International Journal of Livestock Production Vol. 2(9), pp. 134-137, 9 September, 2011
Available online at http://www.academicjournals.org/IJLP
ISSN 2141-2448 ©2011 Academic Journals

*Full Length Research Paper*

# Genetic analyses of generation means for a cross between two local breeds of chickens: Ш- inheritance of egg quality in $F_3$ and backcross generations

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Accepted 13 January, 2011

**External and internal egg quality traits are the primary selection objectives of breeders to maximize the return of saleable eggs. In order to help for developing an effective improvement program for egg quality traits, performances of $F_3$ and backcrosses generations, derived from crossing Gimmizah with Bandarah developed strains, were used to estimate the components of genetic variability of egg quality traits in this experiment. The current results revealed that the differences between genetic groups were highly significant for all traits studied. Also the variations between $F_3$ and backcrosses were highly significant differences for egg weight, shell weight, yolk weight, albumin weight and yolk index, while shell thickness, egg shape index and Haugh unit were not differ significantly in the same trend. Moreover, the results revealed that most of egg quality characteristics had negative estimates of additive ʃ$^{2}$A and dominance $\sigma^2$d genetic variations. This may be due to the parental strains were closely related, what caused presence of many deleterious recessive genes, were expressed largely and resulted a very little genetic variations in egg quality traits. The degree of dominance ($\hat{h}$) was varied from no dominance in shell weight to complete dominance of the low parent in yolk index and from complete dominance of the high parent in albumin weight and egg weight to over dominance of the low parent in Haugh unit. Contrarily, over dominance of the high parent was found in shell thickness, egg shape index and yolk weight, respectively.**

**Key words:** Backcross generations, no dominance, parental strains, additive genetic variance, egg quality, egg weight.

## INTRODUCTION

Locally developed strains of chicken Gimmizah and Bandarah gained more appreciation among the rural areas, due to their well adaptation to harsh environments and their high value of safety and healthy protein source. Basically, they are a dual purpose strains so, the eggs and meat quality are the most important factors for its popularization, although the production of such strains has not been achieved up to their maximum genetic potentiality. The quality of the eggs is more importance price contributing factor in table and hatching eggs (Stadelman, 1977). Different internal and external egg quality characteristics are high importance in analyzing egg quality (Silversides and Scott, 2001). The most important external egg-quality characteristic is shell strength, which decreases with the age of the hen advancing.

Concerning egg weight, the objective is to select towards an intermediate optimum which helps to maximize the percentage of eggs in the preferred weight range and good hatch. Shell color is also receiving attention especially in brown-egg stocks in response to consumer preferences of dark brown eggs. Traditionally internal quality characteristics are albumen height and incidence of blood and meat spots which are to be minimized, while the important factors in measuring freshness of the eggs are thick albumen and air cell. Selection for higher yolk percentage and dry matter increased with increasing use of eggs for further processing. Several interrelationships are apparent between egg size, chick weight, chick growth, hatchability and consumer's acceptability (Wilson, 1991). The successful production of good quality of eggs need several factors should be considered that is breed, strain, variety, temperature, relative humidity, rearing practices and season (Sauter et al., 1954; Washburn, 1990).

Egg weight and proportion of albumen, yolk and shell were varied significantly between the strains of hens (Pandey et al., 1986). Inherited differences between strains of White Leghorn in egg weight and shape index have been reported by (Arafa et al., 1982; Carter and Jones, 1970). Eisen and Bohren (1963) found it possible to list albumin quality as quantitative genetic traits. The proportion of albumin had high heritability and was controlled by additive multiple factors (Scheinberg et al., 1953). Eggs produced by the strain selected for live body weight were larger with proportionately more shell weight than the strains selected for growth rate and breast meat, respectively, whereas yolk and albumen did not differ by strain (Joseph and Moran, 2005).

Nwachukwu et al. (2006) reported that the reciprocal crosses Normal Local chicken x Exotic Broiler Breeder stock, Naked Neck x Exotic Broiler Breeder stock and Frizzle chicken x Exotic Broiler Breeder stock had significantly heavier egg weight at first egg, while shell thickness and yolk weight were not significantly differ ($p>0.05$) in all genetic groups. Contrarily, yolk index, albumen weight and Hough unit were significantly higher for the reciprocal crosses. Most of breeding programs put a little selection pressure on shell quality possibly because of risk of diverting selection pressure away from egg production and egg weight (Hunton, 1982). Moreover, it is difficult to select for these traits within line because there were very little variations among the hens within a line. In order to explore the genetic mechanism which controls the various affecting the performance of these strains and examine how best to model the trait for the purpose of genetic evaluation and selection for improvement, generation means analysis were used to study the performances of $F_3$ and backcrosses derived from crossing Gimmizah with Bandarah parental strains.

The objective of this study was to estimate the components of genetic variability of egg quality traits that may help for developing the effective improvement programs.

## MATERIALS AND METHODS

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

### Experimental design

The two parental lines Gimmizah and Bandarah were crossed to produce $F_1$ crosses. Random mating of $F_1$ crosses were used to establish the $F_2$ generation. All $F_3$ progeny derived from intercrossing of the $F_2$ families. At the same time the males of $F_2$ generation were randomly chosen and backcrossed with females of the two parental strains Gimmizah and Bandarah to produce $F_2$ backcross generations that is $F_2$ x Gimmizah ($BC_1$) and $F_2$ x Bandarah ($BC_2$). Each genetic group of $F_3$, $BC_1$ and $BC_2$ was randomly divided into 5 replicates. They were kept in family pins each contains 12 layer hens. At the age of 42 weeks, a total number of 150 eggs were collected randomly from the three genetic groups 50 eggs per each genetic group to evaluate various external and internal egg quality traits.

All managerial practices were similar as possible throughout the experiment.

### The studied traits

Firstly the external characters like egg weight (EW) and egg diameter were recorded. Thereafter the eggs were broken and the other traits like shell weight (Sh.W), shell thickness (Sh.Th) including shell membranes was measured using a micrometer at three locations on the egg that is air cell, equator and sharp end, albumin weight (Al.W), yolk weight (Y.W), were recorded using standard procedure. Egg Shape Index % (E.Sh.I) (Carter and Jones, 1970), Yolk index % (Y.I) Funk (1948) and Haugh unit score (HU) (Haugh, 1937) were calculated.

### Statistical analysis

The data of egg quality traits, which derived from $F_3$ and backcross generations were analyzed using analysis of variance appropriate for Complete Randomized Block Design with 5 Replicates. All percentages were first converted to arcsine transformation prior to statistical analysis. Partitioning of the variance into its components (that is, between replicates, between genotypes, between backcrosses, within $F_3$ generation and $F_3$ vs. backcrosses) together with estimating the genetic variance components ($\sigma^2A$ and $\sigma^2d$) were done by using the method of (Kearsey and Jinks, 1968). The degree of dominance ($\hat{h}$) was estimated according to equations given by (Griffing, 1950):

$(\hat{h}) = (\sigma^2d / \sigma^2A)0.5$

$\sigma^2A$ = additive mean square, $\sigma^2d$ = dominance mean square.

## RESULTS AND DISCUSSION

### External egg quality traits

It is obvious in Table 1 that the backcross that had Gimmizah dame ($BC_1$) had the heaviest egg weight and shell weight of 51 and 6.6 g, compared with $F_3$ generation which ranked second (50 and 5.9 g) and $BC_2$ which had Bandarah dame 46 and 5.6 g, respectively. The previous results were in agreement with those reported by Joseph and Moran, (2005) they showed that selection for live body weight of chicken can result in increased egg size with more proportionately shell weight. The contrasts are shown for shell thickness and egg shape index, where $F_3$ generation being the best among all genetic groups (0.35 mm, and 75%, respectively). Whereas, shell thickness being similar in $BC_1$ and $BC_2$ 0.31 mm, also $F_3$ generation had the same percentage of egg shape index as $BC_2$ 75%. It could be concluded that shell thickness decreased significantly as the breeder age advance. The same conclusion was reported by (Rayan et al., 2010).

**Table 1.** Means and S.d of some egg quality traits from F3 and backcross generations.

| Genotypes | No. | Traits | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E.W | Sh.W | Sh.Th | E.Sh.I% | Al.W | Y.W | Y.I% | H.U |
| $F_3$ | 50 | 50±4.6 | 5.9±0.7 | 0.35±0.04 | 75±4.1 | 27±4.1 | 17±1.5 | 45±3.9 | 97±14.4 |
| $BC_1$ | 50 | 51±39 | 6.6±0.9 | 0.31±0.03 | 74±3.1 | 28±4.4 | 17±1.3 | 46±5.6 | 97±9.6 |
| $BC_2$ | 50 | 46±26 | 5.6±0.7 | 0.31±0.04 | 75±5.2 | 25±2.8 | 16±1.6 | 45±3.6 | 95±9.3 |
| Total backcrosses | 100 | 51±4.1 | 6.6±0.9 | 0.31±0.04 | 74±4.3 | 28±3.8 | 17±1.6 | 46±4.7 | 97±9.4 |

E.W = egg weight, Al.W = albumin weight, Y.W = yolk weight, Sh.W= egg shell weight, Sh.Th = shell thickness, E.Sh.I. = egg shape index, Y.I. = yolk index, HU = Haugh units, $BC_1$ = backcross 1, $BC_2$ = backcrosses 2, $F_3$ = 3rd generation.

**Table 2.** Mean squares of some egg quality traits from F3 and backcross generations.

| S.O.V | d.f | Traits | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E.W | Sh.W | Sh.Th | E.Sh.I | Al.W | Y.W | Y.I | H.U |
| Bet. Rep. | 4 | 2.39$^{NS}$ | 1.07* | 0.03$^{NS}$ | 22.8$^{NS}$ | 3.95$^{NS}$ | 1.71$^{NS}$ | 0.006* | 415.9** |
| Bet. Genotypes | 2 | 1039** | 30.2** | 8.67** | 1005** | 473** | 186** | 0.067** | 5456.7** |
| Bet. Backcrosses | 1 | 561** | 24.5** | 0.001$^{NS}$ | 35$^{NS}$ | 136** | 47** | 0.001$^{NS}$ | 115$^{NS}$ |
| Within $F_3$ | 49 | 22** | 0.48$^{NS}$ | 0.001$^{NS}$ | 1.3$^{NS}$ | 16.9$^{NS}$ | 2$^{NS}$ | 0.002$^{NS}$ | 208** |
| $F_3$ vs. Backcross | 1 | 283.5** | 9.29** | 0.51$^{NS}$ | 15.7$^{NS}$ | 93.3** | 67.8** | 0.020** | 36.0$^{NS}$ |
| Error | 243 | 12 | 0.42 | 0.06 | 13 | 12.5 | 2 | 0.002 | 74 |

E.W = Egg weight, Al.W = albumin weight, Y.W = yolk weight, Sh.W= egg shell weight, Sh.Th = shell thickness, E.Sh.I. = egg shape index, Y.I. = yolk index, HU = Haugh units, $BC_1$ = backcross 1, $BC_2$ = backcrosses 2, $F_3$ = 3rd generation, *= significant differences, **= highly significant differences, NS= insignificant differences.

**Table 3.** Components of genetic variation for some egg quality traits.

| Traits | $\sigma^2A$ | $\sigma^2d$ | $\hat{h}$ |
|---|---|---|---|
| Egg weight | -3.1 | -2.66 | 0.9 |
| Shell weight | -0.92 | -0.15 | 0.4 |
| Shell thickness | 0.001 | 0.002 | 1.6 |
| Egg shape index | 16.7 | 45.8 | 1.6 |
| Albumin weight | -2.91 | -3.39 | 1.1 |
| Yolk weight | -0.03 | -1.58 | 7.4 |
| Yolk index | -0.0017 | 0.0015 | -0.9 |
| Haugh units | -26.9 | 236.8 | -2.9 |

$\sigma^2A$ = Additive genetic variance, $\sigma^2d$ = dominance variance, $\hat{h}$ = degree of dominance, $F_3$= 3rd generation, BC= backcrosses.

Table 2 revealed that all the external egg quality traits showed highly significant differences (P<0.01) among all genetic groups (genotypes). The backcrosses were statistically differ significantly (P<0.01) for egg weight and shell weight, but did not differ significantly for shell thickness and egg shape index. Also the same trend was found for shell thickness and egg shape index in within $F_3$ generation and $F_3$ vs. backcrosses.

The genetic differences between the strains for egg weight were reported by (Carter and Jones, 1970; Arafa et al., 1982). Also Nwachukwu et al. (2006) found that shell thickness was not significantly differing among different genetic groups of chicken. The estimates of additive and dominance genetic variations for external egg quality traits in $F_3$ and backcross were presented in Table 3. The results reflected negative and low estimates of additive genetic variance $\sigma^2A$ (-3.1 and -0.92) and dominance variance $\sigma^2d$ (-2.66 and -0.15) for egg weight and shell weight, respectively. These results suggested that the genetic variation for this trait was largely unexpressed or may be the environmental effects were large and masked observable genetic variation. The same conclusion was reported by Cannings et al. (1978). The estimated degree of dominance ($\hat{h}$) 0.9 and 0.4 for egg weight and shell weight showed that the dominance was ranged from no dominance for shell weight to complete dominance for egg weight, respectively. Also Table 3, pointed out that dominance genetic variance $\sigma^2d$

accounted a major part of the total genetic variance for shell thickness 0.002 and egg shape index 45.8, since the estimates of additive variance $\sigma^2A$ in these traits were relatively low 0.001 and 16.7, respectively.

The former results indicate that dominance genetic variance may be common in the inheritance of these traits. Moreover, the degrees of dominance ($\hat{h}$) were the same 1.6 for these traits, this means that over-dominance was present in the inheritance of shell thickness and egg shape index. The same findings were found by Abou et al. (2009).

## Internal egg quality traits

It appears from Tables 1, that $BC_1$ had significantly heaviest albumin weight 28 g, followed by $F_3$ 27 then $BC_2$ 25 g. The most desirable yolk weights were achieved by the two genotypes $BC_1$ and $F_3$ 17 g, while the lowest yolk weight was achieved by $BC_2$ 16 g. The same trend was found for Haugh unit percentage, where $BC_2$ have the lowest percentage 95% compared with $BC_1$ and $F_3$ generations 97 and 97%, respectively. Contrarily, the estimate of yolk index in $BC_1$ was larger than both $BC_2$ and $F_3$ generations 46 vs. 45 and 45, respectively. The same findings for these traits were reported by Abou et al. (2009). There were significant differences ($P<0.01$) among all genetic groups for albumin weight, yolk weight, yolk index and Haugh unit traits. Also significant differences ($P<0.01$) were shown for these traits except for Haugh unit concerning the variations between $F_3$ and backcrosses, which were insignificant (Table 2). The same findings were reported by Pandey et al. (1986), Joseph and Moran (2005), Nwachukwu et al. (2006), Abou et al. (2009) and Nawar (2009).

It could be seen from Table 3 that negative estimates of $\sigma^2A$ -2.91 and $\sigma^2d$ -3.39 for albumin weight indicated that the genes with negative effects were present with high frequencies in the inheritance of albumin weight. The same conclusion was reported by Cannings et al. (1978). The same findings of $\sigma^2A$ -0.03 and $\sigma^2d$ -1.58 were found for yolk weight. Contrarily, dominance seems to be the major source of variation for yolk index and Haugh unit (0.0015 and 236.8), while negative estimates of additive variance were found for these traits -0.0017 and -26.9, respectively. Such results together with the values of the degrees of dominance ($\hat{h}$) 7.4, -2.9, 1.1 and - 0.9, suggested that over dominance to the high parent and to the low parent was present in the inheritance of both yolk weight and Haugh unit, respectively. While complete dominance was found in the inheritance of albumin weight and yolk index, respectively.

These results disagreed with those reported by Scheinberg et al. (1953) and Abou et al. (2009).

## Conclusion

Generally, results of the current study showed that most of these traits had negative estimates of additive $\sigma^2A$ and dominance $\sigma^2d$ genetic variations, this may be due to the effects attributed to the maternal strains on egg quality traits were minimal and/or many recessive genes were expressed what reduces the observable genetic variations in egg quality traits.

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