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ESTIMATION OF VARIANCE COMPONENTS BASED ON DIALLEL CROSSES OF FOUR LINES OF NORFA CHICKENS

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Abstract

Data of full 4 x 4 diallel crosses involving four Norfa lines of chickens characterized with early sexual maturity (LSM), more egg number at the first ninety days of laying (LEN), heavy egg weight mean of the first laid five eggs (LEW) and heavy body weight at sexual maturity (LBW), were analyzed by Griffing (1956) method I model II. A total of 60 males and 180 females were used to produce each line cross and line group. The L BW parental line had the highest body weights at hatch, 4, 8, 12 and 16 weeks of age (i.e. 34.2, 225.5, 536.3, 1049.3 and 1561 g., respectively). The additive genetic variances (δ^2 A) for body weight were 1.66, 100.48, 595.19, 8188.45 and 31800.59 for body weights at hatch, 4, 8, 12 and 16 weeks of age, respectively. The non-additive genetic variance (δ^2 s) were 1.65, 208.18, 655.3, 1484.73 and 3878.7 at the same ages, respectively. The estimates of general combining ability / specific combining ability mean squares ratio were 0.50, 0.24, 0.45 , 2.75 and 4.09 for body weights at hatch, 4, 8, 12 and 16 weeks of age, respectively. Heritability estimates were 0.31, 0.28, 0.13, 0.42 and 0.66 for the same ages. These estimates showed an increase of additive genetic variance (δ^2 A) as the age advanced.

INTRODUCTION

One of the most effective breeding methods for increasing the genetic variations is to partition the population into lines and crossing these lines to exploit both additive and non-additive variations. The genetic variance components are useful as parameters to predict the amount of heterosis expected in the next generation.

However, most of the native breeds had high non-additive genetic variance (Shebl *et. al.*, 1990). Similar results were found by Mandour *et. al.*, (1992) for body weights at hatch, 4 and 7 weeks of age in Alexandria and commercial broiler strains of chickens (Cobb and Nichols). Also Mandour *et. al.*, (1996) found the same results for

body weight at 12 weeks of age in the crosses of local breeds (i.e. Alexandria, G. Montazah, S. Montazah and Matrouh).

Diallel crosses of four lines of Norfa chickens were performed when studying the genetic variance components for body weight traits. The diallel analysis provides information on the nature and amount of genetic parameters and general and specific combining abilities of parents and their crosses, respectively. Therefore, data in the present experiment were analyzed according to the method 1 of Griffing (1956), with parental line (P) and P (P-1)/2 for crosses.

The main purpose of this study was to estimate the components of genetic variance of body weight traits. To achieve this purpose, four lines of Norfa chickens were developed by using four sub-indices proposed by Abdou *et. al.*, (1997). These lines characterized as early in reaching sexual maturity , more egg number laid in the first 90 d. of laying, heavy egg weight at sexual maturity and heavy body weight at sexual maturity. Crossing these lines was carried out to determine whether parental lines had desirable genetic effects on body weight traits.

MATERIALS AND METHODS

The present experiment had been carried out at the Poultry Farm of the Faculty of Agriculture, Minufiya University, Shebin El-Kom, Egypt as a part of the Norwegian – Egyptian Project " NORFA" for improving hens .

EXPERIMENTAL STOCK

The experiment started on 1997 / 1998 , four dam lines of " NORFA" chickens were developed by using four sub indices, IGSM , IGEN, IGEW and IGBW, which characterized with high performance in a specific trait (i.e. sexual maturity, egg number at the first ninety days of laying, egg weight mean of the first laid five eggs and body weight at sexual maturity, respectively)(Abdou *et. al.*, 1997).

The dam lines were artificially inseminated with two sire lines (i.e. light body weight and heavy body weight). The line of light body weight males was mated to the two dam lines sexual maturity (LSM) and egg number (LEN), while, the sire line of heavy body weight was mated to the two dam lines body weight (LBW), and egg weight (LEW).

In 1999 /2000, a total of 60 males and 180 females were used to produce each line cross and line group. A full 4x 4 diallel cross was used, which resulted in four

pure – lines, six cross line and six reciprocal cross line progenies. Four shifts of males were involved in producing the crosses. Each shift was composed of a different sample of males (15 males per line and shift).

Management conditions were similar as possible as throughout the experiment. Fertile eggs were collected from each dam twice a week and stored with broad ends up in egg cooler at 55° F and 85-90 % relative humidity. The stored eggs were moved to hatching room one night before incubation in full-automatic draft machine. At one day old, all chicks were wing-banded and weighed to the nearest gram. The chicks were fed ad libitum a starter ration containing 18.0 % crude protein and 2825.0 Kcal ME/kg.

THE STUDIED TRAITS

Body weight at different ages

Body weights at hatch , 4 , 8 , 12 , and 16 weeks of age were recorded for the parental lines and F1 crosses.

STATISTCAL ANALYSIS

The data were first analyzed to test the significance of the ten different genotypes (Snedecor and Cochran, 1974). If the genotype mean squares were found to have significant difference there was a need to proceed for further analysis (i.e. combining ability analysis). Duncan's new multiple range test was used to compare every two means of the different traits studied (Steel and Torrie , 1960).

Combining ability analysis and genetic components were computed according to Griffing (1956). Method I model II (random model) with parent lines (P), P (P-1)/2 F'1s and reciprocals.

Heritability in the narrow sense was defined as that fraction of total variance associated with only the additive genetic component of variance, (Luch, 1949) .

$$h^2 = 2\delta^2 g \; / \; 2\delta^2 g + \delta^2 s + \delta^2 r + \delta^2 e$$

where, $\delta^2 g$, the variance due to general combining ability.

$\delta^2 s$ = the variance due to specific combining ability.

$\delta^2 r$ = the variance due to reciprocal effect.

$\delta^2 e$ = the variance due to sampling error.

RESULTS AND DISCUSSION

A – Means

Table 1 presents live body weights for different genetic groups. Data showed that the L BW parental line had the highest body weights at hatch, 4, 8, 12 and 16 weeks of age (i.e. 34.2, 225.5, 536.3, 1049.3 and 1561 g., respectively). Most of crosses had body weights at hatch lower than those of their parental lines except the cross LEW x LSM (29.6 g.) which was higher than its parental lines and the cross LBW x LEW (32.6 g.) which was higher than the parental line L EW (27.6 g.). However, crosses of LEN x LSM , LEW x LSM and LEW x LEN yielded heavier body weight than those of their mid-parental lines at 4 weeks of age (i.e. 192, 181 and 180.7 g., respectively).

At 8 weeks of age, body weights of the crosses LEN x LSM, LBW x LSM, LBW x LEN, LBW x LEW and LEW x LEN were 528, 539, 578.3, 597.7 and 549 g., respectively. On the other hand, the crosses LEN x LSM , LBW x LSM, LBW x LEN, LBW x LEW and LEW x LEN had the heaviest weights at 12 weeks of age (i.e. 902.6, 981.3, 1093, 1131.7 and 964 g., respectively). Those crosses had the heaviest weights at 16 weeks of age also (i.e. 1127.7 , 1312.7 , 1520 , 1634.7 and 1266 g., respectively).

Analysis of variance for body weight at different ages are presented in Table 2. Data revealed that there were highly significant differences among genotypes at all ages studied. Duncan's new multiple range test differences among these means were significant (Table 1). However, body weight of chick at hatching depended mainly on egg size. These findings dealt with those cited by, Bordas *et.al.*, (1996) who reported that the average body weight at 8 weeks of age were 687.8, 712.8, 715.2 and 741.7 g. for line (R+), line (R-) of R.I.R. and their F1 crosses (R+R-) and (R-R+), respectively. El-Gendy (2000) showed that the chicks from pure genotype RR were significantly heavier than pure genotype SS at 2, 4 and 6 weeks of age, while, the chicks of both reciprocal crosses RS and SR were not significantly different in body weight at all ages. Hanafi and Iraqi (2001) reported that the overall means of body weight at 8 weeks of age were 679.9 and 676.5 g. for purebreds (i.e. N. Hampshire , W. P. Rock , W. Cornish and W. Leghorn) and their crosses, respectively.

B – Effect of combining ability

Analysis of variance for general and specific combining abilities (GCA and SCA) of body weight are presented in Table 3. It was noticed that there were highly significant

differences due to SCA at all ages studied, while, the variance due to GCA was highly significant at all ages except at hatch. Moreover, the variance due to reciprocal effects was highly significant at 8, 12 and 16 weeks of age, but, it was significant at hatch and insignificant at 4 weeks of age. These observations suggested that additive and non-additive gene effects were of major importance in the inheritance of body weight of chickens.

These findings are dealing with those presented in Table 4, which showed that the additive genetic variance (δ^2 A) of body weight at hatch was 1.66 and the non-additive genetic variance (δ^2 s) at the same age was 1.65. Meanwhile, the intermediate estimated GCA / SCA mean squares ratio (0.50) and the estimate of heritability (0.31) indicated that the additive and non-additive gene effects played the main role in the inheritance of body weight at hatch. Regarding body weight at 4 weeks of age, Table 4 showed that GCA mean square was 50.24 vs. 208.18 for SCA mean square, while, the low obtained δ^2g / δ^2 s ratio (0.24) and medium heritability estimate (0.28) suggested that non-additive portion was more important than additive and have the main role in controlling this trait.

Similar results were found in body weight at 8 weeks of age, the low estimated (δ^2g) 297.59 , additive genetic variance (δ^2A) 595.19, δ^2g / δ^2s ratio 0.45 and low estimate of heritability 0.13 on the contrary of high obtained SCA mean square (δ^2s) 655.30 suggested that non-additive gene effects controlled body weight at 8 weeks of age.

Table 4 illustrates that GCA / SCA mean squares ratio was obtained to be high 2.75 and 4.09 for body weights at 12 and 16 weeks of age. Also, additive genetic variances were 8188.45 and 31800.59 for body weights at 12 and 16 weeks of age, respectively. These estimates showed an increase of additive genetic variance (δ^2A) as the age advanced. Also the heritability estimates (i.e. 0.42 and 0.66 for body weight at the same ages) dealt with this conclusion. These results were in agreement with those of Amrit (1980) who found that there were significant GCA , SCA and reciprocal effects for body weight at 12 weeks of age. Contrarily, Shebl *et. al.* (1990) reported that, most of the native breeds had high non-additive genetic variance.

It is evident, from the results discussed that, additive variance was the most important for most body weight traits studied. Therefore, breeding by selection is appropriate and should be effective to the improvement of these traits.

Table 1. Means and S.E of body weights at different ages in the different genetic groups.

Pure lines	day-old		4-wks.		8-wks.		12-wks.		16-wks.	
	$\bar{X}$ ± S.E		$\bar{X}$ ± S.E		$\bar{X}$ ± S.E		$\bar{X}$ ± S.E		$\bar{X}$ ± S.E	
L SM	29.3 ± 0.36	c	173.8 ± 4.05	b	449.0 ± 12.36	e	751.7 ± 21.03	gh	1036.5 ± 27.02	ef
L EN	30.8 ± 0.81	bc	182.7 ± 7.79	b	522.0 ± 20.42	b	883.7 ± 15.2	e	1139.7 ± 8.65	c
L BW	34.2 ± 0.66	a	225.5 ± 5.49	a	536.3 ± 8.71	b	1049.3 ± 18.94	b	1561.0 ± 32.28	a
L EW	27.6 ± 0.53	d	169.0 ± 5.24	b	517.0 ± 13.96	bc	966.7 ± 13.31	c	1378.3 ± 14.91	b
Mean	30.5		187.8		506.1		912.9		1278.9	
Cross lines										
LSM x LEN	27.8 ± 0.64	cd	160.7 ± 6.19	cd	480.0 ± 16.03	cd	811.7 ± 17.17	fg	1036.7 ± 16.85	e
LSM x LBW	27.6 ± 0.46	d	163.7 ± 6.24	bc	375.7 ± 17.19	f	707.0 ± 13.49	h	1038.0 ± 15.39	e
LSM x LEW	26.0 ± 0.54	f	147.3 ± 4.41	e	434.7 ± 18.39	e	760.0 ± 25.43	g	1069.0 ± 27.64	de
LEN x LSM	30.0 ± 0.79	c	192.0 ± 7.38	b	528.0 ± 18.20	b	902.6 ± 32.03	de	1127.7 ± 19.23	cd
LEN x LBW	28.9 ± 0.82	c	185.3 ± 5.39	b	432.3 ± 6.65	e	821.0 ± 8.25	f	1201.3 ± 11.43	bc
LEN x LEW	26.6 ± 0.69	ef	157.3 ± 6.78	de	482.7 ± 13.66	c	875.3 ± 12.71	ef	1245.7 ± 17.91	b
LBW x LSM	30.3 ± 0.55	c	173.9 ± 5.52	b	539.0 ± 15.23	b	981.3 ± 26.92	c	1312.7 ± 13.46	b
LBW x LEN	29.6 ± 1.03	c	185.0 ± 9.29	b	578.3 ± 20.52	a	1093.0 ± 33.69	ab	1520.0 ± 33.90	a
LBW x LEW	32.6 ± 0.74	ab	191.7 ± 5.64	b	597.7 ± 14.41	a	1131.7 ± 22.85	a	1634.7 ± 35.12	a
LEW x LSM	29.6 ± 0.86	c	181.0 ± 7.90	b	471.3 ± 15.21	de	784.7 ± 21.24	g	1020.0 ± 26.63	f
LEW x LEN	27.4 ± 0.66	de	180.7 ± 5.91	b	549.0 ± 9.49	ab	964.0 ± 12.02	cd	1266.0 ± 13.44	b
LEW x LBW	29.8 ± 0.72	c	189.0 ± 5.86	b	458.3 ± 13.32	e	883.4 ± 9.33	e	1307.3 ± 9.06	b
Mean	28.9		175.6		493.9		892.9		1232.3	

Means in columns with different letters within the same age are differ significantly at 0.05 level.

Table 2. Analysis of variance for body weight at different ages.

S.O.V	d.f	W0	W4	W8	W12	W16
		M.s	M.s	M.s	M.s	M.s
Bet. rep.	2	2.23 NS	133.96 NS	989.28 NS	3537.65 *	643.87 NS
Bet. treat.	15	13.81 **	977.21 **	11094.46 **	47184.86 **	117428 **
Error	30	2.82	122.31	421.58	835.28	1807.22

Equal number for each treatment withn trait = 15

** significant at 1 % level.

* significant at 5 % level.

NS = not significant.

W4 = 4 weeks body weight.

W0 = day-old weight.

W12 = 12 weeks body weight.

W8 = 8 weeks body weight.

W16 = 16 weeks body weight.

Table 3. Analysis of variace for combining ability of body weight at different ages.

S.O.V	d.f	W0 M.s		W4 M.s		W8 M.s		W12 M.s		W16 M.s	
GCA	3	10.071	NS	754.96	**	3504.24	**	35259.3	**	133627	**
SCA	6	3.63	**	379.06	**	1205.39	**	2691.11	**	6905.3	**
r. effects	6	2.83	*	57.79	NS	6287.87	**	18999.9	**	24138.3	**
error	30	0.94		40.77		140.52		278.42		602.4	

** significant at 0.01 level.
* significant at 0.05 level.
NS = not significant.
GCA = General combining ability.
SCA = Specific combining ability.
r = Reciprocal effects.
W0 = day-old weight.
W4 = 4 weeks weight.
W8 = 8 weeks weight.
W12 = 12 weeks weight.
W16 = 16 weeks weight.

Table 4. Components of genetic variance , d^2 g / d^2s ratio and heritability estimates for body weight at different ages.

Genetic parameters	W0	W4	W8	W12	W16
δ^2 g	0.83	50.24	297.59	4094.22	15900.8
δ^2 s	1.65	208.18	655.3	1484.73	3878.7
δ^2 r	0.94	8.51	3073.67	9360.75	11767.9
δ^2 e	0.94	40.77	140.52	278.42	602.4
δ^2 A	1.66	100.48	595.19	8188.45	31800.6
δ^2 g / δ^2 s	0.5	0.24	0.45	2.75	4.09
$h^2 \delta$	0.31	0.28	0.13	0.42	0.66

W0 = day-old weight. W4 = 4 weeks weight.

W8 = 8 weeks weight. W12 = 12 weeks weight.

W16 = 16 weeks weight. δ^2 g = variance due to GCA

δ^2 s = variance due to SCA δ^2 r = variance due to reciprocal effects

δ^2 e = error variance δ^2 A = additive genetic variance

h^2 = heritability estimates

δ^2 g / δ^2 s = the ratio between mean squares of GCA / SCA

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تقدير مكونات التباين علي أساس التهجين التبادلي لأربعة خطوط من سلالة دجاج النورفا

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تم تحليل بيانات الهجن التبادلية لأربعة خطوط من سلالة دجاج النورفا تميزت بالنضج الجنسي المبكر (LSM)، أكبر عدد من البيض خلال التسعين يوم الأول من الإنتاج (LEN)، اثقل متوسط وزن لأول خمس بيضات من الإنتاج (LEW) وأثقل متوسط لوزن الجسم عند النضج الجنسي (LBW) بواسطة الطريقة الأولي الموديل الثاني (الموديل العشوائي) Griffing 1956 وقد استخدم عدد ٦٠ ديكاً وعدد ١٨٠ دجاجة لإنتاج مجاميع الأباء والهجن المختلفة.

أظهرت النتائج أن السلالة الأبوية LBW كانت الأعلى في وزن الجسم عند الفقس ، ٤ ، ٨ ، ١٢ و١٦ أسبوعاً من العمر (٣٤,٢ ، ٢٢٥,٥ ، ٥٣٦,٣ ، ١٠٤٩,٣ و ١٥٦١ جرام علي التوالي). بلغت قيم التباين الوراثي المضيف (σ^2_A) ١,٦٦ ، ١٠٠,٤٨ ، ٥٩٥,١٩ ، ٨١٨٨,٤٥ و ٣١٨٠٠,٥٩ لوزن الجسم عند الفقس ، ٤ ، ٨ ، ١٢ و ١٦ أسبوعاً من العمر علي التوالي في حين أن قيم التباين الوراثي الغير مضيف (σ^2_S) ١,٦٥ ، ٢٠٨,١٨ ، ٦٥٥,٣ ، ١٤٨٤,٧٣ و ٣٨٧٨,٧ لوزن الجسم عند نفس الأعمار السابقة.

قدرت النسبة σ^2_S / σ^2_g بـ ٠,٠٥ ، ٠,٢٤ ، ٠,٤٥ ، ٢,٧٥ و ٤,٠٩ وذلك لوزن الجسم عند الفقس ، ٤ ، ٨ ، ١٢ و ١٦ أسبوعاً من العمر ، كما قدرت نسبة التوريث h^2 بـ ٠,٣١ و ٠,٢٨ و ٠,١٣ و ٠,٤٢ و٠,٦٦ لوزن الجسم عند نفس الأعمار السابقة. هذه التقديرات أوضحت زيادة التباين الوراثي المضيف لصفة وزن الجسم مع التقدم في العمر.