11 Egyptian J. Desert Res., 57, No1, 193-205 (2007)

GENETIC AND CROSSING EFFECTS IN THE CROSSING BETWEEN SINAI AND WHITE LEGHORN CHICKENS FOR EGG PRODUCTION TRAITS

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The Sinai fowl (S), White Leghorn breeds (WL) and their reciprocal crossbreds (SxWL) and (WLxS) were used to evaluate the effects of crossing on egg production and estimates the heterosis, additive, maternal, sex-linked and reciprocal effects during the first three months of production. Egg number (EN), egg weight (EW), egg production (EP), age at first egg (AFE), body weight at sexual maturity (BWM) and egg quality traits were evaluated under desert conditions. Significant differences (P<0.05) were found between genetic groups for EN, EW, EP and BWM. The Sinai females matured earlier but produced less egg than WL females. White Leghorn showed higher EN and EP and reached later at sexual maturity when compared to Sinai and the crossbreds. Significant differences between the crossebreds were found for all production traits. Hybrid (WLxS) females commenced lay at an earlier age and produced more eggs than crossbred (SxWL) females. The mean egg weight of Sinai was 51.8 g. It was significantly (P<0.05) higher than that of the WL (47.2 g) and of the crossbreds (52.3 and 48.5 g) in (WLxS) and (SxWL), respectively. There were significant differences between genetic groups for all egg quality traits. Sinai females had better egg quality traits than other genetic groups. Additive genetic and sex-linked effects were highly significant (P<0.001) for EN, EP and EW at 90 days of production. Maternal and sex-linked had negative effects on EN and EP at 90 days of production. The reciprocal effects for egg production did not show any significance. No heterosis was detected in EP at 90 days of production. Significant heterosis was observed in F_1 crosses for increased egg weight (1.8%) and percentage of egg production (1.54%). Most of egg quality traits had little or no heterosis. Sex-linked effects increased (P<0.001) proportion of yolk but decreased albumen and shell percentages. High genetic correlations were found between egg production traits (EN, EP and AFE).

Negative and significant (P<0.05) genetic correlation between EN and EW was -0.22. There was a moderate negative phenotypic correlation between EN and EW. AFE showed negative and high correlation with EW.

Keywords: crossing, egg production, egg quality, heterosis, Sinai fowl, White Leghorn, chicken

The Sinai fowl, native to the Sinai Peninsula, were as first studied by Arad *et al.* (1975) who observed differences in productive performance between the Sinai fowl and commercial White Leghorn under desert conditions. The performance of the chickens of White Leghorn x Sinai female and Sinai male x White Leghorn female crosses was considerably better than that of the Sinai fowl (Arad and Marder, 1982). Soltan and Ahmed (1990) worked with the Sinai fowl that was selected for egg number during the first three months. They found that the selected Sinai fowl reached sexual maturity earlier than the control group. That could explain higher production for the selected line than the control line. The Sinai fowl lay heavier eggs than both Fayoumi and Baladi chickens. The egg production during the first three months was 37.1% and the age at the first egg was 186.2 days. Egg weight was 41.9 g. and the egg number was 34.5 egg under normal conditions (Soltan and Ahmed, 1990). The egg weight of the Sinai fowl was considerably lower than that of the White Leghorn (P<0.01). The reciprocal crossbreds of the Sinai x White Leghorn and White Leghorn x Sinai chickens had similar body weights. They were considerably (34%) lower than those of the crossbreeds. Arad and Marder (1982) discussed decrease in laying rate in the Sinai and Sinai x Leghorn under desert conditions. That might be due to the effect of short photoperiod. The egg shell was significantly thicker and stronger in the Sinai fowl than in White Leghorn. Arad and Marder (1982) suggested that good shell quality may contribute to solving shell quality problems in consumable eggs. Few experiments were published about the Sinai fowl and the egg production under the desert conditions.

The objectives of this study were to evaluate and compare the egg production traits for the Sinai Bedouin and the White Leghorn breeds and their reciprocal crosses under the desert conditions, to estimate additive, maternal, sex-linked, reciprocal and heterotic effects on egg production traits, and to estimate heritabilitaties and genetic and phenotypic correlations between egg number, egg weight, percentage of egg production and age at the first egg .

MATERIALS AND METHODS

The chickens used in this work pertain of the parental lines and their reciprocal crosses. Available data were obtained from chickens that have been hatched between the years 2002 and 2004. Two breeds were used the Sinai fowl and the White Leghorn (WL) and also their reciprocal crosses (SxWL) and (WLxS). Two generations were obtained in Ras Suder Research station belonging to the Desert Research Center.

Reciprocal F_1 (WLxS) and (SxWL) were obtained by crossing populations of Sinai fowl and White Leghorn. Sire line was designated first and dam line was second. The White Leghorn and Sinai hens were progeny of 20 sires in each of the two stocks. Reciprocal crosses were made between lines of Sinai fowl and White Leghorn breeds. One male from each line was mated with five females from the Sinai and Leghorn populations. Hundred females from both populations were used for the crosses. Two hatches of F_1 offspring with an interval of 4 weeks were obtained. The same females were used as dams for purelines (WLxWL) and (SxS). The interval between egg collections for the two crosses was 4 weeks to eliminate the semen effects of the previous males.

The data set on egg production was collected daily during the experimental period. Egg production period started as each group reached 5% egg production. The egg number (EN) was recorded daily. Cracked, broken or soft-shelled eggs were recorded separately. Egg production (EP) was computed as total egg number divided by number of hens housed. The production period was divided into three parts. The first part was the period between age at the first egg and four weeks of production (P_1). The second part was 60 days of production (P_2).The third part was 90 day of production (P_3). Records were kept for the number of eggs laid until 13 weeks of production. The body weights and age at sexual maturity were recorded for each group.

Hens were fed *ad libitum* a diet containing 18% crude protein and 2700 kcal ME/kg., during the laying period. Chicks were reared intermingled on deep litter until 16 weeks of age and were then housed in three tier cage batteries with 3 (half-sib) hens in each cage (120 cages). Chickens housed in four separate rooms of the laying house. Same light program and same feed regime were used.

Each genetic group was evaluated at the end of the third month of egg production for egg quality. Two eggs/cage were collected. A total of 240 eggs were used in the analysis of EW, yolk weight and albumen height, weight and shell weight and thickness. Fresh whole egg weights were obtained within 24 h of collection. Eggs were weighed using electronic digital balance. Each egg was broken along its mid-section, which produced a clean crack from which two halves of shells were retrieved. Albumen height was measured using a digital micrometer. Albumen and yolk were separated and weighed. The thicknesses of cleaned, washed and air-dried eggshells were measured using a digital micrometer. Albumen weight was estimated as fresh egg weight minus fresh yolk weight minus dry shell weight.

Statistical Analysis

The following traits were recorded, age at first egg (AFE), egg number (EN), laying rate (EP), body weight at sexual maturity (BWM) and egg weight (EW). The fixed effects fitted in the analysis were year, hatch room and genetic groups for all traits. Data of production traits were analyzed using SAS program, General Linear Models procedure of base SAS Software (SAS Institute, 2000).

The following two linear models were used:

Model 1: $Y_{iklmn} = \mu + G_i + R_k + Y_l + H_m + GH_{im} + r_{iklmn}$

Model 2: $Y_{ijklmn} = \mu + G_i + S_{ij} + R_k + Y_l + H_m + GH_{im} + r_{ijklmn}$

where: μ = is the population mean,

G_i = the fixed effect of the i^{th} genetic group,

S_{ij} = the random effect of the j^{th} sire within i^{th} genetic groups,

R_k = the fixed effect of the k^{th} room,

H_m = the fixed effect of the m^{th} hatch,

Y_l = the fixed effect of the l^{th} year,

GH_{im} = the fixed effect of the interaction between i^{th} genetic group and m^{th} hatch and r_{iklmn} and r_{ijklmn} = random error

The two interactions between hatch and room with genetic groups were not found to be significant and it was not included in the model. The genetic effects were estimated from linear contrasts of genotype means (Model1). Heterosis was calculated using means:

H = {(WLxS)+(SxWL)/2 – {(SxS) + (WLxWL)}/2;

Heterosis (%) = H/ {(SxS) + (WLxWL)}/2 *100;

Heterosis (WLxS) = (WLxS) - {(SxS) + (WLxWL)}/2;

Heterosis (WLxS) % =Heterosis (WLxS) /{(SxS) + (WLxWL)}/2 *100;

Heterosis (SxWL) = (SxWL) - {(SxS) + (WLxWL)}/2;

Heterosis (SxWL) % = Hetersis (SxWL) / {(SxS) + (WLxWL)}/2 *100;

Orthogonal contrasts (SAS institute, 2000) were used to estimate additive genetic effects;(contrast of (WLxWL) vs (SxS)), sex linked effects (contrast of average of (WLxWL) vs (SxS) and (WLxS) vs (SxWL), maternal effects (contrast of average of (WLxWL) vs (SxS) and (WLxS) vs (SxWL), reciprocal effects (contrast of average of (WLxS) vs (SxWL).

The estimation of variance co-variance components was obtained using VARCOMP procedure of SAS (SAS, 2000). The genetic parameters were obtained only from the half-sib analysis (Model 2) because the numbers of progeny per dam were small and rendered the dam-component heritabilities unreliable. Estimates of the heritability and genetic correlation among various productive traits were used pooled data from all genetic groups. Also, phenotypic correlations between productive traits were calculated on the data obtained from the all genetic groups.

RESULTS AND DISCUSSION

Least square means and standard errors of egg production and egg quality traits for each genetic group are presented in table (1). Results for the contrasts that were used to compare the genetic groups are given in table (2). There were significant differences between genetic groups for egg number (EN), egg weight (EW) and egg production (EP). The mean age at sexual maturity of the pullets was 167 days for White Leghorn (WL) compared to 157 days for Sinai hens. The Sinai females matured earlier but produced lower eggs than (WL) females. Bakir *et al.* (1988) worked with White Plaums Rock, Sinai and White Cornish chickens. They found that the age at sexual maturity means ranged from 172 to 192 days. White Leghorn breed showed a higher EN and EP and reached later at sexual maturity when compared to Sinai and their crossbreds. Similar results were observed by Dattavio *et al.* (1995 and 2001) on White Leghorn, Fayoumi, Rhode Island Red and their crossbreds. They reported that the WL hens laid their eggs later than the other genetic groups. Also, Khalil *et al.* (2004) ended with the same results for WL compared with Baladi Saudi strains. Body weights were heavier for WL than the Sinai female at sexual maturity age (Table 1). F_1 crossbreds have heavier BWM than parental lines. The observed differences in means of F_1 crossbreds indicated that the heterosis was present. Significant differences between crosses (WLxS) and (SxWL) were found for all production traits. Hybrid (WLxS) females commenced to lay at an earlier age and produced higher percentage of eggs than (SxWL) females. The reciprocal differences might be due to unequal contributions between sire and dam (Liu *et al.*, 1993).

The mean egg weight of the Sinai Bedouin was 51.8 g. It was significantly ($P<0.05$) higher than that of the WL (47.2 g) and of the crossbreds (52.3 and 48.5 g in WLxS and SxWL, respectively). The results were supported by the results obtained by Arad and Marder (1982). They found that the mean egg weight of Sinai was 45.54 g. It was significantly ($P<0.05$) lower than that of the Leghorn (58.77 g) and of the crossbreds (52.44 and 52.31 g. in WLxS and SxWL, respectively). The laying rate of the Sinai (45.2 %) was also significantly lower than those of other groups (52.4, 50.4 and 48.5% for WL, (WLxS) and (SxWL), respectively). Similar results were observed by Arad and Marder (1982) where the egg production of the Sinai fowl was significantly lower than those of the groups WL, WLxS and SxWL. In studies with a selected line of Sinai fowl for egg production, Soltan and Ahmed (1990) found that the egg production of the selected Sinai fowl was more than 43 % during the three month-period vs 16.7%, 40.4% and 32.5% for Sinai control line, Fayoumi and Baladi chickens, respectively.

Means and standard errors for egg quality traits per genetic groups are presented in table (1). There were significant differences between genetic groups for all traits. The Sinai females showed better egg quality traits than other genetic groups. This result is in agreement with results of Arad and Marder (1982), where the egg shells of Sinai fowl was significantly thicker and stronger than that of the Leghorn. In this study, the differences in crossbred involving WL male and Sinai female were significantly higher than the crossbreds of Sinai male and WL female for all egg quality traits. Soltan (1991) found no significant differences between Sinai control and selected line for egg quality traits. Also, the author reported yolk, albumen and shell percentages of 32.3, 53.6 and 13.8 % respectively, for egg of Sinai fowl.

Estimated additive, sex-linked, maternal effects, for egg production and egg quality traits for Sinai, WL and their crossbreds are presented in table (2). The additive and sex-linked effects were highly significant ($P<0.001$) for egg number (EN), egg production (EP) and egg weight (EW) at 90 days of production. Differences in egg production traits between Sinai and WL were observed in earlier investigations by Arad and Marder (1982). The additive genetic had negative effect on egg weight. Also, the maternal and sex-linked effects were negative on egg number at 90 days of production (EN90) and egg production at 90 days (EP90). This was expected because the average EN of crosses (WLxS) and (SxWL) were lower than the average of parental lines. Hagger (1989) found that significant sex-linked or maternal effects could be observed for egg weight and egg production at 40 weeks of age. Such results are in agreement with those reported by Fairfull *et al.* (1983) and Hagger (1985).

Reciprocal effects for egg production did not show any significant differences. The influence might be increased with age. There were significant effects ($P<0.001$) for EN and EW. This finding was supported by obtained results by Fairfull and Gowe (1986) and Ledur *et al.* (2000), who reported that reciprocal effects for some egg production traits were influenced by age. Liljedahl *et al.* (1999) reported an increase in the effect of heterozygsity with age for fitness traits in female. No significant heterosis were detected in egg production at 90 days. The present results are in agreement with the findings obtained by Fairfull *et al.*, (1983 and 1987) and Hagger (1986 and 1989). Negative heterosis was found for egg number. The F_1 crossbreds laid 4.4 eggs lower than parental lines. Significant heterotic effects were found on egg weight. The mean heterosis that was expressed as an absolute value was highly significant ($P< 0.001$) for EN and EP traits and was also influenced by age (Table 2). In general, EN and EP showed a curvilinear pattern with age increasing from P1 to P3 (Figure 1).

The mean heterosis for the egg quality traits was not significant with the exception of shell percentage. This is in typical agreement with the results obtained by Ledur *et al.*, (2002). Most egg quality traits had little or no heterosis (Fairfull and Gowe, 1986; Fairfull *et al.*, 1987). The sex-linkage had an important effect on differences in egg composition. Sex-linked effects increased (P<0.001) the proportion of yolk but decreased the albumen and shell percentages. On the other hand, maternal effect was little on egg quality traits. Reciprocal effects significantly increased for yolk percentage and yolk/albumen ratio and decreased the shell and albumen percentages but were not significant. Reciprocal effects for egg quality traits were also reported by Fairfull and Gowe (1986), however the magnitude of the differences were low, but were more important than heterosis for egg quality traits. Also, the results are concurrent with the findings of Ledur *et al.*, (2002). Additive effects significantly (P<0.001) increased the egg weight and albumen percentage. Differences in additive genetic effects were the most important source of variation on egg weight (Ledur *et al.*,2002).

Table (3) presents the estimates of heritablities, genetic and phenotypic correlations between EN, EW, EP, AFE and BWM traits. The heritablities of EN and EW were similar to the findings of Sewalem (1998). The heritability estimates were nearly double to the estimates of individual monthly egg production reported in the literature. Anang *et al.*, (2001) reported heritability estimates from 0.0 to 0.15 and from 0.13 to 0.18 for individual monthly egg production using 4-month and 8- month production, respectively. Heritability of egg production for 273 days production and 497 days production ranged from 0.14 to 0.25 and 0.12 to 0.22, respectively (Poggenpoel *et al.*, 1996). The genetic correlations between egg production traits were extremely high for EN and EP, AFE. The genetic correlation between EN and EW was -0.22, and the phenotypic correlation between EN and EW was also negative, but moderate. AFE showed negative correlation with EW but high. This is in agreement with those of Sewalem (1998).

Heterotic effects for egg production traits were important to explain the variation during the first 90 days of production. The present study showed that heterosis due to genes on sex chromosomes was significant for all reciprocal crosses. This implies that there is an increase of heterozygosity of genes on the sex chromosomes within the lines. The additive effects were very important in the first period. However, the reciprocal and sex-linked effects played an important role during the second period. The present findings suggest that efforts must concentrate on: 1) selecting for highly productive Sinai fowl, 2) crossbreeding the Sinai fowl with various commercial breeds and strains for the production of new crosses with high egg production.

TABLE (1). Least square means and standard error for egg production and egg quality traits for Sinai fowl (S), White Leghorn (WL) and their crossbreds.

Traits	Genetic groups			
	WL	S	(WLxS)	(SxWL)
EN (90 days) egg	52.1±9.4 a	29.4±0.78 d	38.7±0.71 b	34.0±1.2 c
EW (90 days) g	47.2±0.41 c	51.8±0.38 a	52.3±0.11 a	48.5±0.47 b
EP (90 days) %	52.4±1.0 a	45.2±1.2 c	50.6±1.0 ab	48.5±1.6 b
AFE (days)	167	157	160	163
BWM (g)	2266	2267	2315	2406
Mortality of hens (%)	1.5	0.0	0.3	0.7
Shell thickness (mm)	0.334±.19 c	0.407±.18 a	0.363±.25 b	0.342±.28 ab
Shell (%)	8.9±.16 d	11.2±.13 a	10.0±.18 b	9.3±.20 c
Yolk (%)	34.9±.61 a	32.8±.45 b	35.1±.48 a	32.9±.54 b
Albumen height (mm)	7.2±.52 d	8.2±.48 a	8.8±.46 b	8.5±.51 c
Albumen %	54.8±.67 bc	56.7±.54 a	53.9±.56 c	56.4±.62 ab
Yolk/albumen ratio	64.4±1.8 a	58.2±1.3 b	65.5±1.5 a	58.9±1.4 b

a,b,c,d values with different superscripts between rows are significantly different (P<0.05).
EN (90 days) egg= egg number at 90 days of production: EW (90 days) = egg weight at 90 days; EP (90 days) % = egg production percentage at 90 days; AFE (days)= average age at first egg ; BWM= average body weight at sexual maturity; Mortality of hens (%)= average mortality rate percentage.

TABLE (2). Estimates of genetic and crossing effects of Sinai fowl (S), White Leghorn (WL) and their crossbreds on egg production and egg quality traits.

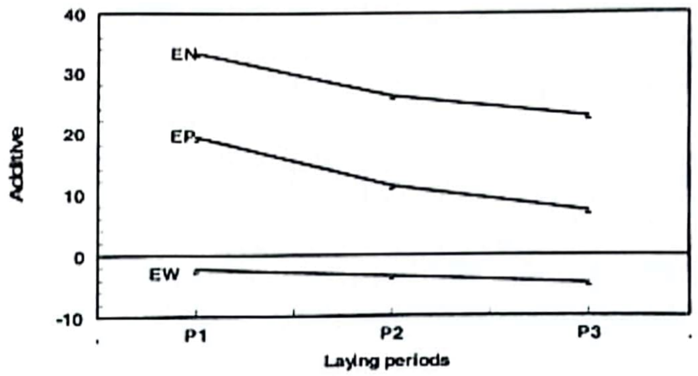
Traits	Additive effect	Maternal effect	Sex-linked effect	Reciprocal effect	H (WLxS)	H(WLxS) %	H (SxWL)	H(SxWL) %	Heterosis (F_1)	H (%)
EP30	19.3±2.0 ***	21.9±2.8 **	16.7±2.8 ***	-2.5±2.0 n.s					-12.3±2.0 ***	
EP60	11.3±1.5 ***	5.8±2.1 **	16.7±2.1 ***	5.4±1.5 ***					-4.2±1.1 ***	
EP90	7.2±1.2 ***	-9.3±1.6 **	-5.1±1.6 ***	2.1±1.2 n.s	1.8	3.6	-0.3	-0.6	0.71±.81 n.s	1.54
EN30	33.3±1.2 ***	23.1±1.8 ***	43.5±1.8 ***	10.1±1.2 ***					-14.5±.9 ***	
EN60	26.1±1.1 ***	18.6±1.5 ***	33.6±1.5 ***	7.4±1.1 ***					-8.0±.78 ***	
EN90	22.7±.81***	-27.4±1.2 ***	-17.9±1.2***	4.8±.84 ***	-2.1	5.0	-6.8	-16.6	-4.4±.59 ***	-10.8
EW30	- 2.2±0.61***	-3.9±.8 ***	-0.60±.8 n.s	1.6±.61 ***					1.3±.4 ***	
EW60	-3.4±.53 ***	-7.8±.75 ***	1.0±.75 n.s	4.4±.53 ***					0.28±.57 n.s	
EW90	-4.6±.38 ***	0.81±.54 n.s	8.4±.54 ***	3.8±.38 ***	2.8	5.7	-1.0	-2.0	0.94±.27 ***	1.8
Egg weight	4.3±1.2 ***	-2.4±1.7 n.s	-6.2±1.7 ***	-1.9±1.2 n.s					1.04±.87 n.s	
Shell %	-.20±.25 n.s	0.49±.36 n.s	-.10±.36 n.s	-.30±.25 n.s	0.32	3.1	0.12	1.2	0.44 ***	4.2
Yolk %	-2.2±.74 **	0.024±1.1 n.s	4.3±1.1 ***	2.2±.74 **	1.24	0.44	-.96	-2.8	0.14 n.s	0.41
Albumen %	2.4±.84 **	-.53±1.2 n.s	-4.3±1.2 **	-1.9±.85 n.s	-1.5	-2.69	0.9	1.6	-0.59 *	-1.1
Yolk/Alb	-6.7±2.1 **	48±3.1 n.s	12.8±3.1 ***	6.2±2.1 **	3.8	6.2	-2.9	-4.7	.91 *	1.5

*** P<0.001; ** P<0.01; * P<0.05; n.s =not significant; EP 30,60 and 90 =Production rate during the periods of (0-30), (0-60) and (0-90) days; EN 30, 60 and 90 = the egg number during the periods of (0-30), (0-60) and (0-90) days; and EW 30, 60 and 90 = the average egg weight during the period (0-30), (0-60) and (0-90) days; H = amount of heterosis effect; H (WLxS) =amount of heterosis for (WLxS) hybrid; H (SxWL) =amount of heterosis for (SxWL) hybrid; H(%)= heterosis percent for F_1(SxWL)+(WLxS).

TABLE (3). Heritabilities (diagonal), phenotypic (below diagonal) and genetic (above diagonal) correlations of egg number (EN), egg weight (EW), egg production (EP), age at the first egg (AFE) and body weight at sexual maturity (BWM) .

Traits	EP	EN	EW	AFE
EP	0.32	0.68***	-0.12*	-0.13*
EN	0.70***	0.28	-0.22**	-0.08 n.s
EW	-0.19**	-0.25**	0.52	-0.35***
AFE	0.26**	0.61***	-0.46***	0.51

* P< 0.05; ** P<0.01 and ***P< 0.001
n.s= no significant



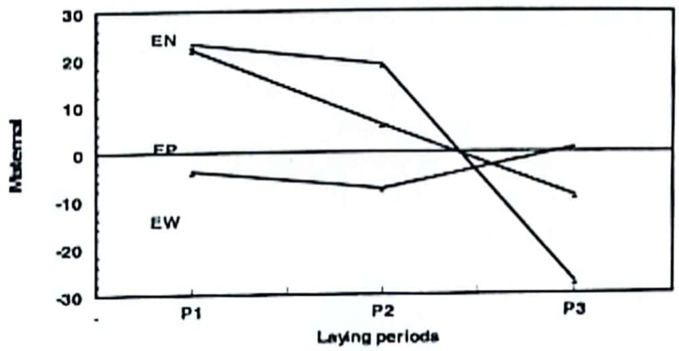


Fig. (1). Estimates of additive and maternal for egg number (EN), egg production (EP) and egg weight measured during three periods of production (P1, P2 and P3).

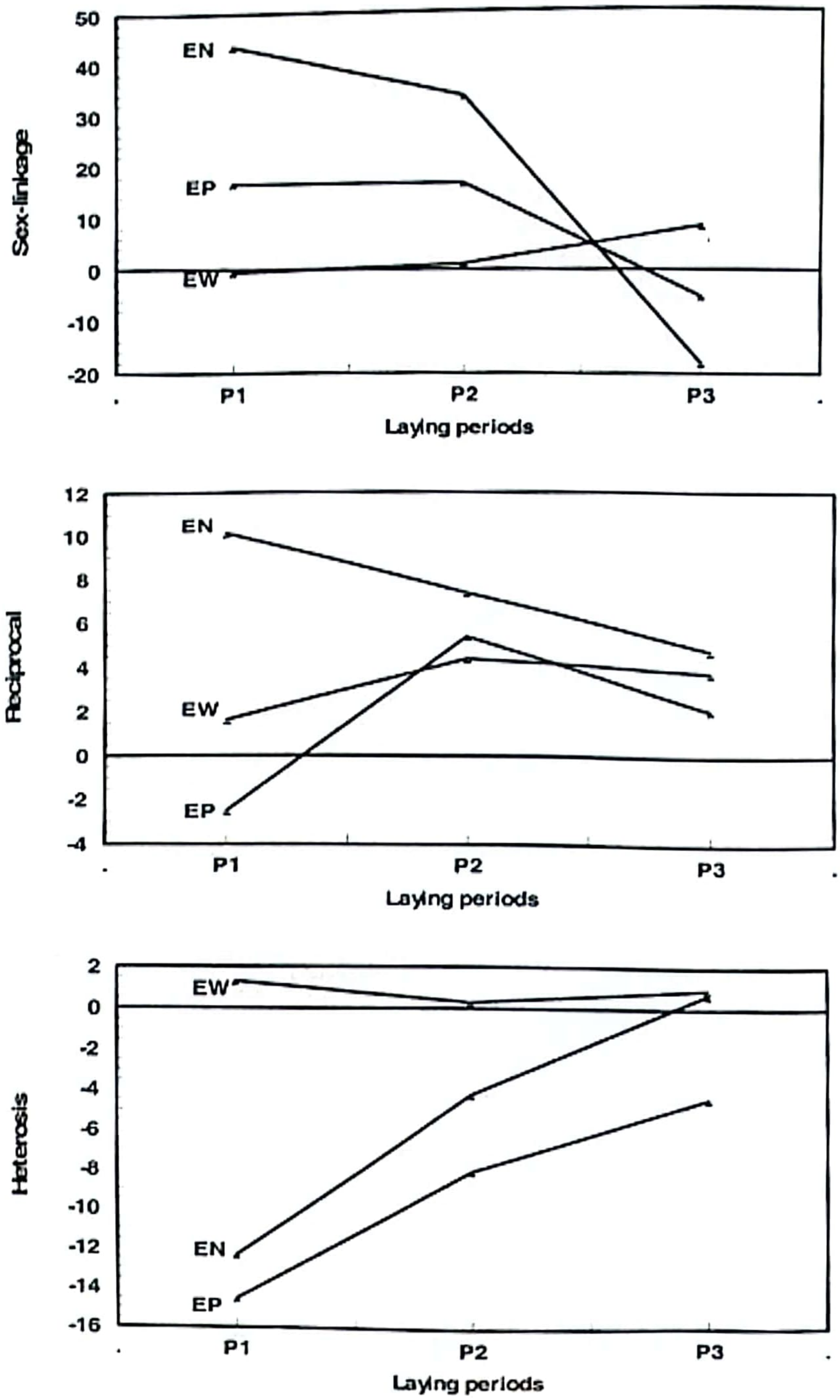


Fig. (1). Estimates of sex-linkage reciprocal and heterosis effects for egg number (EN), egg production (EP) and egg weight measured during three periods of production (P1, P2 and P3).

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Received: 18/09/2006
Accepted: 12/02/2007

تأثيرالوراثة والخلط على صفات انتاج البيض فى دجاج سينا و اللجهورن الابيض والخليط بينهم

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فى دراسة استخدم فيها نوعين من الدجاج سينا (S) واللجهورن الابيض (WL) والخليط بينهم (WLxS) و(SxWL) ذلك لتقييم تأثير الخلط على الصفات الانتاجية وتقدير بعض المكونات الوراثية مثل قوة الهجين وتاثير كروموسوم الجنس و التاثيرالأمى والتاثير التجمعى وتاثير الخلط وذلك خلال الثلاثة شهور الاولى من الانتاج و كانت الصفات التى تناولتها الدراسة هى عدد البيض و معدل انتاج البيض و متوسط وزن البيض و العمر عند النضج الجنسى و بعض صفات جودة البيض. واستخلص من النتائج ان هناك اختلافات بين المجاميع الوراثية فى معظم الصفات تحت الدراسة. وقد وجد ان دجاج سينا تنضج مبكرا وتنتج عدد منخفض من البيض بالمقارنة بدجاج اللجهورن الابيض. كذلك وجد ان الدجاج اللجهورن الابيض يعطى معدل انتاج بيض عالى ويصل الى النضج الجنسى متاخرا نسبيا عن دجاج سينا كذلك وجد مع الخليط بينهما.كما وجدت اختلافات معنوية بين الخلطان فى كل الصفات الانتاجية و ان الخليط (WLxS) كان مبكرا فى انتاج البيض عن الخليط SxWL) وكان متوسط وزن البيضة فى دجاج سينا و اللجهورن الابيض و(SxWL)(WLxS) هو ٥١،٨و ٤٧،٢و ٤٣،٥و ٥٢،٣ جرام على التوالى. كما وجدت اختلافات معنوية فى وزن البيضة بين هذه الانواع وجد كما ان اناث دجاج سينا كانت ذات صفات جودة بيض عالية بالمقارنة بالمجاميع الوراثية الاخرى. كما قدر التاثير التجمعى و تاثير كرموسوم الجنس على الصفات الانتاجية وكان عالى المعنوية لصفات عدد البيض و معدل انتاج البيض ومتوسط وزن البيضة عند ٩٠ يوم انتاج. كما قدر التاثير الامى وتاثير كرموسوم الجنس على عدد البيض و معدل انتاج البيض عند ٩٠ يوم انتاج فكان سلبيا. كذلك وجد ان تاثير الخلط على الصفات الانتاجية ليس له اية معنوية . وكانت قوة الهجين على معدل انتاج البيض عند ٩٠ يوم ليس لها اى تاثير. كذلك لوحظ ان قوة الهجين قد تسببت فى زيادة وزن البيضة بمعدل٨، ١ % و معدل انتاج البيض بنسبة ١،٥% .كما لوحظ انه لا تاثيرلقوة الهجين على صفات جودة البيض. وجد ان تاثير كروموسوم الجنس له تاثير على زيادة النسبة المئوية للصفار فى حين انه تسبب فى خفض نسبة الالبيومين و كذلك النسبة المئوية للقشرة. قدر الارتباط الوراثى بين الصفات الانتاجية فكان عالى بين عدد البيض و معدل الانتاج و العمر عند النضج الجنسى. كذلك الارتباط الوراثى بين عدد البيض ووزن البيض كان سلبيا (- ٢٢،) اما بالنسبة للارتباط المظهرى بين عدد البيض ووزن البيضة فكان سلبيا ايضا ولكن ذات قيمة متوسطة. اما بالنسبة للعمر عند النضج الجنسى فكان سلبيا مع وزن البيضة ولكن عالى القيمة.