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Genetic Analyses of Generation Means for a Cross between Two Local Breeds of Chickens: 4- A Model for Hatchability Prediction as a Function of Some Egg Quality Traits

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Abstract - This study was undertaken to predict hatchability as a function of some physical characteristics of eggs in the third generation (F_3) and backcrosses (BC_1 and BC_2) derived from crossing between two local developed strains of chickens (Gimmizah and Bandarah). The physical parameters used in this study were egg weight, egg shell thickness, egg shape index and yolk/albumin ratio as well as obtained hatchability. The relationships of these parameters in hatchability process were modeled by multiple linear regressions. The performances of the three genetic groups (F_3, BC_1 and BC_2) were used to apply the modeling process. The following model output: $Y = 241.6 + 1.126\ x_1 + 213.5\ x_2 + 79.54\ x_3 + 28.03\ x_4$, where Y presents the predicted hatchability, 241.6 presents □ the intercept parameter (**α**) and the 1.126, 213.5, 79.54 and 28.03 are the slope parameters (**β**i) of egg weight (x_1), shell thickness (x_2), egg shape index % (x_3) and yolk/albumin ratio (x_4), respectively. Furthermore, the mention approach above confirms the existence of a highly significant relationship between the main regression parameters and predicted hatchability.

Keywords : multiple linear regressions, physical characteristics of eggs, hatchability.

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GENETIC ANALYSES OF GENERATION MEANS FOR A CROSS BETWEEN TWO LOCAL BREEDS OF CHICKENS 4- A MODEL FOR HATCHABILITY PREDICTION AS A FUNCTION OF SOME EGG QUALITY TRAITS

Strictly as per the compliance and regulations of :

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Abou El-Ghar [α] & R. Sh. [σ]

Abstract - This study was undertaken to predict hatchability as a function of some physical characteristics of eggs in the third generation (F_3) and backcrosses (BC_1 and BC_2) derived from crossing between two local developed strains of chickens (Gimmizah and Bandarah). The physical parameters used in this study were egg weight, egg shell thickness, egg shape index and yolk/albumin ratio as well as obtained hatchability. The relationships of these parameters in hatchability process were modeled by multiple linear regressions. The performances of the three genetic groups (F_3, BC_1 and BC_2) were used to apply the modeling process. The following model output: $Y = 241.6 + 1.126\ x_1 + 213.5\ x_2 + 79.54\ x_3 + 28.03\ x_4$, where Y presents the predicted hatchability, 241.6 presents the intercept parameter (α) and the 1.126, 213.5, 79.54 and 28.03 are the slope parameters (β_i) of egg weight (x_1), shell thickness (x_2), egg shape index % (x_3) and yolk/albumin ratio (x_4), respectively. Furthermore, the mention approach above confirms the existence of a highly significant relationship between the main regression parameters and predicted hatchability. Contrarily, determination coefficients adjusted (R^2) were found to be 0.08, 0.11 and 0.13 in F_3, BC_1 and BC_2, respectively. These R^2 were closer to 0 indicates a regression line did not fit the data.

Keywords : multiple linear regressions, physical characteristics of eggs, hatchability.

I. Introduction

Experimental studies have shown that predicting hatchability may depend on the main physical characteristics of eggs (Peruzzi et al., 2012). Hatchability is very important trait in breeding program which has a great economical impact in the poultry industry and insures the sufficient day-old chicks. The variability between and within strains raises the question weather reproductive performance can be improved by breeding program, Sapp et al. (2005) reported a low direct heritability below 10% in most studies. Also, estimated of heritability for hatchability of fertile eggs in the literature range from 0.15 to 0.20 (Förster, 1993; Szwacz kowski et al., 2000 and Bennewitz et al., 2007). Therefore their improvement would be achieved through the optimization of environment by hatchery and breeder farm management (Förster et al., 1992). Egg characteristics greatly influence the process of incubation and responsible for its success (Narushin and Romanov, 2002a,b). Egg weight and egg shell quality were effective on hatchability of fertile eggs (Altan et al., 1995 and Wolanski et al., 2007). Concerning egg weight, it is preferable to have eggs of average weight to achieve good hatchability as far as chickens, turkeys, ducks and ostriches are concerned (Wilson, 1991; Brah et al., 1999 and Gonzales et al., 1999). The egg shell has important rule in hatchability, an increase in shell thickness of one micrometer in the range of 0.29 to 0.35 mm led to an increase in hatchability of about 2% (Sergeyeva, 1986). Moreover, it isolated the embryo from the external environment while allowing the proper gas exchange across the shell at the same time, Shatokhina (1975) reported that eggs with extremely thick or thin shells resulted in increased embryonic mortality when compared to embryonic mortality from eggs of average thickness. Moreover, some other quality traits are also important for hatching and consumed egg like shell thickness, specific gravity, albumen height and yolk height (Wolanski et al., 2007), and yolk/albumen ratio (Harms and Hussein, 1993). Egg shape, which can be easily described in terms of the ratio of the maximum breadth and length, remains constant during the whole period of incubation; Burtov et al. (1990) reported that eggs of normal shape hatch more successfully than those shaped abnormally. As demonstrated that Gimmizah and Bandarah local developed strains of chickens, while available domestic literature on selection deals with problems may be associated with hatchability. Sonaiya and Swan (2004) reported that the satisfactory range of hatchability among free range chickens is considered from 75 to 80%. A model encompassing some egg quality traits may be used for predicting hatchability as closely as possible to the realized hatchability. Such prediction needs to incorporate egg weight, egg shape index, egg shell thickness and yolk/albumin ratio. Therefore, this study aims to use information about some egg quality traits and reference hatchability of the third generation

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and backcrosses to establish a model for hatchability prediction.

II. Materials and Methods

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

a) *Experimental Design*

Hatching eggs produced by the third generation and backcrosses hens aged 42 wks, the birds which divided from intercrossing of all the second generation families of the two parental lines Gimmizah and Bandarah to produce all the third generation (F_3) progeny, at the same time the males of second generation were backcrossed with females of Gimmizah and Bandarah to produce the two backcrosses (BC_1) and (BC_2), respectively. A sample of 57 eggs was selected at random from the eggs produced to measure egg weight, egg axes (length and width), egg shell with membranes thickness from 3 different regions by using a micrometer and weights of yolk and albumen using the standard procedure. Egg Shape Index was calculated by the formula cited by Carter and Jones (1970). The remainder hatching eggs were stored for 7 d and incubated in full-automatic draft machine to calculate the hatchability % in relation to the number of total eggs set from the genetic groups F3, BC_1 and BC_2, which considered as reference of obtained hatchability.

b) *Statistical Analysis*

The data of egg weight (EW), egg shell thickness (Sh.Th), egg shape Index (E.Sh.I) and yolk/albumin ratio (Y/Al ratio) which derived from F3 and backcross generations were performed using the GLM procedure of SAS software (2003). To satisfy the requirements of multiple linear regression arcsin transform was applied. A Logistic regression was applied to fit a model to the binomial response variable considering the probability of hatching. The logistic regression model fits the log of the odds by a function of the explanatory variables (Hosmer and Lemeshow, 1989).

$$\text{Logit}(\pi) = \log\left[\frac{\pi}{1-\pi}\right] = \alpha + \sum_{i=1}^{m} \beta_i \chi_i$$

Where χ indicates the explanatory variables (e.g. EW, Sh.Th, E.Sh.I and y/al ratio), π is the probability defined by the proportion of hatched eggs, given a set of *m* explanatory variables including reference hatchability, α is the intercept parameter, β_i is the slope parameter for the *ith* explanatory variable and x_i is the observation for the ith explanatory variable.

III. Results and Discussions

a) *Effect of Genotype on the Studied Traits*

It is obvious in Table (1) that the backcross BC_1 was the heaviest egg weight (50.8 g), compared with F_3 generation and BC_2 (49.7 and 46.3 g, respectively). Moreover, EW trait revealed significant differences (P<0.01) in the three studied groups (Table 2). The previous results are in agreement with those reported by Joseph and Moran (2005) they showed that selection for live body weight of chicken resulted in increased egg size with more proportionately shell weight. Shell thickness and yolk/albumin ratio were highest (0.43 mm and 0.62, respectively) in F_3 generation females compared with the other genetic groups. These values of Sh.Th and Y/Al ratio were differ significantly (P<0.01 and P<0.05, respectively) in F_3 generation. While, the traits Sh.Th and Y/Al ratio in BC_1 being 0.32 mm and 0.61, while the BC_2 had 0.31 mm and 0.59 values for the same traits, respectively, with no significant differences between the backcrosses as shown by Duncan test. The contrasts are shown for egg shape index, where BC_2 backcross being the best among all genetic groups 76.5 while, the same trait (E.Sh.I) being similar in F_3 and BC_1 74.5 and 74.2%, respectively. Table (2) revealed that all egg quality traits showed significant differences among all genetic groups (genotypes). Whereas, the backcrosses (BC_1 and BC_2) were differ significantly (P<0.01) for only egg weight trait, the same trend was found for shell thickness between F_3 and the two backcrosses (BC_1 and BC_2). While egg weight differences between F3 generation and BC_2 were insignificant, as shown by Duncan test (Table, 2). The genetic differences between the studied groups for egg weight were reported by Carter and Jones (1970); Arafa et al. (1982) and Nwachukwu et al., (2006) found that shell thickness was not significantly differing among different genetic groups of chicken. Regarding the obtained hatchability, it could be seen that the hatchability of total egg sets had insignificant differences in the three genetic groups (Table 2). Hatchability was highest (70.8%) in F_3 generation, this value was insignificantly higher than for BC_1 (66.7%) and BC_2 (68.9%), as shown by Duncan test (Table 1). The obtained hatchability in local chickens are in agreement with low hatchability reported in Aseel hen by Kamble et al. (1996); (Byarugaba et al., 2002) reported it ranged

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45-75% in earlier studies in Uganda; (Sola-Oja, 2011) 70.1-78.3% in Nigeria and it was lower than 70-100% reported in other studies by (Fayeye et al., 2005; Alaba, 1990; Atteh, 1990).

Comparing the results of predicted hatchability in relation to input variables (EW, Sh.Th, E.Sh.I and Y/Al ratio) it could be noticed that as the EW in BC_1 (50.8 g) was increased by 1.1 and 4.5 g for F3 and BC_2, respectively. It could be concluded that EW had no significantly affect as the predicted hatchability. As far as the Sh.Th was concerned significant reductions from 0.34 mm in F_3 generation to 0.32 and 0.31 mm in BC_1 and BC_2, respectively. These observed differences have insignificant effects on predicted hatchability. Also Table 1 pointed out that E.Sh.I and Y/Al ratio had no significant effects on predicted hatchability in all genetic groups. These results reflect the application of prediction of hatchability models in this study appears not sufficient to fit all the investigated variables.

b) A Model for Predicting Hatchability

This study provides related model hatchability prediction using EW, Sh.Th, E.Sh.I and Y/Al ratio as well as reference hatchabilities. The following model output where α is the intercept parameter, β_i is the slope parameter for the *ith* explanatory variable and x_i is the observation for the ith explanatory. Table 3 shows the estimated values of parameters and their significance levels. In BC_1 the intercept parameter (α) 241.6 was a highly significant, this means that, if an intercept parameter is included then the determination coefficient (R^2) is simply the square of the sample correlation coefficient between the outcomes and their predicted hatchability. Also, there was a highly significant of slope parameters (β_i) for (Sh.Th) 213.5 in F_3 generation and (EW) 1.126, (E.Sh.I) 79.54 and (Y/Al ratio) 28.03 in BC_2. Furthermore, the mentioned approach above confirms the existence of a highly significant relationship between the main regression parameters and predicted hatchability (Table 3). On the other hand, the linear relationship between the obtained and the predicted hatchabilities in the three genetic groups were insignificant (Table 4).

These results provide that EW, Sh.Th, E.Sh.I, Y/Al ratio and obtained hatchabilities can be used to predict hatchability. These results correspond with those of Farooq et al. (2001) who considered egg and shell weights as the two most important factors affecting hatchability. Moreover, the curvilinear relationship between egg weight and hatchability was investigated by Shatokhina (1975) in fowls, he observed that the hatchability of eggs weighing between 46 and 50 g as well as those weighing between 66 and 74 g was between 8 and 10.5% lower than for eggs weighing between 50 and 66 g. Similar results were obtained by Nordskog and Hassan (1971) who found that hatchability was maximal at an egg weight of about 50 g. Also many authors agree that it is preferable to have eggs of average weight to achieve good hatchability (Wilson, 1991; Brah et al., 1999; Gonzales et al., 1999). Moreover, Tsarenko (1988) suggested that hatchability is not well estimated by considering egg weight alone, but also, by taking into account the ratio of egg weight to shell surface area. On the other hand, determination coefficients adjusted were found (R^2) = 0.08, 0.11 and 0.13 for F_3, BC_1 and BC_2, respectively. These R^2 were closer to 0 indicates a regression line does not fit the data, although the model above confirms the existence of a significant relationship between the main morphological parameters of the egg and predicted hatchability (Wilson, 1991; Narushin, 1997; Narushin and Romanov, 2002a,b). This low relationship could be justified by the fact that, in the hatching process, there were embryos that can adapt to hatch despite inadequate egg morphological parameters.

IV. Conclusion

It could be concluded that the multiple linear regression equation for predicting hatchability using some functional characteristics of egg as well as reference hatchability led to the following model output: $Y = 241.6 + 1.126\,x_1 + 213.5\,x_2 + 79.54\,x_3 + 28.03\,x_4$, where Y presents the predicted hatchability, 241.6 presents the intercept parameter (α) and the 1.126, 213.5, 79.54 and 28.03 are the slope parameters (β_i) of egg weight (x_1), shell thickness (x_2), egg shape index % (x_3) and yolk/albumin ratio (x_4), respectively. Furthermore, the approach above confirms the existence of a highly significant relationship between the main regression parameters and predicted hatchability. On the other hand, determination coefficients adjusted (R^2) were found to be 0.08, 0.11 and 0.13 for F_3, BC_1 and BC_2, respectively. These R^2 were closer to 0 indicates a regression line does not fit the data.

Table 1 : Means and standard deviation of some egg quality traits from third generation and backcrosses

Genotypes	Traits					
	E.W	Sh.Th	E.Sh.I	Y/Al Ratio	Ob. H %	Pr. H %
F3	49.7±5.6[a]	0.34±0.03[a]	74.5±3.5	0.62±0.075	70.8±24.9	71.1±7.1
BC1	50.8±3.8[a]	0.32±0.03[b]	74.2±3.3	0.61±0.065	66.7±19.8	66.9±6.5
BC2	46.3±3.0[b]	0.31±0.03[b]	76.5±6.4	0.59±0.097	68.9±16.3	70.1±5.6

E.W = egg weight, Sh.Th = shell with membranes thickness, E.Sh.I = egg shape index, Y/Al ratio = yolk/albumin ratio, Ob. H %= obtained hatchability, Pr. H %= predicted hatchability, BC1 = backcross of F_2 x Gimmizah parents, BC2 = Backcrosses of F_2 x Bandarah parents, F3 = the third generation, means with the same letters in the same column are not significantly different.

Table 2 : Mean squares of some egg quality traits from third generation and backcrosses

S.O.V	d.f	Traits					
		E.W	Sh.Th	E.Sh.I	Y/Al Ratio	Ob. H %	Pr. H %
Bet. Genotypes	2	104.1**	0.00439**	0.00290**	0.00397*	48.51[NS]	48.03**
Error	54	18.3	0.00089	0.00221	0.00660	425.7	41.99

E.W = egg weight, Sh.Th = shell thickness, E.Sh.I = egg shape index, Y/Al ratio = yolk/albumin ratio, Ob. H %= obtained hatchability, Pr. H %= predicted hatchability, BC1 = backcross of F_2 x Gimmizah parent, BC2 = Backcrosses of F_2 x Bandarah parent, F3 = the third generation, *= significant differences, **= highly significant differences, NS= insignificant differences.

Table 3 : Estimated values of arithmetic parameters in relation to predicted hatchability

Genotype	Arithmetic parameters of hatchability					
	Intercept	E.W	Sh.Th	E.Sh.I	Y/Al Ratio	Pr. H %
F3	-3.05 [NS]	-0.462 [NS]	213.5 **	43.15 [NS]	-12.96 [NS]	71.1
BC1	241.6 **	-1.091 [NS]	-73.99 [Ns]	-103.9 [NS]	-30.19 [NS]	66.9
BC2	-42.01 [NS]	1.126 **	-57.09 [NS]	79.54 **	28.05 **	70.1

E.W = egg weight, Sh.Th = shell thickness, E.Sh.I = egg shape index, Y/Al ratio = yolk/albumin ratio, Pr. H %= predicted hatchability, BC1 = backcross of F_2 x Gimmizah parent, BC2 = Backcrosses of F_2 x Bandarah parent, F3 = the third generation, *= significant differences, **= highly significant differences, NS= insignificant differences.

Table 4 : Relationship between obtained and predicted hatchability

Genotype	Ob. H %	Pr. H %	R^2
F3	70.8	71.1	0.08
BC1	66.7	66.9	0.11
BC2	69.9	70.1	0.13

R^2 = coefficient of determination. BC1 = backcross of F_2 x Gimmizah parent, BC2 = Backcrosses of F_2 x Bandarah parent, F3 = the third generation.

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