GENETIC STUDIES ON YOLK AND PLASMA CHOLESTEROL CONCENTRATION IN A LOCAL LAYING HENS STRAIN
2- CORRELATED RESPONSE OF REPRODUCTIVE TRAITS

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Abstract

The present experiment was conducted throughout five successive generations to decrease the egg yolk cholesterol concentration in local strain, selected for egg production traits. Cholesterol and total lipids concentration for egg yolk and plasma were determined and reproductive traits were taken to calculate the correlated response for low level of egg yolk cholesterol content. Fertility and hatchability percentage, age and body weight at sexual maturity, egg number, egg weight and egg mass during the first 90 days of laying estimated the h^2_s for these traits. The main results obtained could be summarized as follows:

Selection for low level of egg yolk cholesterol content decreased both hatchability percentage and body weight at sexual maturity by 1.96% and 0.07 g, respectively, after four generations of selection, but, increased age at sexual maturity, egg number, egg weight and egg mass by 6.7 day, 4.27 egg, 1.59g and 260.62g, respectively. The heritability for age and body weight at sexual maturity, egg number, egg weight and egg mass during the first 90 days of laying were 0.19, 0.32, 0.05, 0.12 and 0.11, respectively, for selected line, while, the corresponding estimates for control line were 0.51, 0.34, 0.47, 0.13 and 0.18, respectively.

INTRODUCTION

Selection experiment for improving certain trait has frequently resulted in the occurrence of a correlated response in unselected traits (Marks, 1990). The association between selected and unselected traits is due to the genetic effects, environmental influences and combination of both . Pleiotropy is probably the main cause of correlation between traits. Linkage is another important cause which has a similar transitory effect.

Selection for improving certain traits sometimes resulted in a correlated response for other traits unselected. If the unselected traits represent the total fitness, these traits may be expected to decline in response to selection for other traits (Falconer, 1981).

The amount of cholesterol in eggs is known to be influenced by genetic as well as environmental factors and many methods have been used to reduce the amount of cholesterol in egg yolk. These included the use of anti-cholesterol agents in the birds' feed and supplementation diets with different kinds of probiotics and selective breeding. Jiang *et al.* (1990) reported that no influence was found for hatchability percentage when added 1% cholesterol for the diet for S.C.W. Leghorn. El-Kin and Yan (1999) reported that the overall correlation of egg cholesterol content with hatchability was high (0.82), and hatching rates rangied from 0 to 67 % in different weeks. Washburn and Marks (1977) studied selection for divergence yolk cholesterol concentration for four generations in the Athens Canadian population, and for three generations in the Cornell Leghorn population. In both populations, the high yolk cholesterol lines matured later than the low yolk cholesterol lines. Washburn and Marks (1985) found that mean of egg weight of the high cholesterol line was 3 g greater than that of the low one after selection for divergence yolk cholesterol concentration in both Athens Canadian and Cornell Leghorn populations. Many studies have confirmed a significant inverse relationship between yolk cholesterol concentration and egg production traits (Washburn and Marks, 1977). The aim of the present study was estimated for the correlated response as a result of selection for low yolk cholesterol content on reproductive traits.

MATERIALS AND METHODS

The present experiment was conducted at the Poultry Research Center, Poultry production Department, Faculty of Agriculture, Alexandria University, throughout five successive generations from 1996/1997 to 2000/2001. Two lines were used of Alexandria strain in this study in each generation. The first line was selected for low level of yolk cholesterol (milligrams cholesterol/gram yolk). The females were selected according to combined selection and the males were selected according to the records of their full and half- sib sisters. The second line was taken randomly as a control. Both the selected and control lines had used 12-15 breeding pens in each generation to produce the pedigree chicks. All experimental parents and chicks had received as possible the same managerial treatments through the period of the experiment. The pedigreed eggs were set in an electric forced draft incubator, the percentages of fertility and hatchability were recorded. Age and weight at sexual maturity were calculated and egg number and weight during the first 90 days of production were recorded daily. All data analysis were performance least squares means (SPSS 8. 1997), the pooled heritability estimates and standerd errors based on sire variance components calculated were performed according to the following model (Harvey 1990).

$$\mathbf{Y_{ijk} = \mu + S_i + G_j + e_{ijk}}$$

Where: μ = the overall mean, $\mathbf{S_i}$= the effect of the i Th sire,

$\mathbf{G_j}$= the effect of the j th generation, $\mathbf{e_{ijk}}$= the random error.

RESULTS AND DISCUSSION

Least square means of fertility percentages are shown in Table 1, while, the eggs of the first generation had the highest value of fertility percent (94.17%) as average of the two lines, eggs of the 3rd generation had the lowest one (87.75%). The analysis of variance showed highly significant differences ($p \leq 0.001$) within generations and lines. There is a clear effect of the selection for low level of egg yolk cholesterol concentration on the egg fertility percentages. As for estimates of hatchability percentage of the fertile eggs produced from the two lines are shown in Table 1. It could be seen that the overall means of hatchability percent were 86.93 and 87.05 for both the selected and the control lines, respectively. The differences between generations were highly significant ($p \leq 0.001$) and the difference between the two lines was insignificant, These results agreed to those reported by Cuningham *et al.* (1974) who reported that the selected line had a lower value of fertile eggs hatchability than the control one using selection for low egg yolk cholesterol concentration The cumulative correlated response for this trait was –1.96 as a result of selection for lower egg yolk cholesterol concentration (Table 2).

Least square means for age and body weight at sexual maturity as affected by generations and lines are displayed in Table 3. Pullets at the base and the third generations were significantly heavier than the pullets of the other ones. Results in Table 2 indicated that the cumulative response for body weight at sexual maturity was negative (-0.07 g) as a result of selection for low egg yolk cholesterol content. The overall means of age at sexual maturity after four generations of selection for low egg yolk cholesterol content were 165.37 and 165.69 days for the selected and control lines, respectively. No significant difference was found between the two lines. The cumulative correlated response for age at sexual maturity was 6.74 days.

Least square means of the average of egg number, egg weight and egg mass during the first 90 days of laying as influenced by the generations and the lines are shown in Table 4. Egg number, produced during the first 90 days from the selected pullets significantly increased during all generations studied, compared with the control. Depending on the overall mean, the selected pullets produced significantly ($p \leq 0.001$) more eggs than control one (55.89 vs. 52.04), generally, the overall mean of egg number during the first 90 days of laying was 54.49 eggs. The cumulative correlated response for this trait was 4.27 eggs as a result of selection for low egg yolk cholesterol content. Washburn and Marks (1977) reported that selection for low egg yolk cholesterol content in two different populations increased egg laying rate after three and four generations.

In contrast, Ansah *et al.* (1985) found that selection for low yolk cholesterol concentration for three generations in White Leghorn cannot be attributed to egg production. Average weight of eggs produced from pullets of the 3rd generation was significantly heavier (46.56 g) than those produced by the other ones, while mean weights of the eggs produced at the base generation were the lowest (42.84 g). Eggs produced from the selected pullets were heavier than those produced by the control ones (45.14 vs. 44.69 g). There were highly significant differences between the four generations and between the two lines. The cumulative correlated response for this trait was 1.59 g. This selection increased egg weight as found by El-Medney *et al.* (2001) , but, Ansah *et al.* (1985) suggested that egg weight did not contribute in Leghorn population. Also, pullets of the base generation produced the highest egg mass while, the pullets of the 1st generation had the lowest values of egg mass during the first 90 days of laying. Highly significant differences ($p \leq 0.001$) were found among the four generations and between the two lines, the selected pullets produced egg mass heavier than the control ones, the cumulative response for egg mass during the first 90 days of laying as a result of selection for low egg yolk cholesterol content was 260.62 gm. As mentioned before this selection increased both egg number and weight as reported by Ansah *et al.* (1985). The pooled heritability estimates and standard errors (S.E.) based on sire variance components for body weight and age at sexual maturity, egg production traits (egg number, egg weight and egg mass) during the first 90 days of laying were presented in Table 5. The pooled sire component estimates of heritability for body weight and age at sexual maturity of the selected line were 0.19 and 0.32, respectively. Similar results were reported by El-Tahawy (2000). Also, the pooled estimates of h^2_s for egg number, average egg weight and egg mass during the first 90 days of the selected line were 0.05, 0.12 and 0.11, respectively. These results were lower than those reported by Kotajah and Renganathan (1981), while, they were in agreement with those reported by El-full (2001). In summary, the h^2_s estimates of the selected line traits were generally lower than those of the control line. Selection decreased the genetic variance as reported by Dunnington and Siegel (1985).

In conclusion, after four successive generations, selection for low level of egg yolk cholesterol content in Alexandria strain decreased hatchability percentage and body weight at sexual maturity, but, increased age at sexual maturity, egg number, egg weight and egg mass during the first 90 days.

Table 1 . Least-square means $(\overline{X})$ and standard errors (±S.E.) of the fertility and hatchability percentages by generations and lines .

Generation	Line	N*	Fertility %	Hatch of fertile eggs %
1	Selected	50	95.66 ± 0.98	91.41 ± 1.66
	Control	38	92.21 ± 1.49	89.95 ± 1.76
	Total	88	94.17 ± 0.86^{A}	90.78 ± 1.21^{A}
2	Selected	47	95.68 ± 0.84	91.96 ± 1.30
	Control	38	90.44 ± 1.29	90.16 ± 1.73
	Total	85	93.34 ± 0.79^{A}	91.16 ± 1.05^{A}
3	Selected	52	86.68 ± 1.26	78.89 ± 1.68
	Control	38	89.22 ± 1.62	81.63 ± 2.58
	Total	90	87.75 ± 1.00^{B}	80.05 ± 1.46^{C}
4	Selected	44	94.96 ± 1.06	85.95 ± 1.45
	Control	38	81.40 ± 4.13	86.45 ± 2.34
	Total	82	88.68 ± 2.18^{B}	86.18 ± 1.32^{B}
Overall mean	Selected	193	93.09 ± 0.60^{a}	86.93 ± 0.86
	Control	152	88.32 ± 1.28^{b}	87.05 ± 1.09
	Total	345	90.98 ± 0.67	86.98 ± 0.68

Means in each column within each factor having the same letter are non-significant at $P \leq 0.05$

* Number of dam

Table 2 . Realized correlated response for reproductive traits in selected line by generations.

Traits	Generations				
	1	2	3	4	Total
Hat.F.E %	-	0.34	-4.54	2.24	-1.96
BWSM (g)	81.8	-36.73	18.56	-63.7	-0.07
ASM (d)	6.56	-2.89	1.00	3.07	6.74
EN During the first 90 days (egg)	-0.57	-0.3	-1.38	6.52	4.27
EW During the first 90 days (g)	1.37	0.33	0.83	0.8	1.59
EM During the first 90 days (g)	50.76	15.11	-147.19	341.95	260.62

Hat.F.E %:hatchability percentage BWSM: Body weight at sexual maturity, ASM: Age at sexual maturity
EN: Egg number, EW: Egg weight, EM: Egg mass

Table3 . Least-square means ($\overline{X}$) and standard errors (± S.E.) for age (ASM) and body weight at sexual maturity (BWSM) by generations and lines.

Generation	Line	N.	ASM (d)	BWSM (gm)
			$\overline{X}$ ± S.E.	$\overline{X}$ ± S.E.
0	Selected	107	147.97 ± 1.08	1557.51 ± 15.34
	Control	47	150.70 ± 1.84	1626.38 ± 21.69
	Total	154	148.11 ± 0.94^{C}	1578.53 ± 12.77^{A}
1	Selected	101	154.02 ± 1.18	1465.90 ± 20.84
	Control	81	151.19 ± 1.08	1452.97 ± 19.78
	Total	182	152.76 ± 0.82^{B}	1460.15 ± 14.50^{C}
2	Selected	148	147.42 ± 1.01	1457.05 ± 13.74
	Control	68	147.48 ± 1.38	1480.85 ± 23.03
	Total	216	147.44 ± 0.82^{C}	1464.55 ± 11.88^{C}
3	Selected	152	186.48 ± 1.31	1610.68 ± 14.84
	Control	83	185.54 ± 1.66	1615.92 ± 19.24
	Total	235	186.15 ± 1.03^{A}	1612.53 ± 11.74^{A}
4	Selected	106	189.55 ± 1.72	1505.38 ± 20.56
	Control	74	185.54 ± 1.88	1574.32 ± 23.31
	Total	180	187.91 ± 1.28^{A}	1533.72 ± 15.61^{B}
Overall mean	Selected	416	165.37 ± 0.96	1522.39 ± 7.86^{b}
	Control	353	165.69 ± 1.18	1543.18 ± 10.30^{a}
	Total	967	165.49 ± 0.75	1530.71 ± 6.25

Means in each column within each factor having the same letter are non-significant at $P \leq 0.05$.

Table 4 . Least- square means ($\overline{X}$) and standard errors (±S.E.) of egg number (egg), egg weight (g), and egg. mass (g) during the first 90 days of laying by generations and lines.

Generation	Line	N.	Egg number	Egg weight	Egg mass
			$\overline{X}$ ± S.E.	$\overline{X}$ ± S.E.	$\overline{X}$ ± S.E.
0	Selected	107	66.00 ± 0.40	42.64 ± 0.25	2812.59 ± 20.86
	Control	47	63.02 ± 0.76	43.30 ± 0.33	2726.83 ± 35.58
	Total	154	65.59 ± 0.38^{A}	42.84 ± 0.20^{E}	2786.42 ± 18.33^{A}
1	Selected	99	49.70 ± 1.30	45.37 ± 0.20	2258.82 ± 61.02
	Control	73	47.29 ± 1.73	44.66 ± 0.29	2122.30 ± 82.28
	Total	172	48.67 ± 1.05^{C}	45.07 ± 0.17^{C}	2200.88 ± 49.65^{C}
2	Selected	137	55.66 ± 1.06	46.11 ± 0.21	2571.87 ± 50.92
	Control	67	53.55 ± 1.49	45.07 ± 0.23	2420.24 ± 69.90
	Total	204	54.97 ± 0.86^{B}	45.77 ± 0.16^{B}	2522.07 ± 41.40^{B}
3	Selected	137	54.31 ± 1.01	46.61 ± 0.20	2503.25 ± 36.02
	Control	76	53.58 ± 0.98	46.48 ± 0.27	2498.82 ± 50.32
	Total	213	54.05 ± 0.74^{B}	46.56 ± 0.16^{A}	2501.67 ± 29.24^{B}
4	Selected	103	53.75 ± 0.67	44.29 ± 0.19	2381.35 ± 31.30
	Control	70	46.50 ± 1.66	43.36 ± 0.28	2034.97 ± 77.42
	Total	173	50.82 ± 0.82^{C}	43.91 ± 0.16^{D}	2241.20 ± 38.56^{C}
Overall mean	Selected	583	55.89 ± 0.48^{a}	45.14 ± 0.11^{a}	2513.11 ± 20.46^{a}
	Control	333	52.04 ± 0.71^{b}	44.69 ± 0.14^{b}	2335.15 ± 33.31^{b}
	Total	916	54.49 ± 0.40	44.98 ± 0.09	2448.41 ± 18.00

Means in each column within each factor having the same letter are non-significant at $P \leq 0.05$.

Table 5 . Heritability estimates (h^2_s) and standard errors (+ S.E.) of reproductive traits by generations and lines.

Traits	Selected line	Control line
BWSM	0.19 ± 0.12	0.51 ± 0.35
ASM	0.32 ± 0.17	0.34 ± 0.26
EN During the first 90 days	0.05 ± 0.60	0.47 ± 0.22
EW During the first 90 days	0.12 ± 0.09	0.13 ± 0.12
EM During the first 90 days	0.11 ± 0.09	0.18 ± 0.14

BWSM: Body weight at sexual maturity, ASM: Age at sexual maturity EN: Egg number, EW: Egg weight, EM: Egg mass

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دراسات وراثيه على تركيز كوليسترول الصفار والبلازما فى سلالة من الدجاج المحلية

٢- الاستجابة المرتبطة لصفات التكاثر

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أجريت هذه الدراسة لمدة خمسة اجيال متتالية و ذلك لخفض نسبة كوليسترول الصفار في سلالة محلية منتخبة أساسا لصفات إنتاج البيض ، و بالإضافة إلى تقدير كل من الكوليسترول و الدهون الكلية في كل من الصفار و البلازما تم تقدير الصفات الآتية كصفات مرتبطة: نسبتي الخصوبة والتفريخ و العمر و الوزن عند البلوغ الجنسي و عدد و وزن و كتلة البيض خلال ال٩٠ يوما الأولي من الإنتاج وقد تم تقدير المكافئ الوراثي لهذة الصفات

و كانت أهم النتائج ما يلي: أدى الانتخاب لخفض نسبة كوليسترول الصفار إلي تخفيض كل من نسبتى التفريخ بنسبة ١,٩٦% و وزن الجسم عند البلوغ ٠,٠٧ جم و ذلك بعد أربعة أجيال من الانتخاب بينما إزداد كل من العمر عند البلوغ وعدد ووزن وكتلة البيض بمقدار ٦,٧٤ يوم ٤,٢٧ بيضة ١,٥٩ جم ٢٦٠,٦٢ جم علي الترتيب. بلغ المكافئ الوراثي لصفات العمر و الوزن عند البلوغ و عدد ووزن وكتلة البيض خلال ال٩٠ يوما الأولي للإنتاج ٠,٣٢، ٠,١٩، ٠,٠٥، ٠,١٢، ٠,١١ في العشيرة المنتخبة وكانت القيم المقابلة للعشيرة الكنترول ٠,٣٤، ٠,٥١، ٠,٤٧، ٠,١٣، ٠,١٨ علي الترتيب.