

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.

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, F_2 and F_3 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 F_3 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.

MATERIALS AND METHODS

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

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 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).

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.

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:

$$Y_{ijklm} = \mu + s_i + b_{ij} + m_{ik} + f_{il} + (m \times f)_{ikil} + e_{ijklm}$$

Where: Y_{ijklm} is the kth observation on i x jth progeny, μ is the overall mean, s_i is the effect of ith set, b_{ij} is the effect of jth replication in ith set,

m_{ik} is effect of the ith male, f_{il} is effect of the jth female,

$(m \times f)_{ikil}$ is the interaction effect, and e_{ijklm} 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.

RESULTS AND DISCUSSION

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.

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 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.

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 0.28, 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 F_3 generation for the traits under consideration, it was notable from Table 3, that additive genetic variations in F_3 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 et al. 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.

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 F_3 (-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.

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
F ₃	SM	5.6 ^{NS}	10.9 ^{NS}	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
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.

REFERENCES

- Abd El-Galil, M.A, (1993).** *Evaluation the performance of some local breeds of chickens under certain plans of nutrition. Ph.D. Minia Univ., Egypt.*
- Abou El-Ghar, R.Sh. (2005).** *Evaluation of genetic variance components based on the concept of generation means for some economic traits in chickens: absence of epistasis. Proc.2nd Conf. Anim. Prod. Res. Inst., Sakha, 27-29 Sep. 2005: 475-480.*
- Abou El-Ghar, R.Sh. and F.H. Abdou, (2004).** *Evaluation of genetic variance components based on the concept of generation means for some economic traits in chickens. Egypt. Poult. Sci. 24: 687-699.*
- Comstock, R.E. and H.F. Robinson, (1948).** *The components of genetic variance in populations of biparental progenies and their use in estimating the degree of dominance. Biometrics 4: 254-266.*
- Comstock, R.E. and H.F. Robinson, (1952).** *Estimation of average dominance of genes. Pp. 494-516 Heterosis. Edited by John W. McGowen. Iowa State College Press. Ames, Iowa.*
- Cannings, C.; E.A. Thomeson and M.H. Skolnick, (1978).** *Probability functions on complex pedigrees. Adv. Appl. Prob. 10: 26-61.*
- El-Itriby, A.A. and I.F. Sayed, (1966).** *“Dokki4” ...Anew breed of Poultry. Agric. Res. Rev. Cairo 44: 102-109.*

- Fairfull, R.W.; R.S. Gowe and L.A.B. Emsley, (1983).** *Diallel cross of sex long-term selected Leghorn strains with emphasis on heterosis and reciprocal effects. Br. Poult. Sci. 42: 133-158.*
- Goto, E. and A.W. Nordskog (1959).** *Heterosis in poultry. 4. Estimation of combining ability variance from diallel crosses of inbred lines in the fowl. Poult. Sci. 33: 1331-1388.*
- Hill, J.B. and A.W. Nordskog (1958).** *Heterosis in poultry. 3. Predicting combining ability of performance in the crossbred fowl. Poult. Sci. 37: 1159-1169.*
- Jamison, M.G.; J.M. White; W.E. Vinson and K. Hinkelmann (1975).** *Diallel analysis of growth traits in mice. Genetics 81: 369-376.*
- Mahmoud, T.H.; I.F. Sayed; Y.H. Madkour and M.M. Honein, (1982).** *The Gimmizah A new breed of chickens. Agric. Res. Rev. Cairo 60: 55-68.*
- Mahmoud, T.H.; J.E. Abd El-Hameid and A.I. El-Turkey, (1989).** *Bandarah A new breed of chickens. Agric. Res. Rev. Cairo 67: 229.*
- Mather, K. (1949).** *Biometrical Genetics. London, Methuen and Co.*
- Merritt, E.S. and R.S. Gowe, (1960).** *Combining ability among breeds and strains of meat type fowl. Can. J. Genet. Cytol. 2: 286-294.*
- Redman, C.S. and R.N. Shoffner, (1961).** *Estimation of egg quality parameters utilizing a polyallel crossing system. Poult. Sci. 40: 1662-1675.*
- Robinson, H.F.; R.E. Comstock; A.H. Khalil and P.H. Harvey, (1956).** *Dominance versus overdominance: Evidence from crosses between open pollinated varieties of maize. Am. Naturalist 90: 127-131.*
- Shebl, M.K.; Mervat A. Ali; Magda M. Balat and T.H. Tag El-Din (1990).** *Evaluation of combining ability for some body size traits and feathering in a diallel cross of chickens. Egypt. Poult. Sci. 10: 159-177.*
- Sheridan, A.K., (1986).** *Selection for heterosis from crossbred populations: Estimation of the F1 heterosis and its mod of inheritance. Br. Poult. Sci., 27:541-550.*
- Wearden, S.; D. Tindell and J.V. Craig (1965).** *Use of a full diallel cross to estimate general and specific combining ability in chickens. Poult. Sci. 44: 1043-1053.*

Yao, T.S. (1961). *Genetic variations in the progenies of diallel crosses of inbred lines of chickens. Poult. Sci. 40: 1048-1059.*

Zaky, H.I. (2005). *Genetic effects in crossbreeding and estimate of genetic components in crossbred chickens of Fayoumi and Rhode Island Red. Egypt. Poult. Sci. 25 (IV): 1085-1101.*

الملخص العربي

تحليلات وراثية لمتوسطات الأجيال في الخلط بين سلالتين من الدجاج المحلي

II- مقارنات بين الجيل الثالث والخلط الرجعي بالنسبة لصفات إنتاج البيض

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أجرى هذا البحث بمحطة بحوث الدواجن بالصباحية حيث استخدمت مقارنة نتائج أبناء الجيل الثالث والهجن الرجعية لخليط الجميزة والبندرية في تقدير فعل الجين المضيف وتأثير السيادة ومتوسط درجة السيادة في صفات إنتاج البيض ولقد استخدم التصميمان الثاني والثالث لحساب مكونات التباين الوراثي ولقد أوضحت نتائج كلا التصميمين السابقين وجود اختلافات موجبة ترجع لتأثير عوامل الإضافة بالنسبة لصفات العمر عند النضج الجنسي، عدد البيض خلال الـ 90 يوم الأولى من مرحلة إنتاج البيض و عدد البيض خلال 52 أسبوع من العمر وذلك في الهجن الرجعية مقارنة بنفس الصفات في الجيل الثالث التي بلغت قيم التباين الوراثي المضيف لها 52.0، 14.8 و 9.9 على التوالي.

على الجانب الآخر وجدت قيم صغيرة موجبة للتباين الوراثي المضيف بالنسبة لصفات وزن الجسم ووزن البيضة عند تمام النضج في الهجن الرجعية في حين كانت تلك التقديرات سالبة في الجيل الثالث ومن هذه النتائج يتضح أن فعل الجين المضيف يتجمع ويزداد تأثيره على تلك الصفات في الهجن الرجعية.

وعلى العكس من نتائج الجيل الثالث فلقد تحققت أعلى قيم للتباين الراجع لتأثير عوامل السيادة بالنسبة لصفات العمر عند النضج الجنسي ووزن البيضة عند تمام النضج عن مثيلتها في حالة الهجن الرجعية في حين كانت قيم التباين الراجع لتأثير السيادة في الهجن الرجعية أعلى من مثيلتها في الجيل الثالث بالنسبة لصفات وزن البيضة عند النضج الجنسي، عدد البيض خلال الـ 90 يوم الأولى من الإنتاج وعدد البيض عند عمر 52 أسبوع. وبالنظر الى نتائج النسبة بين تباين السيادة إلي التباين الوراثي المضيف يمكن إستنتاج أن السيادة تندرج من سيادة جزئية إلي سيادة فائقة في معظم المواقع الوراثية الخاصة بصفات إنتاج البيض في الهجن الرجعية في حين أن السيادة في الجيل الثالث تقع في حيز السيادة الفائقة. وعموما هذه النتائج توضح أن الانتخاب الطبيعي قد أثر على تجميع الجينات ذات التأثير المضيف في صفات العمر عند النضج الجنسي وصفات إنتاج البيض علاوة على توقف الانتخاب لوزن الجسم في السلالتين الأبويتين الجميزة والبندرية.