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GENETIC EVALUATION FOR EGG QUALITY TRAITS IN CROSBREEDING EXPERIMENT INVOLVING MANDARAH AND MATROUH CHICKENS USING ANIMAL MODEL

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Abstract: *A crossbreeding experiment was carried out between two Egyptian strains namely Mandarah (*MN*) and Matrouh (MA). Forty sires and 450 dams from each strain were used to produce four genetic groups (two purebreds of MNxMN and MAxMA and two crossbreds of MNxMA and MAxMN). Three eggs were taken in successive three months from each daughter within each strain and their crosses (608 daughter) to study the egg characteristics with a total number of 1735 eggs. Egg components such as egg weight (EW), albumen weight (AW), yolk weight (YW), shell weight (SW), and Haugh units (HU); shell characteristics such as shell thickness of narrow (NST), equatorial plan (EST) and broad (BST) regions and egg specific gravity (ESG); and shape indexes such as egg shape index (ESI), albumen index (AI) and yolk index (YI) were studied. Multi-trait animal model was used to analyze the data of egg quality.*

MN had the highest means of egg components, ESG and shape indexes, while MA had the highest means for most shell thickness traits. Estimates of heterosis were positive for most egg components and shape indexes as well as for ESG. While, they were negative for YW, SW and shell thickness. Heritability estimates were moderate or high for egg components (ranged from 0.25 to 0.67), but they were low for HU, shell thickness and shape indexes (ranged from 0.002 to 0.17). Pullets mothered by MN and sired by MA gave an advantage in most egg quality traits over the reciprocal cross.

INTRODUCTION

Egg weight, shell characteristics as well as egg shape index play important role for marketing and/or hatching egg (Hanafi and El-Labban, 1990). One of the most important traits of shell characteristics is shell thickness, since it affects the hatchability percentage. Also, egg specific gravity was considered as a good indicator for both shell weight and shell thickness (Hanafi, 1981; Hanafi and El-Labban, 1990).

Local strains usually were not subjected to intensive selection program and consequently, high additive and non-additive genetic variations appeared to have meaningful effect (Iraqi et al., 2000). This was an encouraging factor to cross our local strains together. Hybrid vigor is considered to be an important tool for producing several strains of chickens. Results of most crossbreeding experiment carried out in Egypt (e.g. Ezzeldin and El-Labban, 1989; Nawar and Abdou, 1999; Nawar and Bahie El-Deen, 2000) reported that crossing between local breeds or strains of chickens with other local ones was generally associated with an existence of considerable heterotic effects on egg quality. Conversely, Kosba et al. (1978) stated that crossbreeding had no advantageous heterotic effect on egg quality.

Many investigators (e.g. Kosba et al., 1978; Ezzeldin and El-Labban, 1989; Nawar and Abdou, 1999; Nawar and Bahie El-Deen, 2000) estimated the crossbreeding effects for egg quality in chickens using sire and/or dam models. While, Van Vleck (1993) reported that a true model for prediction of breeding values from crossbred data, however, also includes the genetic deviations of individual hens from the breed and heterosis constants. Because the breed and heterosis constants usually must be estimated from the same data used to predict the deviations, then the appropriate model is a mixed model for an animal model including the breed and heterosis constants, both direct and maternal genetic effects as well as genetic deviation predictions.

The aim of this work were: (1) to evaluate heterosis, maternal breed additive and direct additive effects and (2) to estimate additive genetic variance and heritability for egg quality traits in purebreds (namely Mandarah and Matrouh) and their crosses using multi-trait animal model analysis.

MATERIAL AND METHODS

Two developed local strains namely Mandarah (MN) and Matrouh (MA) were used in a crossbreeding experiment, which was carried out during the period from March 1990 to December 1991 in the Poultry Breeding Research Station at Inshas, Sharkia Governorate, Animal

Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt.

Breeding Plan

Forty sires and 450 dams from each strain were chosen randomly from 200 cockerels and 1000 pullets, respectively, to produce purebred and crossbred groups of progeny. Pullets of each of the two strains were divided randomly in two breeding pen groups. The first group of hens of each of the two strains was mated with cocks from one strain while the second group was mated with cocks from the other strain. Consequently, eggs produced from the four mating groups (two purebreds of MNxMN and MAxMA and two crossbreds of MNxMA and MAxMN) were collected and incubated in one hatch. The numbers of sires, dams and daughters as well as produced eggs used in all genetic groups are given in Table 1.

On the day of hatch, all chicks were wing-banded, then brooded on the floor and were grown in open houses up to 16 weeks of age. All chicks were medicated similarly and regularly and subjected to the same managerial, hygienic and climatic conditions. During the growing and rearing periods, all chicks were fed *ad-libitum* using diet containing 20.4% and 16% crude protein and 2997 and 2780 metabolizable energy kcal/kg, respectively. All pullets at 17 weeks of age transferred to the rearing houses on the floor using the same diet of rearing period. The pedigreed eggs from each individual hen were collected and recorded regularly.

Measurements Of Egg Quality Traits

Three eggs were taken during three successive months (one egg in each month) from each hen within the four genetic groups (608 daughter). A total number of 1735 eggs were characterized.

The day after laying, all collected eggs were individually weighed to the nearest gram. Egg characteristics such as egg weight (EW), albumen weight (AW), yolk weight (YW) and shell weight (SW) were recorded to nearest gram. Haugh units (HU) were calculated from egg weight and thick albumen height by the conversion chart of interior quality calculator (1959).

Shell thickness of narrow (NST), equatorial plan (EST) and broad (BST) regions were measured to the nearest millimeter using the instrument of Ames shell Thickness Gauge. Egg specific gravity (ESG) was calculated as: ESG = [egg weight / egg volume]; where egg volume = [egg weight – egg weight in water]. Shape indexes such as egg shape index (ESI), albumen index (AI) and yolk index (YI) were calculated. Width and length of eggs were taken by a vernier caliper.

Statistical Analysis

Multi-trait animal model (MTAM) was used to analyze the data of egg characteristics (five traits included in the model in the same time), shell characteristics (four traits included in the model in the same time) and shape indexes (three traits included in the model in the same time). The following model in matrix notation (Henderson, 1984) was used:

$$y = Xb + Za + e$$

Where y= vector of observed egg quality trait on the hen, b= vector of fixed effects of breed group (4 levels) and month (3 months), a= vector of random effect of the hen, X and Z are the incidence matrices relating records to fixed effects and the additive genetic effects, respectively, and e= vector of random residual effects. Variances and covariances obtained by the sire model (REML method using procedure VARCOMP, SAS, 1996) were used as starting values (guessed values) for the estimation of variance and covariance components using MTAM. All calculations of BLUP estimates for MTAM were carried out using the MTDFREML program (Boldman et al., 1995). Convergence was assumed when the variance of the log-likelihood values in the simplex reached $<10^{-6}$. A MTAM was used to estimate direct additive genetic, error, phenotypic variances and heritability. Heritability was computed according to Boldman et al. (1995) as:

$$h_a^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_e^2}$$

Where σ_a^2 and σ_e^2 are variances due to effects of direct additive genetic and random error, respectively.

Estimates of individual direct heterosis, maternal breed additive (i.e. reciprocal crosses differences or breed genetic maternal effect) and direct additive effects for all traits were calculated using the contrast statement in MTDFREML program (Boldman et al., 1995). Estimates of each component were calculated according to Dickerson (1992) as follow:

Direct heterosis (H^I): {[MNxMA + MAxMN] – [MNxMN + MAxMA]}

Maternal breed additive (G^M): [MAxMN – MNxMA]

Direct additive (G^I): {[MNxMN – MAxMA] – [MAxMN – MNxMA]}

RESULTS AND DISCUSSION

Means Of Genetic Groups

Means of egg characteristics and shape indexes in purebreds and crossbreds are given in Table 2. These results showed that MN had the highest means of egg components, ESG and shape indexes compared to MA. Meanwhile, MA characterized by thicker shell in most cases relative to the MN chickens. This is because the MN characterized by larger body weight at sexual maturity (1505 gm) than in MA (1253 gm) as shown in Table 1. Also, body weight at sexual maturity was 1710 gm in MN as showed by Abd el-Gawad, (1981) and 1460 gm in MA as showed by Mahmoud et al. (1974). In addition, the differences between the two strains in their physiological ability could be another cause. Hanafi and El-Labban (1990) with Dokki-4 chickens found that means of HU, ESG, and shell thickness were 82.6, 1.094 mm and 0.403 mm, respectively. Differences between the two purebreds in most traits of egg and shell characteristics were highly significant, while insignificant differences for shape indexes were observed (Table 2). Hanafi (1981) and Ezzeldin and El-Labban (1989) confirmed significant breed effects on shell thickness and ESG ($P<0.05$). While, Hanafi (1981), Kosba et al. (1978) and Ezzeldin and El-Labban (1989) reported non-significant breed effects on egg weight and egg shell index.

In crossbreds, estimates of egg quality were higher in the parental line cross MA than the maternal line one (Table 2). These results may by attributed to sex-linked and maternal effects (Fairfull, 1990)

Direct Heterosis (H^I)

Estimates of H^I were positive for most egg characteristics (EW, AW and HU), shape indexes and ESG (Table 3). However, negative estimates were found for YW, SW and shell thickness. Ezzeldin and El-Labban (1989) showed a negative heterosis estimates for shell thickness when crossed Dandarawi with Silver Montahzah chickens. Bordas et al. (1996) found a significant ($P<0.05$) direct heterosis for egg weight and shell thickness when crossed two lines of Rhode Island Red. Also, Kosba et al. (1978) found significant differences between purebreds and their crossbreds in ESG. Thus, results in this study indicated that crossing between MN and MA are associated with existence of heterotic effects on most egg quality. These results are in agreement with reports of Kosba et al., 1978; Ezzeldin and El-Labban, 1989; Bordas et al., 1996; Nawar and Abdou, 1999; Nawar and Bahie El-Deen, 2000.

Percentages of heterotic effect ranged from -5.25 to 6.18% for egg components, -1.56 to 1.87% for shell characteristics and 1.78 to 11.1% for shape indexes. Most of these ranges are within the range of those compiled by Fairfull (1990) and Nawar and Bahie El-Deen (2000).

Maternal Breed Additive (G^M)

Estimates of maternal breed additive (G^M) are given in Table 4. Percentages of G^M were low or moderate and ranged from –4.11 % to 2.02% for egg components, 0.56 to 1.65 for shell characteristics and –1.41 to 1.02 for shape indexes. Nawar and Abdou (1999) found that percentage of G^M was 4.06% for egg weight when crossed Fayoumi with Rhode Island Red. Bordas et al (1996) found that percentages of G^M were 0.57% for egg weight and 0.30% for shell thickness. Kosba et al., (1978) found significant effects of maternal breed additive on egg weight and egg specific gravity, but non-significant effects on egg shape index.

Estimates of G^M on most egg quality traits were in favor of pullets mothered by MN (Table 4). While, those pullets mothered by MA were superior for only SW, HU and AI. Superiority of MN dams could be due to a large body weight at sexual maturity. Similarly, Nawar and Abdou (1999) concluded that pullets mothered by Fayoumi breed were superior to those mothered by Rhode Island Red.

Direct Breed Additive Effect (G^I)

Estimates of G^I are given in Table 4. Percentages of G^I effects ranged from 0.95 to 4.39% for egg components, -0.1 to -2.86% for shell characteristics and –1.77 to 2.74% for shape indexes. These percentages are agreement with results of Bordas et al. (1996). Kosba et al. (1978) found significant effect of G^I on egg weight and egg shape index. Estimates of G^I showed that MA-sired hens were superior in most egg quality traits compared to MN-sired hens (Table 4). Nawar and Abdou (1999) found that pullets sired by Rhode Island Red were superior in egg weight than pullets sired by Fayoumi.

Variance Components And Heritabilities

Estimates of additive (σ_a^2) and error (σ_e^2) variances for egg quality traits are given in Table 5. Results showed that percentages of σ_a^2 were moderate or high for egg components (ranged from 24.8 to 66.7%) compared to shell thickness (ranged from 15.3 to 17.0%) and shape indexes (ranged from 0.02 to 6.48%). These results indicate that egg components had high additive genetic variance comparable to shell quality and shape indexes. Thus, the improvement of egg components by selection could be possible. These results are in agreement with results of Koerhuis and Mckay (1996) and Francesch et al. (1997).

Heritabilities (h^2) presented in Table 5 indicate that egg components had moderate or high estimates of h^2. They ranged from 0.25 to 0.67 egg components, 0.15 to 0.17 for shell characteristics and 0.002 to 0.06 for shape indexes. It seems that egg components are largely influenced by direct gene additive and therefore could be improved by selection. Based on multi-trait animal model for egg quality, Koerhuis and Mckay (1996) and Koerhuis et al. (1997) found that heritability estimate was high (0.55) for egg weight in broiler chickens. On the other hand, Hanafi and El-Labban (1990) found, based on sire model, that estimates of h^2 for yolk weight was low (0.11) and moderate (0.46) for shell weight, but very high (0.89) for egg specific gravity in Dokk-4 chickens. Also, Hagger (1994) found that estimate of h^2 was 0.75 for egg weight.

Table (1): Number of sires, dams, daughters and eggs used in all genetic groups.

Item	Purebreds+		Crossbreds+		Total
	MN x MN	MA x MA	MN x MA	MA x MN	
Number of sires	20	17	18	18	73
Number of dams	121	120	99	93	433
Number of daughters	182	167	128	131	608
Body weight at sexual maturity	1505	1253	1519	1459	---
Number of eggs	521	467	369	378	1735

+ First letters denoted to breed of sire and the second denoted to breed of dam.

Table (3): Estimates of direct heterosis (H^I) for egg quality traits.

Trait+	Direct heterosis (H^I)	
	Estimate	%++
Egg components:		
EW (gm)	0.687±0.92	1.50
AW (gm)	1.596±0.70	6.18
YW (gm)	-0.714±0.26	-5.25
SW (gm)	-0.252±0.14	-3.99
HU	3.573±1.14	0.48
Shell characteristics:		
NST (mm)	-0.0021±0.005	-0.54
EST (mm)	-0.0043±0.005	-0.37
BST (mm)	-0.0029±0.005	-1.56
ESG	0.0172±0.012	1.87
Shape indexes (%):		
ESI	1.431±0.37	1.85
AI	1.250±0.31	11.1
YI	0.852±0.31	1.78

+Traits as defined in Table 2.

++percentages of H^I computed as {Estimate of H^I / [(MNxMN + MAxMA)/2] x 100}.

Table (2): Means of egg quality traits in purebreds and crossbreds and the difference between purebreds.

Trait[+]	Symbol	Purebred		Purebred difference		Crossbred[++]	
		MN x MN	MA x MA	Estimate±SE	Significance	MN x MA	MA x MN
		Mean±SE	Mean±SE			Mean±SE	Mean±SE
Egg components:							
Egg weight (gm)	**EW**	46.86±0.25	44.63±0.27	2.163±0.63	**	45.89±0.30	46.24±0.30
Albumen weight (gm)	**AW**	26.65±0.19	24.96±0.19	1.681±0.48	**	26.34±0.22	26.81±0.22
Yolk weight (gm)	**YW**	13.87±0.09	13.37±0.09	0.455±0.18	**	13.22±0.10	13.32±0.10
Shell weight (gm)	**SW**	6.34±0.05	6.30±0.05	-0.009±0.09	ns	6.33±0.06	6.11±0.06
Haugh Unit	**HU**	87.22±0.50	86.69±0.53	0.4193±0.753	ns	88.99±0.60	88.51±0.60
Shell characteristics:							
Narrow shell thickness (mm)	**NST**	0.375±0.02	0.373±0.02	0.0016±0.003	ns	0.372±0.02	0.374±0.02
Equatorial shell thickness (mm)	**EST**	0.361±0.02	0.368±0.02	-0.0059±0.003	**	0.362±0.02	0.363±0.02
Broad shell thickness (mm)	**BST**	0.361±0.02	0.366±0.02	-0.0046±0.003	**	0.360±0.02	0.365±0.02
Egg specific gravity	**ESG**	1.048±0.04	1.033±0.04	0.0131±0.008	**	1.040±0.05	1.057±0.05
Shape indexes (%):							
Egg shape index	**ESI**	77.52 ±0.14	77.20 ±0.14	0.365±0.25	ns	77.97 ±0.16	78.17 ±0.16
Albumen index	**AI**	11.33±0.17	11.17±0.18	0.156±0.21	ns	11.96±0.20	11.80±0.20
Yolk index	**YI**	47.83±0.14	47.50±0.15	-0.361±0.21	ns	47.51±0.17	48.00±0.17

[++] First letters denoted to breed of sires and the second denoted to breed of dams.

Table (4): Estimates of direct additive (G^I) and maternal breed additive (G^M) effects for egg quality traits.

Trait[+]	Maternal additive (G^M)		Direct additive (G^I)	
	Estimate	%[++]	Estimate	%[+++]
Egg components:				
EW (gm)	0.518±0.67	1.44	1.644±0.92	3.55
AW (gm)	0.517±0.52	2.02	1.164±0.70	4.39
YW (gm)	0.205±0.19	1.54	0.255±0.26	1.88
SW (gm)	-0.229±0.10	-3.63	0.220±0.14	3.47
HU	-0.418±0.86	-4.11	0.837±1.14	0.95
Shell characteristics:				
NST (mm)	0.0020±0.004	0.56	-0.00037±0.005	-0.10
EST (mm)	0.0013±0.004	1.18	-0.00725±0.005	-2.01
BST (mm)	0.0056±0.004	0.80	-0.01030±0.005	-2.86
ESG	0.0194±0.009	1.65	-0.00627±0.012	-0.60
Shape indexes (%):				
ESI	0.223±0.28	0.29	0.142±0.37	0.18
AI	-0.163±0.23	-1.41	0.319±0.31	2.74
YI	0.483±0.24	1.02	-0.843±0.31	-1.77

[+]Traits as defined in Table 2.
[++]percentages of G^M computed as {Estimate of G^M / [(MAxMA + MNxMA)/2] x 100}.
[+++] percentages of G^I computed as {Estimate of G^I / [(MNxMN + MNxMA)/2] x 100}.

Table (5): Estimates of additive (σ_a^2), error (σ_e^2) variances and heritability (h^2) for egg quality traits.

Trait+	Additive variance		Error variance		Total Variance	Heritability
	σ_a^2	%	σ_e^2	%	σ_P^2	(h^2)
Egg components:						
EW (gm)	10.153	66.7	5.059	33.3	15.212	0.67
AW (gm)	3.260	49.9	3.278	50.1	6.538	0.50
YW (gm)	0.682	29.8	1.603	70.2	2.285	0.30
SW (gm)	0.140	24.8	0.425	72.2	0.565	0.25
HU	1.264	2.0	63.320	98.0	64.585	0.02
Shell characteristics:						
NST (mm)	0.00014	16.3	0.00072	83.7	0.00086	0.16
EST (mm)	0.00013	15.3	0.00072	84.7	0.00085	0.15
BST (mm)	0.00013	16.0	0.00068	84.0	0.00081	0.16
ESG	0.00760	17.0	0.00370	83.0	0.00446	0.17
Shape indexes (%):						
ESI	0.1615	6.48	8.874	93.52	9.489	0.06
AI	0.280	3.54	7.639	96.46	7.919	0.04
YI	0.002	0.02	10.366	99.98	10.368	0.002

+Traits as defined in Table 2.

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Mandarah And Matrouh Chickens, Egg Quality Traits, Heterosis, Maternal Additive, Direct Additive, Heritability, Multi-Trait Animal Model.

الملخص العربى

التقييم الوراثى لصفات جودة البيضة فى تجربة خلط شملت دجاج المندرة والمطروح باستخدام نموذج الحيوان

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قسم الانتاج الحيوانى – كلية الزراعة بمشتهر – جامعة الزقازيق /فرع بنها – مصر

أجريت تجربة خلط بين دجاج المندرة والمطروح حيث استخدم 40 أب ، 450 أم عشوائيا لانتاج أربعة مجاميع وراثية (مندرة x مندرة ، مطروح x مطروح ، مندرة x مطروح ، مطروح x مندرة) . وقد أخذ ثلاثة بيضات من كل بنت داخل كل سلالة وكذلك خلطانها (608 دجاجة) فى ثلاثة شهور متتالية (بيضة واحدة كل شهر) لدراسة صفات جودة البيضة فى عدد 1735 بيضة من كل المجاميع الوراثية. وكانت الصفات المدروسة : مكونات البيضة (وتشمل وزن البيضة ، وزن الألبيومين ، وزن الصفار ، وزن القشرة ، وحدات "هو") وصفات القشرة (وتشمل سمك القشرة فى الطرف الضيق ، الطرف العريض ، السطح المستوى للقشرة والكثافة النوعية للبيضة) وصفات أدلة الشكل (وتشمل دليل شكل البيضة ، دليل الصفار ، دليل البياض) . وتم تحليل البيانات باستخدام نموذج الحيوان متعدد الصفة بهدف تقدير قوة الهجين المباشرة ، التأثير الأمى التجمعى ، التأثير التجمعى المباشر ، والمعايير الوراثية للصفات. وقد أظهرت النتائج ما يلى:

١. كانت متوسطات صفات البيضة والكثافة النوعية للبيضة وأدلة الشكل الأعلى فى دجاج المندرة ، بينما كانت معظم متوسطات سمك القشرة الأعلى فى دجاج المطروح .

٢. كانت تقديرات قوة الهجين موجبة لمعظم صفات البيضة وأدلة الشكل وكذلك للكثافة النوعية للبيضة ، بينما كانت التقديرات سالبة لصفات وزن الصفار وسمك القشرة .

٣. كان تأثير كل من قوة الهجين والأثر التجمعى المباشر والأثر الأمى التجمعى للسلالة عالى المعنوية لمعظم صفات مواصفات البيضة .

٤. كانت تقديرات المكافئ الوراثى متوسطة و مرتفعة القيمة لصفات البيضة (تراوحت من 0.25 الى 0.67) ولكنها كانت منخفض القيمة لوحدات "هو" وسمك القشر وأدلة شكل البيضة (تراوحت من 0.002 الى 0.17) .

٥. أظهرت النتائج أن البدارى الناتجة من أم مندرة وأب مطروح أعطت تفوقا واضحا فى معظم صفات جودة البيضة عن البدارى الناتجة من الخلط العكسى .