimmizah x White Cornish to produce

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Bandarah, (Mahmoud et al., 1989). The two parental lines were crossed to produce F1 hybrids. Random mating of F1 hybrids used to form the F2 generation. All F3 progeny derived from intercrossing the F2 families. At the same time the males of F2 generation were randomly chosen and backcrossed with females of the two parental breeds (Gimmizah and Bandara) to produce F2 backcross generations i.e. F2 x Gimmizah (BC1) and F2 x Bandara (BC2). Twenty-four families of this mating structure were produced and constituted the material to obtain estimates of genetic variances and covariances for the population, natural mating was used in the family pens (1 male per 12 females).

b) Management Procedures

Management conditions were similar as possible as throughout the experiment. Two hatches in each mating combinations were used, for each hatch eggs were collected from each pen throughout 7 d and incubated in full-automatic draft machine. At hatch, all chicks were wing-banded and weighed to the nearest gram. The chicks were fed *ad libitum* a commercial starter till 16 weeks of age then the ration was changed by commercial layer ration throughout the experiment. The egg production traits studied were age at sexual maturity (SM), body weight at sexual maturity (BW1), early egg weight at sexual maturity (EW1), egg number at the first ninety d. of production (EN90), mature body weight (BW2), mature egg weight (EW2) and egg number at 52 wk. of age (EN2), respectively.

c) Statistical Analysis

All data were first converted to Log. transformation prior to statistical analysis to avoid the effects of epistasis. Data of the traits under this study were analyzed using North Carolina Designs II and III (Comstock and Robinson, 1952) with the following model:

$$Yijklm = \mu + si + bij + mik + fil + (m \times f)ikil + eijklm$$

Where: $Yijklm$ is the kth observation on i x jth progeny, μ is the overall mean, si is the effect of ith set, bij is the effect of jth replication in ith set, mik is effect of the ith male, fil is effect of the jth female, $(m \times f)ikil$ is the interaction effect, and $eijklm$ is the random error. The degree of dominance was estimated according to Mather, (1949) as follows: $d' = (\sigma^2D / \sigma^2A)0.5$ Where: d' is the degree of dominance, σ^2D is the dominance variance and σ^2A is the additive genetic variance.

III. Results and Discussion

a) Means

As seen in Table (1) Backcross (BC1) which had Gimmizah dam was early reaching sexual maturity 193 d. than both backcross2, that had Bandarah dam (BC2) 194 d. and F3 generation 197 d., while BC2 had the lowest body weight at sexual maturity 1591 g. compared with BC1 and F3 generations 1642 and 1622 g., respectively. Early egg weights at sexual maturity were nearly similar in the two backcrosses and the corresponding F3 generation 45, 45 and 44.8 g., respectively. At the first 90 d. of production BC1 laid more eggs (46) than both BC2 and F3 generations (42 and 38 egg). Also BC1 gained the heaviest body weight at maturity 1667 g., while F3 generation ranked second 1564 g. and the BC2 had the lowest weight 1524 g. The contrasts are shown for egg weight at maturity, where F3 generation was the heaviest egg weight than those of BC1 and BC2 (49.8 vs. 49.0 and 49.0 g.). The same differences among generations for egg number at 52 wk of age were present, where the hens of the two backcrosses laid eggs more than of F3 generation 81 and 74 vs. 64 eggs, respectively. The previous results were in agreement with those reported by Abd El-Galil, (1993) who showed significant differences among local strains during all laying intervals studied. Also it could be concluded that the diversity of the two backcrosses shown in Table 1 may be due to the differences in maternal performance of the dams (Gimmizah and Bandarah). Same conclusion was reported by Jamison et al., 1975.

b) Generation Variances

Regarding the backcrosses variations, Table 2 shows insignificant differences between females for age at sexual maturity (SM); body weight at sexual maturity (BW1); early egg weight at sexual maturity (EW1) and egg weight at maturity (EW2). These results indicated that there were no significant differences between the two backcrosses in these traits. The contrasts are shown for egg number in the first 90 d. of production (EN1); body weight at maturity (BW2) and egg number at 52 wks of age (EN2), which showed highly significant differences between females. This means that the genetic variations associated with these traits, which were inherited from the parental strain Gimmizah, may be expressing most of variations in backcrosses families. The same findings were reported by Sheridan, (1986). Also the mean squares due to males were insignificant for (SM); (BW1); (EW1) and (EW2). Furthermore, highly significant differences between males were obtained for EN1 and EN2 traits in backcross generations, while BW2 had significant differences between males. In this regard, the M x F interaction components of variance are insignificant for all traits studied except for EN1 and BW2. They had highly significant differences. However, these analyses explained relatively little variation in some egg production traits.

Concerning the variations of F3 generation presented in Table 2, which shows insignificant differences between males in all traits studied. Early egg weight at sexual maturity (EW1) was significantly differed in between females, while the other traits had

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insignificant differences. Also, the M x F interaction components of variance were insignificant for SM, EW1, EN1, BW2 and EN2. The contrasts are shown for body weight at sexual maturity (BW1) and egg weight at maturity (EW2), which had highly significant differences. Generally, these results reflect the relatively small variation in egg production traits in F3 generations.

c) Components of the genetic variance

Estimates of additive and dominance variations in backcross presented in Table 3, pointed out that additive genetic variance σ^2A accounted a major part of the total genetic variance for SM (20.4) and EN2 (848.7), since the estimates of dominance variance σ^2D in these traits were relatively low 8.3 and 20.5, respectively. Obvious results indicate that additive genetic variance may be a common in the inheritance of these traits. These results were in agreement with those of (Fairfull et al., 1983). Contrarily, the estimates of σ^2D are larger than those of additive for BW1, EW1, EN1, BW2 and EW2 (0.009, 8.7, 165.8, 0.079 and 8.14, respectively), compared with those of additive mean squares σ^2A (-0.018, -2.98, 149.8, 0.014 and o.28, respectively), support the conclusion that both the two backcrosses contains a high proportion of non-additive genes from each parental breeds, controlling the inheritance of these traits. These findings dealt with those cited by Abou El-Ghar and Abdou, (2004) and Abou El-Ghar, (2005). In this regard, the negative direction of additive variance for BW1 and EW1 may be due to the presence of the genes with negative effects with the high frequencies. The same conclusion was reported by Mather, (1949) and Cannings et al., (1978).

The observed estimates of environmental variation for BW1, EW1 and EW2 traits (0.012, 4.36 and 3.31) suggested that non-additive genetic variation or the environmental effects may be masked the effects of additive genes. The same conclusion was cited by (Shebl et al., 1990 and Zaky, 2005). Further analysis fit the presence of dominance effects on BW1, EW1, EN1, BW2 and EW2 traits that the ratio of the mean square of dominance to the additive mean square (d') were estimated to be -1.4, -1.7, 1.1, 2.4 and 5.4, respectively. Such results suggested that complete dominance is present in the inheritance of BW1, EW1 and EN1 and over dominance is controlling the inheritance of BW2 and EW2. On the other hand, partial dominance is important in both SM and EN2 traits. These results are around the figures reported by Robinson et al., 1956.

According to the genetic variations in F3 generation for the traits under consideration, it was notable from Table 3, that additive genetic variations in F3 generation were estimated to be -52.0, -0.035, -1.167, 14.8, -0.018, -9.87 and 9.94 for SM, BW1, EW1, EN1, BW2, EW2 and EN2, respectively. A simple explanation of the negative direction of additive variance for SM, BW1, EW1, BW2 and EW2 traits may be due to the presence of the genes with negative effects with higher frequencies. The same conclusion was reported by (Mather, 1949 and Cannings et al., 1978). Although, the mean squares due to additive genetic variance σ^2A were much larger than those for σ^2D -39.9 and -167.6 for both EN1 and EN2 indicating that additive genetic variation accounted for most of the variation among the variations components for these traits. The same findings were in agreement with those reported by Fairfull et al. 1983. On the other hand, there were considerable non-additive genetic variations σ^2D for SM, BW1, BW2 and EW2 (287.7, 0.124, 0.042 and 48.6, respectively). According to these results, it could conclude that dominance may control the inheritance of the majority of the loci for these traits. The same conclusion was reported by Robinson etal. 1956. The same findings were reported by Abou El-Ghar and Abdou, 2004 and Abou El-Ghar, 2005. In the same order environmental variations were estimated to be 8.95, 0.023, 5.61, 20.78, 0.024, 5.17 and 48.7 for SM, BW1, EW1, EN1, BW2, EW2 and EN2, respectively. Also, these results are dealing with those of the observed (d') ratios were -3.3, -2.7, 5.1, -2.3, -2.2, -3.1 and -5.8 for SM, BW1, EW1, EN1, BW2, EW2 and EN2, respectively. According to these results, it could be conclude that over dominance is controlling the inheritance of these traits under consideration.

IV. Conclusion

Generally, the large positive additive variations σ^2A of SM (20.4), EN1 (149.8) and EN2 (848.7) traits in backcrosses compared with those of F3 (-52.0, 14.84 and 9.94, respectively), support the conclusion that both of the two backcrosses contains a high proportion of additive genes from each parental breeds, controlling the inheritance of these traits. On the other hand, it could be concluded that dominance was partial to over dominance for the majority of the loci for egg production traits. Generally, these results showed the effects of natural selection on accumulation of additive genes for age at sexual maturity and egg number traits a combined with relaxation of selection for body weight in the parents Gimmizah and Bandarah.

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Table 1 : Means of different traits and generations

Traits	BC_1 *	BC_2 *	F_3 **
	Mean ± SE	Mean ± SE	Mean ± SE
SM	193 ± 3.8	194 ± 5.4	197 ± 5.7
BW1	1624 ± 195	1591 ± 175	1622 ± 218
EW1	45 ± 3.6	45 ± 3.8	44.8 ± 3.4
EN90	46 ± 7.2	42 ± 6.9	38 ± 6.3
BW2	1667 ± 230	1524 ± 211	1564 ± 214
EW2	49 ± 3.2	49 ± 3.5	49.8 ± 3.4
EN2	81 ± 13.8	74 ± 12.2	65 ± 10.1

*N= 54, ** N= 72, BC1 = backcross with Gimmizah, BC2 = backcross with Bandara, F3 = third generation, SM = age at sexual maturity, BW1 = body weight at sexual maturity, EW1 = early egg weight at sexual maturity, EN90 = egg number at the first ninety d. of production, BW2 = mature body weight, EW2 = mature egg weight and EN2 = egg number at 52 wk. of age.

Table 2 : Analysis of variance of the different traits in backcrosses and F3

Generations	Traits	Mean Squares			
		M	F	M x F	Error
Backcrosses	SM	48. 4 NS	34.4 NS	42.8 NS	17.8
	BW1	0.008 NS	0.029 NS	0.062 NS	0.035
	EW1	8.6 NS	15.6 NS	39.3 NS	13.1
	EN90	235.1 **	363.0 **	507.8 **	10.4
	BW2	0.027 *	0.552 **	0.245**	0.005
	EW2	10.3 NS	11.3 NS	34.3 NS	9.9
	EN2	1341.8 **	1014.5 **	130.4 NS	68.9
F3	SM	5.6 NS	10 .9NS	161.8 NS	17.9
	BW1	0.003 NS	0.017 NS	0.107 **	0.045
	EW1	0.556 NS	35.6 *	3.6 NS	11.2
	EN90	66.1 NS	56.2 NS	21.6 NS	41.6
	BW2	0.015 NS	0.008 NS	0.069 NS	0.049
	EW2	5.0 NS	18.9 NS	34.6 **	10.3
	EN2	43.6 NS	159.4 NS	13.7 NS	97.5

NS = insignificant differences, * = significant differences, ** = highly significant differences, Backcrosses degrees of freedom of M = 5, F = 1, M x F = 5, Error = 93, F3 degrees of freedom of M = 1, F = 5, M x F = 5, Error = 58

Table 3 : Variance components for different traits and generations

Traits	Backcrosses				F_3			
	σ^2A	σ^2D	σ^2E	d'	σ^2A	σ^2D	σ^2E	d'
SM	20.4	8.3	5.9	0.6	-52	287.7	8.95	-3.3
BW1	-0.018	0.009	0.012	-1.4	-0.035	0.124	0.023	-2.7
EW1	-2.98	8.72	4.36	-1.7	-1.17	-15.31	5.61	5.1

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EN90	**149.8**	**165.8**	**3.46**	**1.1**	**14.84**	**-39.93**	**20.78**	**-2.3**
BW2	**0.014**	**0.079**	**0.002**	**2.4**	**-0.018**	**0.042**	**0.024**	**-2.2**
EW2	**0.281**	**8.14**	**3.31**	**5.4**	**-9.87**	**48.6**	**5.17**	**-3.1**
EN2	**848.7**	**20.52**	**22.95**	**0.16**	**9.94**	**-167.6**	**48.7**	**-5.8**

σ^2A = additive genetic variance, σ^2D = dominance genetic variance, σ^2E = environmental variance, d' = the degree of dominance.

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