Minufiya J.Agric.Res.Vol.35 No. 4(1):1341-1357(2010)"http://agri.menofia.edu.eg/megla.html"

GENETIC AND PHENOTYPIC PARAMETERS OF ANTIBODY RESPONSE TO SRBCs IN RELATION TO SOME EGG PRODUCTION TRAITS IN CHICKENS

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(Received: May 24, 2010)

ABSTRACT*: Genetic and Phenotypic parameters were estimated for egg production traits and primary antibody response (Ab) against SRBCs antigen in the base and the first generations (selected and control lines) in Norfa chickens. Production traits studied were antibody titers to SRBCs (Ab), body weight at maturity (BWm) , age at sexual maturity (Asm), body weight at sexual maturity (BWsm),egg weight at sexual maturity (EWsm) ,egg weight at maturity(EWm), egg number in the first 90-d after sexual maturity(EN_{90}) and egg number till 42–wk of age. Mean estimates for Ab titers, BWm, Asm, BWsm ,EWsm, EWm, EN_{90} and EN_{42} in the selected line for high antibody response to SRBCs (Hl) were 10.24±0.38 Hl(log_2) , 1287.36±14.26 g., 161.3±1.367d., 1009.5±1.125 g., 36.2±0.378g., 45.3±0.606g., 36.2±0.606 egg, 58.9±0.997 egg, respectively. Heritability estimates were 0.13, 0.14, 0.32, 0.39, 0.53, 0.33, 0.08 and 0.29 in the same order. Genetic and phenotypic correlations between antibody response and the other egg production traits were mostly positive. The magnitudes of heritability, genetic and phenotypic correlations estimates obtained in this study indicated good prospects of improving these traits in Norfa chickens through direct selection for high antibody response.*

Key Words*: Genetic and phenotypic parameters, antibody response, chickens.*

INTRODUCTION

Antibody titer defines as the concentration of a specific antibody against specific antigen in the serum, an increasing of antibody titer is considered as an indication of a high immune response of the body. Antibody titer may be affected by some factors, these factors are, genetics, age, sex, antigen administration, antigen type, antigen dose, and major histocompatability complex (MHC) Abou-Elewa (2004).

The success of breeding programs through selection depends on existence of adequate genetic variation for traits under consideration in the population of interest determined by the magnitudes of genetic parameters (heritability, genetic and phenotypic correlations). (Sakata *et al*. 2004).

Heritability (h^2) estimates are helpful in making any decision regarding the type of mating system that will allow for the fastest improvement in the selection experiments. Although, heritability estimates permit the prediction of response to selection (Pinard *et al.,* 1992). However phenotypic and

genetic parameters for antibody response are lacking in most of local chickens including Norfa strains. Therefore, this study was carried out to estimate heritability, phenotypic and genetic parameters for antibody response and some production traits in Norfa chickens.

MATERIALS AND METHODS

This study was carried out at the Poultry Research Farm, Department of Poultry Production, Faculty of Agriculture, Shibin El-Kom, Minufiya University, Egypt, in order to estimate some genetic and phenotypic parameters of antibody response and some productive trait in Norfa chickens. A total number of 573 unsexed Norfa chicks one day old divided by using its pedigree to 374 birds of selected line and 199 birds as control group, these individuals obtained by mating of selected parents from base population. At hatching, all chickens were wing banded and pedigreed. Chicks were brooded and reared in batteries. They were fed a starter diet containing 17.8% crude protein until 8^{th} week of age and from 9^{th} to 16^{th} week of age, chickens were fed a growing diet containing 14.01% CP. Then, pullets were fed at production period a layer ration containing 18.02% CP, Cockerels were separated from pullets in brooding house, at 8^{th} week of age and at 14^{th} wk ,cockerels moved to individual cages in cocks' house while pullets were moved to individual cages in laying house at 16^{th} week of age.

1.1. Primary antibody titers to SRBCs:

Antibody serves as indication of an immune response to the body. Antibody titers for SRBCs were determined by injecting 0.1 ml of 0.25 % SRBCs suspension in physiological saline (0.9 Nacl) to each bird intravenously. Immune sera were collected at 7 day post- immunization. The antibody titer was determined by hemagglutination test assay. The last positive dilution exhibiting each behavior, expressed as $\log_2$ values for reciprocal of the highest titer where complete agglutination was observed, (Siegel and Gross, 1980).

1.2. Body weight at sexual maturity (BWsm):

Individual body weight in grams was recorded at sexual maturity for each pullet, in selected and control lines.

1.3. Body weight at maturity (BWm):

Individual body weight at maturity was recorded for each laying hen and cockers at 38 weeks of age in grams, in base population and first generation (selected and control lines).

1.4. Age at sexual maturity (Asm):

Age at sexual maturity in days was recorded at first egg laid for each pullet, in base population and first generation (selected and control lines).

1.5. Egg number (EN):

Individual egg number was recorded as the number of eggs laid during the first 90 days of laying (EN_{90}), as well as, during the first 42 weeks of age (EN_{42}), during the experimental period.

1.6. Egg weight (EW):

Average egg weight was measured in grams as an average weight of the first five eggs laid (EWsm) , as well as, the average weight of five eggs laid at 38 weeks of age ($EW_{42\text{- wk}}$) .

STATISTICAL ANALYSIS:

Least-square means and their standard errors (LSM±S.E) for each studied trait were calculated. Also, line and sex effects were studied on antibody titers and body weight at maturity by using SAS procedure (SAS, 1996). By using the following fixed model:

$$Y_{ijk} = \mu + L_i + S_j + L_i S_j + e_{ijk} \quad \text{(Model 1)}$$

Where:

Y_{ijk1m} **= The observation on the** n^{th} **hen,**

n

μ **= The over all mean,**

L_i **= The fixed effect of the** j^{th} **line,**

S_j **= The fixed effect of the** j^{th} **sex ,**

$L_i S_j$ **= The fixed effect of interaction between the** i^{th} **line and the** j^{th} **sex, and**

e_{ijk} **= The random error assumed to be normally distributed with zero mean and variance** σ^2_e**.**

Data of age and body weight at sexual maturity, body weight at maturity and egg production (EN, EW) during the first 90-d of laying and 42-wk of age were analyzed using the following fixed model:

$$Y_{ijk} = \mu + L_i + e_{ij} \quad \text{(Model 2)}$$

Where:

Y_{ij} **= The observation on the** m^{th} **hen,**

k

μ **= The over all mean,**

L_i **= The fixed effect of the** j^{th} **line,**

e_{ij} **= The random error assumed to be normally distributed with zero mean and variances** σ^2_e**.**

k

2.2. Genetic parameters of the first generation:

The genetic parameters (heritability, genetic and phenotypic correlations) were estimated by derivative free REML with a simplex algorithm using the Multiple Trait Derivative Free Restricted Maximum Likelihood (MTDFREML) programs of Boldman *et al*. (1995).

The animal model in matrix notation was:

$$Y = Xb + Za + e \quad \text{model (3)}$$

Where:

Y= the vector of observations (body weight at mature and antibody titers)

b= the vector of fixed effect (line and sex)

a= the vector of random additive genetic direct effects;

X and Z=Known incidence matrices relating observations to the respective

e= fixed and random effects with Z augmented with columns of zeros for animals without records; and the vector of residual effects.

Y = Xb + Za + e model (4)

Where:

Y= the vector of observations (Asm , BWsm , EWsm , EWm ,EN_{90} ,EN_{42})

b= the vector of fixed effect (line)

a= the vector of random additive genetic direct effects;

X and Z=Known incidence matrices relating observations to the respective

e= fixed and random effects with Z augmented with columns of zeros for animals without records; and the vector of residual effects.

RESULTS AND DISCUSSION

1. Direct response to mass selection for antibody titers to SRBCs:

The results in Table (1) show that the general average of Ab in selected line for high Ab titers in the first generation 10.24 Ab titers. Females showed the highest averages of Ab titers (10.75) while males had the lowest Ab titers (9.8) .The analysis of variance of this trait showed that there were significant differences between males and females.

The differences between sexes for antibody titers to $SRBC_s$ in selected lines found in the present study agree with the results reported by Gross *et al.* (1980).They found that the direct response to mass selection was immediate as evidenced by a highly significant difference between the high and low lines in the first generation (6.27 and 6.92 for males and females, respectively).This progress became larger in successive generations such as second one which was 7.42 and 7.87 for males and females, respectively.

On the other hand, Abou-Elewa (2004) showed that within high line, males significantly had higher antibody titers than female over three generations of selection in both Leghorn and Norfa chickens. Contrary to the observation of Yang *et al.* (2000) who found that sexes responded antibody titers similarly to $SRBC_s$ antigen. The differences between sexes were not statistically significant.

The results in Tables 4 and 5 show that the general average of Ab titers in selected line in the first generation was 10.24, while control line was

(8.75).The analysis of variance of this trait in the first generation showed that there were significant differences (P≤0.05) between selected and control lines.

The superiority of selected high line over control line in the present study agreed with the results of Yang *et al.*, (2000); Abou-Elewa (2004);Lwelamira *et al.* (2009)and Lwelamira and Kifaro (2010).They measured the antibody response to $SRBC_s$ in lines of chicken divergently selected for high antibody titers and found that there were statistical differences between lines and the chickens of the high line had significantly higher antibody titers than those from the control lines.

2. Correlated response to mass selection for antibody titers to SRBCs:

Direct selection for high antibody titers to SRBCs antigen had positive effects on some correlated traits to selection. The correlated traits studied are:

2.1. Body weight at maturity:

The differences between selected and control lines for Ab response were statistically significant ($p \leq 0.05$). Control line had heavier body weight than that selected line, (Table 1). The least square means were 1287.36 g and 1324.32 g in selected and control lines, respectively.

These results concluded that the direct mass selection for high antibody titers to $SRBC_s$ had a negative relationship between immune status of chickens and body weight. The control line had heavier body weight than the selected line in the first generation. The present results agree with the previous findings reported by parmentier *et al.*, (1998). They found that the high line chickens for Ab titers were significantly lower in body weight at 38 weeks of age than the control and low line selected for high antibody response to SRBCs.

In addition, Yang *et al.* 2000, concluded that low line chickens for Ab titers were significantly heavier in body weight at maturity than their high or control lines. Similar results were observed by Abou–Elewa (2004). She applied mass selection experiments for high and low immune response during three generations. She found that body weights in control and low lines had almost similar and heavier average at maturity in Norfa chickens in all generations as compared to the high Ab titers line.

2.2. Body weight at sexual maturity:

The differences between selected and control lines in the present study were statistically not significant. However, the control line had higher body weight at sexual maturity than that selected line, (Table 1). The least square means were 1009.47, 1024.78 g in selected female and control lines respectively.

Table (1): Least squares means (LSM± S.E) of Ab titers and BWm affected by sex and line of the first generation in Norfa chickens.

Trait*	Line	sex	NO.	LSM ± S.E	Line means
Ab	selected	male	200	9.8+0.524	10.24^{a}+0.38
		female	174	10.75+0.552	
	Control	male	104	8.57+0.762	8.75^{b}+0.53
		female	95	8.94+0.734	
BWm	selected	male	200	1460.8^{a}+16.33	1287.36^{a}+14.26
		female	174	1088.04^{b}+12.669	
	Control	male	104	1530.04^{a} +24.724	1324.32^{b}+21.13
		female	95	1099.11^{b} +14.314	

*** Ab = antibody titers , BWm= body weight at maturity**

These results are similar to the results reported by Martin *et al.*, (1990). They found that body weights in the low line were greater than those in the high or control lines at 24 weeks of age in chickens selected for antibody response to $SRBC_s$. Also, parmentier *et al.*, (1998) studied the antibody responses and body weight of chicken selected for high and low antibody response to $SRBC_s$. They reported that body weights of control and low lines were significantly higher than body weights of high line birds at all times.

Abou-Elewa (2004) showed that Least square means of body weight (g) at sexual maturity of different selected lines for high and low antibody titers and control over three generations in both White Leghorn and Norfa chickens .The differences among lines and generations were highly (P≤ 0.01) significant .

2.3. Age at sexual maturity:

The differences between selected and control lines observed in the present study were statistically not significant. But control line had higher age at sexual maturity than that selected line, (Table 2). The least square means were 161.3, 162.5-d. in selected and control lines, respectively. The differences between lines were 1.2 days in the first generation.

The present results are similar to the results reported by Siegel *et al.*, (1982). They found that the high immune response to $SRBC_s$ pullets reached sexual maturity earlier than low pullets. The differences between lines were 13 days in the tenth generation. In addition, Martin *et al.*, (1990) studied the effect of divergent selection for high and low antibody response to $SRBC_s$, antigen on age at sexual maturity for 14^{th} generation. They found that the high immune response line reached sexual maturity earlier than low line. The differences between lines were 22 days in the 14^{th} generations. Similar results were reported by Abou-Elewa (2004).

On the other hand, Dunnington *et al.*, (1996) selected lines of White Leghorn chickens for high or low antibody response to $SRBC_s$ antigen for five generations. They reported that long term selection for antibody titers

delayed the sexual maturity in the line of chickens selected for high antibody response.

2.4. Egg weight

Concerning egg weight at sexual maturity, the differences between selected and control lines were statistically not significant. But control line had higher egg weight at sexual maturity than selected line. The least square means were 36.23 and 37.58g in selected and control lines, respectively. Also, control line had higher egg weight at maturity than that selected line, (Table 2). The least square means were 45.3 and 45.4 g in selected and control lines, respectively.

These findings were in contrast of the results reported by Abou-Elewa (2004). She found that there was significant differences in egg weight at sexual maturity and at maturity between two selected (i.e. high, low) and control lines for immune response in Norfa and White Leghorn chickens. High line had the lowest egg weight than low line, while control line was medium between high and low lines.

2.5. Egg number at 90-d. of laying:

The differences between selected and control lines were statistically not significant. Both selected and control lines had almost similar egg number at 90-d. of laying, (Table 2). The least square means were 36.2 and 36.9 eggs in selected and control lines respectively.

Table (2): Least squares means (LSM± S.E) of egg production traits affected by line of first generation in Norfa chickens.

Trait*	line	NO.	LSM ± S.E
Asm	selected	173	161.3 +1.367
	control	95	162.5 +1.633
BWsm	selected	173	1009.5+1.125
	control	95	1024.78+14.602
EWsm	selected	173	36.2+ 0.378
	control	95	37.6+ 0.444
EWm	selected	173	45.3 +0.606
	control	95	45.4 +0.355
EN_{90}	selected	173	36.2+0.606
	control	95	36.9+0.868
EN_{42}	selected	173	58.9 +0.997
	control	95	55.7 +1.574

*** Asm = age at sexual maturity , BWsm= body weight at sexual maturity, EWsm= egg weight at sexual maturity, EWm= egg weight at mature,EN90= egg number at 90 of production,EN42= egg number till 42 wk of age**

These results were in agreement with the findings of Martin *et al.*, (1990). They found that the control line had high hen-day egg production than the selected line. But the differences between lines were not significant.

On the other hand, these results are in contrast with those found by Pitcovski *et al.*, (1987). They observed greater egg number in the high antibody response line than the low line. Also, Abou-Elewa (2004) reported that the divergent mass selection for high and low antibody response to $SRBC_s$ had positive effect on egg production at 90-day of laying in both White Leghorn and Norfa Layers. The high line had the highest significant means of egg number at 90-d of laying than the low line and control, in the third generation,

2.6. Egg number at 42-wk of age:

The differences between selected and control lines in EN_{42} were statistically not significant. Selected line had higher egg number till 42-wk of age than the control line, (Tables 2). The least square means were 58.9 and 55.7 eggs in selected and control lines, respectively.

These results are in agreement with the results reported by Martin *et al.*, (1990). They observed that the statistical differences in egg number at 42-wk of age were not significant.

On the other hand, these results are in contrast with the results reported by Pitcovski *et al.*, (1987). They observed greater egg number in the high antibody response line than the low line. Also, Abou-Elewa (2004) reported that the divergent selection for high and low antibody response to $SRBC_s$ had positive effect on egg production at 42-wk of age in both White Leghorn and Norfa Layers. The high line had the highest significant means of egg number than the low line and control, in the third generation.

3. Phenotypic and genetic parameters:

3.1. Heritability estimates:

Heritability estimates of all studied traits in both base population and the first generation (selected and control lines) in Norfa strain are given in Table (3). Generally most of these heritability estimates were in the biological limits while few of these estimates were not .Enab (1991) stated that the heritability estimates that equal to or more than one or less than zero , are due to sampling errors.

Table (3), show that the standard errors of some heritability estimates were high, whereas these estimates may caused due to sampling errors. Heritability estimates of all studied traits showed that EN_{90} of selected lines in the first generation had the lowest heritability estimates (0.08), while EWsm in the base population had the highest estimates (0.88).

3.1.1. Heritability estimates of antibody titers:

Heritability estimates for antibody titer (Ab) of the base population and two lines in the first generation (selected and control lines) were ranged from 0.13 to 0.32 .These estimates were agree with most of the previous studies on antibody titer (Table 3).

Siegel and Gross (1980) estimated the realized heritability for 5-day antibody titers to SRBC through the third generation. They reported that realized heritabilities were 0.30 in the high line and 0.23 in the low line. Realized heritabilities for generations 10th through 14th were 0.25 and 0.23 for high and low lines, respectively. However, Gyles *et al.*, (1986) estimated the heritabilities of antibody titers to several antigens which ranged from 0% to 40%.Also, Kim *et al.*, (1987) estimated the heritability of anti SRBCs antibody at 4-week of age as 0.34 ± 0.25.

Table (3): Heritability estimates of (h^2 ± S.E) studied traits during both the base population and the first generation (selected and control lines) in Norfa strain.

trait	Base population	The first generation	
		selected	control
Ab	0.19± 0.15	0.13±0.09	0.32±0.16
BWm	0.24±0.18	0.14±0.90	0.09±0.12
Asm	0.25±0.28	0.32±0.19	0.41±0.25
BWsm	0.59±0.24	0.39±0.18	0.55±0.25
EWsm	0.88±0.44	0.53±0.50	0.40±0.24
EWM	0.54±0.39	0.33±0.18	0.47±0.28
EN_{90}	0.56±0.30	0.08±0.14	0.43±0.34
EN_{42}	0.57±0.33	0.29±0.15	0.65±0.34

***Ab=antibody titer,BWm= body weight at mature,BW4,8,12,16=body weight at4,8,12,16 wk of age. Asm = age at sexual maturity , BWsm= body weight at sexual maturity, EWsm= egg weight at sexual maturity, EWm= egg weight at mature,EN90= egg number at 90 of production,EN42= egg number till 42 wk of age.**

Moreover, Gebriel (1990) studied the genetic parameters of the immune response to $SRBC_s$ antigen within the B blood group genotypes. The heritability estimates (h_s^2) of antibody response were moderate at 7 and 14 days post-immunization (0.11 to 0.31), but the parameters became low due to prolific antibody response at 21 days (0.04 to 0.16) post-immunization. He also found that the additive genetic (r_G) and phenotypic (r_p) correlations between total antibody titers at 7, 14 and 21 days post immunization were generally positive and varied from 0.11 to 0.61 for r_G and from 0.06 to 0.48 for r_p.

In addition, Martin *et al.* (1990) selected White Leghorn chickens for high and low antibody titers to SRBC for 14 generations. They reported that the realized heritabilities between generations 10th Moreover, Abou-Elewa, (2004) reported that, heritability estimates for antibody response to SRBCs antigen were low and ranged from 0.0113 to 0.1979 for both White Leghorn and Norfa chickens. The immunological traits showed low heritability estimates except for antibody response to SRBCs titers and 14th were 0.23 and 0.25 in the low and high lines, respectively.

3.1.2. Heritability estimates of body weights:

Body weights at different ages (Table 3) in Norfa chickens had high to moderate estimates of heritabilities as the most estimates observed which

ranged from 0.14 to 0.59,except body weight at mature of control line in the first generation which had low estimate of heritability (0.09) . It was observed that body weight at sexual maturity (BWsm) had the highest estimates, being 0.59, 0.39 and 0.55 for base population, selected and control lines. These results agree with (Abdou and Kolstad ,1979 ; Enab *et al.* 2000 ; Abou –Elewa 2004).They reported that body weight trait had higher heritability in chickens.

2.1.3. Heritability estimates of age at sexual maturity:

Table (3) shows that the heritability estimates for Asm of the base population and two lines in the first generation (selected and control lines) were ranged from 0.25 to 0.41.It was observed that control line had higher heritability estimates (0.55) as compared to base population and selected line (0.25and 0.32,respectively).

These results consistent with most selected investigators .Sherif *et al.*, (1993); Soltan, (1997) and Abdou and Enab, (1994) showed that the heritability estimates of Asm were moderate to high for many breeds and strains of laying chickens. On the other hand, some authors found that heritabilities of Asm ranged from low to high value (Enab,(2001) ; Kosba *et al.* ,2002 ; El-Full *et al.* 2005).

3.1.4. Heritability estimates of egg weight:

Table (3) show that egg weight at both sexual maturity and at maturity in the base population and the first generation (selected and control lines) in Norfa strain, the estimates ranged from moderate to high heritabilities. Heritability estimate of EWsm in the base population was the highest one (0.88). , while heritability estimate of EWm was the lowest one (0.33) in control line in the first generation

There were many studies supported these results. El-Nady *et al* (1985) reported that heritability estimates of EWsm for two selected lines (egg number and egg weight) in White Leghorn layers were 0.67 and 0.95 respectively. While Nawar (1991) reported that heritability of EWsm in Norfa chickens was 0.11.Also, Enab (1991) used different selection indices to improve some economic traits in Norfa chickens. He reported that the heritability of this trait ranged from 0.01 to 0.54.

Heritability estimates of EWm for the base population and the first generation (selected and control lines) in Norfa strain ranged from moderate to high (Table 3). The heritability estimates were 0.54, 0.33 and 0.47 for base population selected and control lines in the first generation.

These heritability estimates of this trait were in good agreement with those found in Norfa strain by Abou El-Ghar (1994) and Abou El-Ghar *et al.* (2003).They reported that almost similar estimates for heritability at maturity in Norfa layers.

3.1.5. Heritability estimates of egg number:

Heritability estimates of EN trait at 90-d of laying and 42-wk of age had a widely range(from 0.08 to 0.65) (Table 3) .Heritability estimates of EN_{90} were lower than heritability estimates of EN_{42} in the base population and first generation .The heritability estimates of EN_{90} were 0.56,0.0.08 and 0.43 ,while these estimates of EN_{42} were 0.57 ,0.29 and 0.65 for base population, selected and control lines, respectively.

The previous studies show that widely range of heritability estimates of EN_{90}, Enab (1991) found that heritability estimate of EN_{90} in Norfa chicken ranged from 0.12 to 0.35.Also, Nawar (1991) found that heritability estimate of EN_{90} in Norfa chicken ranged from 0.04 to 0.26. Enab *et al*. (2000) found that heritability estimates of EN_{90} in two lines (egg number and egg weight) in Norfa chickens ranged from 0.48 to 0.8 and from 0.12 to 0.8, respectively. Ben Naser (2007) reported that EN_{90} heritability estimates ranged from 0.107 to 0.589 in Norfa chickens.

Heritability estimates of EN_{42} trait ranged from moderate to high being from 0.29 to 0.65 in the base population and the first generation (Table 3). A lot of studies agree with these results, Ben Naser (2007) reported that EN_{42} heritability estimates had moderate to high values during two selected generations. While, Abou El-Ghar *et al.* (2003) estimate heritability of EN_{42} in Norfa chickens and he found it equal to 0.05. Abou El-Ghar *and* Abdou (2004) found that heritability estimates of EN_{42} in Norfa chicken was 0.02.

3.2. Phenotypic and genetic correlations between antibody titers and some correlated traits:

Priston and Willis, (1970) reported that The existence of genetic correlation between two traits means that selection for one trait would cause change, may positive or negative, in the other trait .The estimations of phenotypic and genetic correlations between all traits under selection are very necessary to construct the selection index to determine the total breeding values of candidates' (Hazel, 1943).

3.2.1. Phenotypic correlations:

The phenotypic correlation estimates between antibody titers to SRBCs and some correlated traits in the base population and the first generation in Norfa chickens are presented in Table (4). Most of estimates of the phenotypic correlations between antibody titers and body weights at sexual maturity and at maturity were negative except the body weight at sexual maturity in the base population and in control line in the first generation, which were positive. In addition, positive phenotypic correlations were estimated between antibody titers and egg production traits, except the estimates of egg weight at sexual maturity and mature egg weight in the control line in the first generation, which were negative.

The values of the phenotypic correlations between antibody titers and some correlated traits were ranged from low to moderate, which ranged from -0.016 to 0.281.

Negative relationships have been reported between immune status of chickens and body weight by Siegel and Gross (1980). As general, body weight was low in the high line selected for high immune response (Siegel *et al*., 1982). Selection for increased body weight has been shown to be genetically associated with reduction of immunocompetence and diseases ' resistance in chickens (Qureshi and Havenstein ., 1994) and in turkeys (Bayyari *et al* ., 1997) .

Table 4: Estimates of phenotypic and genetic correlations among antibody titers (Ab) and studied traits during both the base population and the first generation (selected and control lines) in Norfa strain.

Trait*	Phenotypic correlation (rp)			Genetic correlation(rG)		
	Base population	First generation		Base population	First generation	
		Selected	control		Selected	control
BWm	-0.089	-0.297	-0.309	-0.600	-0.630	-0.170
Asm	-0.016	0.177	-0.156	0.130	-0.120	0.240
BWsm	0.007	-0.089	0.281	-0.095	0.050	0.350
EWsm	0.073	0.117	-0.129	0.034	0.620	0.000
EWm	0.092	0.055	-0.038	-0.149	0.600	-0.050
EN_{90}	0.071	0.050	0.172	0.055	0.300	0.010
EN_{42}	0.171	0.045	0.245	0.025	0.160	0.030

***Ab=antibody titer, BWm= body weight at mature,BW4,8,12,16=body weight at4,8,12,16 wk of age. Asm = age at sexual maturity, BWsm= body weight at sexual maturity, EWsm= egg weight at sexual maturity, EWm= egg weight at mature, EN90= egg number at 90 of production,EN42= egg number till 42 wk of age.**

Nestor *et al*., (2000) and Yang *et al*. (2000) ,suggested that selection for fast growth rate of turkeys might have resulted in changes in humeral immunity to SRBCs antigen and BA (*Brucella abortus antigen*) .The low antibody response chicks were heavier than the high antibody response chicks at 14 day of age .

On the other hand, Kundu (1997) observed no consistent trend either in magnitude or direction of phenotypic correlations for different immune response competence traits with growth trait .Pinard, (2002) observed a positive phenotypic correlation, between 9-week body weight and response to PHA in White Leghorn chickens. Also, Siverman *et al*.,(2005) found that phenotypic correlations (r_p) were positive but very low and not significantly difference between body weights and most immunological traits.

3.2.2. Genetic correlations:

The genetic correlation estimates between antibody titers to SRBCs and some correlated traits in the base population and the first generation in Norfa chickens are presented in Table (4). Most of estimates of the genetic correlations between antibody titers and body weights at different ages (at sexual maturity, and at maturity) were negative and ranged from -0.095 to -0.760, except the body weight at sexual maturity in the first generation in both selected and control lines, which were positive and ranged from 0.05 to

0.350. In addition, positive genetic correlations were estimated between antibody titers and egg production traits which ranged from 0.010 to 0.055, except the estimates of age at sexual maturity in the selected line in the first generation, body weight at sexual maturity and mature egg weight in the base population, and mature egg weight in the control line in the first generation which were negative, and ranged from -0.050 to -0.149.

The realized genetic correlation between SRBCs titers and hen–day production was moderately low and negative. Such effects are consistent with other selection studies (Petcoviski *et al.*, 1987).

In addition, Martin *et al.* (1990) reported that the genetic correlation estimate was 0.28 between antibody titers and hen-day egg productions in the H-line. The respective value in the L-line was 0.87.

However, the correlated response to selection for high and low antibody titers to SRBCs in both egg number and egg weight was small and insignificant in both selected lines in turkey (Sacco *et al.,* 1994) or in chickens (Parmentier *et al.,* 1998). The negative relationships between the productive of egg and resistance to infectious diseases have been established (Bayyari *et al.*, 1997and Nestor *et al.*, 2000).

Egg weights of the control line were the heaviest, followed by the low line and finally the high line in an experiment for divergent selection for antibody response for SRBCs which had negative genetic correlations with antibody response (Van Den Brand *et al.*, 2004).They added that differences in immune responses among selected lines may be due to the differences in egg characteristics. Age at first egg was changed dramatically as the results of the divergent selection for high and low antibody response to SRBCs antigen. The high immune response pullets reached sexual maturity earlier than low pullets.

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القياسات الوراثية والمظهرية لصفة الاستجابة المناعية لكرات الدم الحمراء للأغنام وعلاقتها ببعض صفات إنتاج البيض في الدجاج

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تم تقدير القياسات الوراثية والمظهرية للصفات الإنتاجية وكذلك صفة الاستجابة المناعية الأولية ل SRBCs في دجاج النورفا.

وكانت الصفات الإنتاجية المدروسة هي الاستجابة المناعية الأولية، وزن الجسم عند النضج التام، العمر عند النضج الجنسي، وزن الجسم عند النضج الجنسي، وزن البيض عند النضج الجنسي، وزن البيض عند النضج التام،عدد البيض عند ٩٠ يوم من بداية النضج الجنسي و عدد البيض حتي عمر ٤٢ أسبوع من العمر .

وكانت قيم المتوسطات لكلا من الاستجابة المناعية، وزن الجسم الناضج، العمر عند النضج الجنسي،وزن الجسم عند النضج الجنسي، وزن البيض عند النضج الجنسي، وزن البيض عند النضج التام،عدد البيض عند ٩٠ يوم من بداية النضج الجنسي، عدد البيض حتى عمر ٤٢ أسبوع من العمر في الخط المنتخب للاستجابة العالية١٠,٢٤±٠,٣٨ وحده مناعية، ١٢٨٧±١٤,٢٦ جم، ١٦١,٣±١,٣٦٧ يوم، ١٠٠٩,٥±١,١٢٥جم ، ٣٦,٢±٠,٣٧٨ جم، ٤٥,٣±٠,٦٠٦ جم، ٣٦,٢±٠,٦٠٦ بيضة، و٥٨,٩±٠,٩٩٧بيضة. وكانت قيم المكافئ الوراثي ٠,١٣ ،٠,١٤ ،٠,٣٢ ،٠,٣٩ ،٠,٥٣ ،٠,٣٣ ، ٠,٠٨ ،٠,٢٩.بنفس الترتيب وكان معظم قيم الارتباط المظهري والوراثي بين الاستجابة المناعية وصفات انتاج البيض موجبة.

من القيم المقدرة للمكافئ الوراثي والارتباط الوراثي والمظهري بين الصفات المدروسة فإنه يمكن تحسين هذه الصفات في دجاج النورفا عن طريق الانتخاب المباشر للاستجابة المناعية العالية.