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EVALUATION OF PUREBREDS, HETEROSIS, COMBINING ABILITIES, MATERNAL AND SEX- LINKED EFFECTS FOR SOME PRODUCTIVE AND REPRODUCTIVE TRAITS IN CHICKENS

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ABSTRACT

Four pure breeds of chickens namely New Hampshire (NH), White Cornish (WC), White Plymouth Rock (WP) and White Leghorn (WL) were used in 4x4 diallel crossing experiment. A total number of 16 males and 128 females randomly chosen from each breed were used as paternal and maternal lines, respectively. Data of 471 birds (78 cocks and 393 pullets) and 3356 eggs (incubated within five hatches) were used to estimate heterosis, purebreds, general (GCA) and specific (SCA) combining abilities, maternal ability (MA) and reciprocals or sex-linked (SL) effects. Body weights at 8 weeks (BW8) and at sexual maturity (BWSM) of birds were studied. Reproductive traits such as fertility (F%), hatchability (H%) and embryonic mortality percentages at 1st (EM1%), 2nd (EM2%) and 3rd (EM3%) weeks during the incubation period were also studied.

Results showed that breed group was found to have a significant (P<0.01) differences for all studied traits (except for EM3%). Crossbreds were generally superior for most studied traits than purebreds. Crossing between NH and WP gave the highest heterosis effect for body weight traits and F%, while crossing between NH and WL gave generally the highest estimates of heterosis for H% and the lowest for most of embryonic mortality. On the contrary, crossing between WP and WC gave the lowest heterosis estimates for F% and H%. Effects of purebred, GCA, MA, SCA and SL were significant (P<0.01) for body weight traits, while only the SCA effect was significant (P<0.01) for EM2%. Estimate of GCA for NH purebred was higher for body weight, F% and H% traits; and lower for EM1% than the other purebreds. Estimate of MA for WC was higher for body weights and lower for both F% and H% than the other purebreds, while WL had the highest estimates of MA for most reproductive traits. Crossbred between NH and WP gave the highest estimates of SCA for BWSM, while crossbreds between NH and WC gave the highest estimates of SCA for reproductive traits. The NH-WC, WP-WC and WL-WP crossbreds had the highest and positive estimates of SL effect for BW8, BWSM and F%, respectively, while the WL-WC crossbred gave the best for H% and embryonic mortality. From the previous results, NH as sire breed and WP as dam breed could be used to produce commercial crosses superior for growth traits and F%, while NH as sires and WL as dams could be used to produce commercial strains superior for reproductive traits.

Key words: Purebreds, heterosis, general and specific combining abilities, maternal, sex-linked effects and reproductive traits.

INTRODUCTION

For many years much attention has been focused on performance comparisons among poultry breeds and their crosses. This emphasis is justified because genetic differences among breeds or strains are large relative to genetic variation within breeds (Dickerson, 1992). These differences are an important potential source of genetic improvement in the efficiency of human food production from chickens through (1) expansion of superior breeds, (2) gains in performance from complementary breed effects and heterosis in crossbreeding and (3) development of superior new breeds from selected combinations of several breeds.

Many studies were carried out to determine heterotic maternal effects (Bordas et al., 1996; Mandour, et a., 1996; Khalil et al., 1999; Nawar and Bahie El-Deen; 2000; Sabri et al., 2000). Few reports were found in estimation and evaluation of combining abilities, heterosis, maternal ability and sex-liked effects for reproductive traits (e.g. percentages of fertility, hatchability and embryonic mortality).

This study aimed to: (1) evaluate genetically some productive (e.g. body weight at 8 weeks and at sexual maturity of age) and reproductive traits (e.g. fertility, hatchability and embryonic mortality percentages at 1st, 2nd and 3rd weeks during incubation period) in 4x4 diallel mating system, (2) estimate purebreds, general (GCA) and specific (SCA) combining abilities, maternal ability (MA) and reciprocals or sex-linked (SL) effects on such traits and (3) identify superior breeds based on single- and combined two-crosses.

MATERIAL AND METHODS

Experimental work and breeding plan

This study was carried out at the poultry farm of college of Agriculture and Forestry, Mosul University, Hammam, Al-Alil, Iraq. Four pure breeds of chickens named New Hampshire (NH), White Cornish (WC), White Plymouth Rock (WP) and White Leghorn (WL) were used.

The four breeds were introduced into a 4x4 diallel mating system in such a way that all possible crosses were used in thirty-two breeding pens. A total number of 16 males and 128 females randomly chosen from each breed were used as paternal and maternal lines, respectively. Thus, two sires were mated to 16 dams in each breeding pen, to constitute a particular cross and which was repeated twice.

The pedigreed eggs from each individual breeding pen were daily collected for a seven days period. Progeny of F_1 pure breeds, F_1 cross and F_1 reciprocal crosses were produced in eleven hatches.

Data and measurements

Data of 471 birds (78 cocks and 393 pullets) were randomly chosen at 8 weeks of age from the F_1 progeny. Individual body weight was recorded at 8 weeks and at sexual maturity.

A total number of 3356 eggs collected from the F_1 hens of all breed groups were incubated within five hatches. Fertility, hatchability and embryonic mortality (at 1st, 2nd and 3rd weeks of incubation period) percentages were calculated.

Statistical analysis

Data of body weights and reproductive traits were analyzed using SAS program under windows (SAS, 1996) according to the following linear models:

1- **For body weight traits**

$$y_{ijkl} = \mu + G_i + H_j + S_k + (HS)_{jk} + e_{ijkl} \qquad \textit{Model (1)}$$

Where y_{ijkl}= the lth observation on the bird of the kth sex in the jth hatch of the ith breed group, μ= the overall mean, G_i= the fixed effect of the ith breed group, H_j= the fixed of the jth hatch, S_k= the fixed effect of the kth sex, $(HS)_{jk}$= the fixed effect of interaction between jth hatch and kth sex, and e_{ijkl}= the random error of the lth bird assumed to be independently randomly distributed (0, σ_e^2).

2- **For reproductive traits**

$$y_{ijk} = \mu + G_i + H_j + (GH)_{ij} + e_{ijk} \qquad \textit{Model (2)}$$

Where y_{ijk}= the k[th] observation on the measurement of reproductive trait from i[th] group, $(GH)_{ij}$= the fixed effect of interaction between i[th] breed group and j[th] hatch, and e_{ijk}= the random error of the k[th] observation assumed to be independently randomly distributed (0, σ_e^2). The terms of μ, G_i and H_j as defined previously in Model (1).
Least-square means were tested using Duncan's option in SAS program (SAS, 1996). Heterosis was estimated for single- and combined two-crosses.

Genetic analysis

Data adjusted for the fixed effects were analyzed using the following model suggested by Kidwell et al. (1960):

$$y_{hijk} = \mu + a_h + p_{ii} + g_i + g_j + m_j + c_{ij} + r_{ij} + e_{hijk} \qquad (Model\ 3)$$

Where y_{hijk}= the k[th] observation on the individual bird or measurement from the i[th] breed of sire and the j[th] breed of dam in the h[th] type of breeding (purebred or crossbred), μ= the overall mean, a_h= an effect common to progeny of the h[th] type of breeding, P_{ii}= the effect common to all progeny of a mating between of the i[th] breed of sire and the i[th] breed of dam, $g_i(g_j)$= the effect of general combining ability (GCA) of the i[th](j[th]) breed, m_j= the effect of maternal ability (MA) for the j[th] breed of dam, c_{ij}= the effect of specific combining ability (SCA) of the ij[th] or ji[th] cross $(i \neq j)$, r_{ij}= the sex-linked or reciprocal effect (SL) of the ij[th] cross $(i \neq j)$ and e_{hijk}= the random error.

This model was used to test the significance and to estimate the effects of heterosis, purebreds, maternal, GCA, SCA and SL by applying the restrictions suggested by Harvey (1979).

The percentages of reproductive traits were converted to angle with the arcsin transformation before being analyzed in order to approximate normal distribution. After analyzing such transformed percentages, means were retransformed to the original scale.

RESULTS AND DISCUSSION

Least-square means

1- Purebreds

Least square means for traits of body weight at 8 weeks (BW8) and at sexual maturity (BWSM), percentages of fertility (F%), hatchability (H%) and embryonic mortality at 1[st] (EM1%), 2[nd] (EM2%) and 3[rd] (EM3%) weeks are given in Table 1. These results indicate that BWSM of WC was higher than the other purebreds, followed by WP. While the WL had the lightest weight compared to the other breeds. The effect of purebreds was significant ($P<0.001$) for studied body weights as found by Singh et al. (1983) and Sabri et al. (2000), and non significant for all investigated reproductive traits (Table 5).
Results in Table 1 show that F% in WC and WL was significantly ($P<0.05$) higher than in both NH and WP breeds. The H% in WP was significantly ($P<0.05$) higher than that of NH. The only EM1% of NH was significantly ($P<0.05$) higher than that of WC, while the EM2% and EM3% differences between purebreds were insignificant. Vick et al. (1993), Sewalem and Wilhelmson (1999) and Sheble and Soliman (1999) attributed the embryonic mortality to one or more factors of egg size, shell thickness, shell membrane, development of chicken egg, poor albumen quality and cuticle and abnormal embryo position in the shell. Generally, results in the present study showed that most of embryonic mortality percentages were higher in the 1[st] and 3[rd] weeks than in 2[nd] week of incubation period (Table 1). Embryonic mortality during the 3[rd] week of incubation is associated with the condition of incubation and malformation, some of which have a genetic origin (Sewalem and Wilhelmson, 1999). Therefore, hatch effect was highly significantly different for the only EM3% (Table 3).

Table 1. Least-squares means and standard errors for productive and reproductive traits in genotype groups.

Effect[+]	BW8	BWSM	Fertility %	Hatchability %	Embryonic mortality %		
					1-Week	2-Week	3-Week
Genotype group:							
Purebreds:							
NH	448.8±39.44 g	2028.5±42.04 g	79.7±2.86 cd	66.7±2.33 cd	18.22±2.27 bc	1.91±2.17 abc	12.00±3.22 abc
WP	831.5±57.73 ab	2653.8±61.54 bc	91.3±4.05 bc	82.9±3.29 ab	8.51±3.21 cde	0.00±3.07 c	6.90±4.56 c
WC	943.6±82.13 a	2934.3±87.55 a	99.2±4.05 a	80.2±3.29 abc	2.94±3.21 e	0.46±3.07 bc	11.99±4.56 abc
WL	495.7±37.09 fg	1693. 9±39.54 h	99.4±2.86 a	75.9±2.33 abcd	10.50±2.27 bcde	1.10±2.17 abc	14.56±3.22 abc
Crossbred:							
NH-WP	699.2±39.87 bcde	2533.1±42.50 bcd	99.4±2.86 a	80.6±2.33 abc	5.23±2.27 de	0.23±2.17 c	13.89±3.22 abc
WP-NH	730.4±36.34 bcd	2392.3±38.74 de	97.6±2.86 ab	84.0±2.33 ab	7.78±2.27 cde	0.23±2.17 c	5.89±3.22 c
NH-WC	712.9±68.50 bcd	2660.4±73.02 b	97.1±4.05 ab	67.4±3.30 cd	12.95±3.21 bcd	3.34±3.07 ab	24.00±4.56 ab
WC-NH	669.7±68.42 cdef	2378.3±72.93 cd	100.0±4.05 a	76.5±3.30 abcd	5.90±3.21 de	6.34±3.07 a	12.34±4.56 abc
NH-WL	525.5±38.52 ef	1963.6±41.07 g	99.5±2.86 a	86.4±2.33 a	4.95±2.27 de	0.45±2.17 bc	6.56±3.22 c
WL-NH	565.7±41.36 def	1860.7±44.09 g	96.6±2.86 ab	77.8±2.33 abcd	9.30±2.27 bcde	1.78±2.17 abc	11.67±3.22 abc
WP-WC	788.4±75.81 abc	2805.5±80.81 a	70.3±4.05 d	40.8±3.30 e	19.67±3.21 ab	0.00±3.07 c	9.34±4.56 bc
WC-WP	828.8±72.38 abc	2877.7±77.16 a	81.4±4.05 cd	64.6±3.30 d	27.67±3.21 a	0.00±3.07 c	6.67±4.56 c
WP-WL	645.7±37.19 cdef	2204.4±39.64 ef	97.0±2.86 ab	84.4±2.33 ab	6.01±2.27 de	0.86±2.17 bc	12.34±3.22 abc
WL-WP	674.5±36.68 bcdef	2172.3±39.10 f	99.4±2.86 a	71.7±2.33 bcd	8.12±2.27 cde	1.78±2.17 abc	18.90±3.22 abc
WC-WL	631.0±50.53 bcdf	2148.9±44.09 f	99.0±4.05 a	64.0±3.30 d	9.66±3.21 bcde	0.00±3.07 c	29.56±4.56 a
WL-WC	646.7±123.4 bcdef	2415.0±131.6 cd	73.5±2.86 d	69.0±3.30 bcd	16.78±3.21 abc	1.23±3.07 abc	6.10±4.56 c

[+]NH= New Hampshire; WP= White Plymouth Rock; WC= White Cornish; WL= White Leghorn.
Means with the same letters in each column are not-significantly different ($P<0.05$).

Results in Table 6 show that WC had the heaviest body weight being 263.73 gm for BW8 and 683.09 gm for BWSM, while the WL gave the highest F% being 9.20 % over the mean. Moreover, WP had the highest H% being 4.45% over the mean and the lowest embryonic mortality (over all the three weeks of incubation period) being 3.18% below the mean (Tables 1&6). The NH had the inferior for traits of F% (-13.5%), H% (-6.38%), EM1% (7.53%) and EM2% (3.48%).

2- Crossbreds

Results in Tables 1 and 2 indicate that body weights for most crossbreds were significantly higher than those NH and WL purebreds. The WC-WP crossbred gave the heaviest body weight, while NH-WL crossbred gave the lightest one. Significant (P<0.05) body weight differences were obtained for crossbred of WP-WC compared to most other crosses (Table 1), which may be due to the heaviest WC breed.

Table 2. F-ratios of least-squares analysis of variance of factors affecting body weight at 8 weeks and at sexual maturity.

Source of variation	BW8		BWSM	
	d.f	F-value	d.f.	F-value
Breed group	15	6.61***	15	44.81***
Hatch (H)	10	0.92 ns	10	0.99 ns
Sex	1	0.08 ns	1	403.56***
Hatch x Sex	10	0.91 ns	10	1.04ns
Remainder d.f.	**434**		**434**	
Remainder M.S.	**56605.537**		**64322.626**	

ns= non significant; ***= P<0.001.

The F% was the highest when crossed WC with NH, while it the lowest when crossed WP with WC. Moreover, NH-WL crossbred gave the highest H%. Thus, it is considered of the lowest embryonic mortality over the three weeks of incubation period. In general, the embryonic mortality ranged from 0.0% to 29.56% in all crosses (Table 1). From the previous result, one can recommend that utilizing the crossbreds of WC-WP, WC-NH and NH-WL in breeding program to improve body weight, F% and H% traits, respectively.

Heterosis

Heterosis was measured as the comparison of purebreds with crossbreds (Table 5). Heterosis effect was not significant for all studied traits (Table 5). On the contrary, Singh et al. (1983) found that heterosis effect was significant (P<0.01) for body weight at sexual maturity. Results in Table 6 show that estimates of purebreds were higher by 1.67 gm, 68.64 gm and 1.80% over the mean for BW8, BWSM and H% traits, respectively, while it reduced by 0.58%, 0.18% and 0.53% below the mean for EM1%, EM2% and EM3%, respectively. Generally, crossbreds were relatively superior over purebreds for only F% trait. Therefore, we can conclude that F% could be improved by crossbreeding program. Nordskog and Phillips (1960) concluded that crossing improve fertility percentage. El-Gendy (2000) and Hossari and Dorgham (2000) found a positive heterotic effect on fertility and hatchability traits. However, Nestor et al. (1997) concluded that heterosis appeared to be more important for reproductive traits than for growth traits in Turkey.

Heterosis estimates (computed as a percent increase of the crossbred above their parent breeds) based on single cross (superiority) and combined two-cross for body weight and reproductive traits are given in Table 4. When considering single cross, results indicate that crossbreds of NH-WL, WC-WP, WC-NH and WC-WL had the highest estimates of heterotic effects for H%, EM1%, EM2% and EM3% traits, respectively. On the contrary, crossbred of NH-WL had the lowest heterosis for the embryonic mortality during the three weeks of incubation period.

Table 3. F-ratios of least squares analysis of variance of factors affecting reproductive traits of chickens.

Source of variation	Fertility %		Hatch %		Embryonic mortality %					
					1st WK		2nd WK		3rd WK	
	d.f.	F-value	d.f.	F-value	d.f.	F-value	d.f.	F-value	d.f.	F-value
Breed group (BG)	15	9.17^{***}	15	6.07^{***}	15	4.09^{***}	15	2.42^{**}	15	1.77^{ns}
Hatch (H)	4	7.57^{***}	4	11.66^{***}	4	1.45^{ns}	4	1.58^{ns}	4	10.94^{***}
BG x H	60	1.95^{**}	60	2.65^{***}	60	2.69^{***}	60	1.39^{ns}	60	1.70^{*}
Remainder d.f.	40		40		40		40		40	
Remainder M.S.	81.913		54.292		51.543		47.153		103.743	

^{ns}= non-significant; *= P<0.05; **= P<0.01; ***= P<0.001.

Table 4. Estimates of heterosis percentage for productive and reproductive traits of chickens.

Breed group*	**BW8**	**BWSM**	**Fertility %**	**Hatch %**	**Embryonic mortality %**		
					1st Wk	2nd Wk	3rd Wk
Single-cross+							
NH-WP	9.22	8.20	16.27	7.70	-60.87	-75.92	46.98
WP-NH	14.10	2.18	14.20	12.30	-41.79	-75.92	-37.67
NH-WC	2.40	7.21	8.54	-8.27	22.40	181.86	100.08
WC-NH	-3.80	-4.15	11.78	4.14	-44.23	435.02	2.88
NH-WL	11.29	5.50	11.11	21.17	-65.53	-70.10	-50.60
WL-NH	-18.74	-25.01	7.94	5.86	-12.10	50.21	-2.71
WP-WC	-11.17	0.41	-26.20	-49.97	243.58	-100.00	-1.11
WC-WP	-6.62	2.99	-14.54	-20.79	383.32	-100.00	-29.38
WP-WL	-2.69	1.41	1.71	6.35	-36.77	56.36	15.00
WL-WP	1.64	-0.07	4.22	-9.71	-14.57	223.64	76.14
WC-WL	-12.32	-7.14	-0.33	-18.00	43.75	-100.00	122.67
WL-WC	-10.13	4.36	-26.01	-11.59	149.70	57.69	-54.05
Combined two-Crosse+							
NH-WP	11.66	5.19	15.24	10.00	-51.33	-75.92	4.66
NH-WC	-0.70	1.53	10.16	-2.06	-10.62	308.44	51.48
NH-WL	-3.73	-9.76	9.52	13.52	-38.81	-9.94	-26.66
WP-WC	-8.89	1.70	-20.37	-35.38	313.45	-100.00	-15.25
WP-WL	-0.53	0.67	2.97	-1.68	-25.67	140.00	45.57
WC-WL	-11.20	-1.39	-13.17	-14.80	96.73	-21.15	34.31

*NH= New Hampshire; WP= White Plymouth Rock; WC= White Cornish; WL= White Leghorn.
+Heterosis percent=[(single cross – midparent)/midparent] x 100.
++Heterosis percent=[(cross – midparent)/midparent] x 100.

Table 5. F-ratios of least-squares analysis of variance for genetic and non-genetic factors affecting productive and reproductive traits.

Source of variation	d.f.	BW8	BWSM	Fertility %	Hatch %	Embryonic mortality %		
						1st WK	2nd WK	3rd WK
Het	1	0.014 ns	3.159 ns	0.046 ns	0.322 ns	0.172 ns	0.036 ns	0.088 ns
PB	3	25.546**	21.023**	1.585 ns	0.521 ns	2.170 ns	1.161 ns	0.212 ns
GCA	3	5.272**	10.959**	1.390 ns	1.384 ns	1.925 ns	2.043 ns	0.479 ns
MA	2	0.183 ns	25.162**	1.205 ns	0.270 ns	0.600 ns	1.164 ns	0.492 ns
SCA	3	0.001 ns	24.940**	2.078 ns	0.527 ns	1.804 ns	7.066**	1.551 ns
SL	3	0.276 ns	17.218**	0.439 ns	0.827 ns	0.641 ns	0.296 ns	2.024 ns
Remainder d.f.		**455**	**455**	**99**	**99**	**99**	**99**	**99**
Remainder M.S.		**44843**	**327164**	**519.74**	**317.09**	**127.79**	**63.807**	**222.25**

Het= Heterosis; PB= Purebreds; GCA= General combining ability; SCA= Specific combining ability; MA= Maternal ability; SL= Sex linked.
ns= non significant; **= P<0.01.

When considering combined two-crosses, estimates of heterosis for crossbred of NH-WP were the highest for BW8, BWSM and F%. These indicate that high non-additive genetic variabilities appeared between crossbreds of the two breeds (Hanafi et al., 1991; Sabri et al., 2000). Moreover, crossbreds of NH-WL had the highest percentage of heterosis for H% and the lowest for EM3% trait. On the other hand, the lowest percentages of heterosis were obtained for BW8 in WP-WC, for BWSM in NH-WL, for most reproductive traits in WP-WC. Thus, crossbreds of NH-WL increase H% and reduce the embryonic mortality, while crossbred of NH-WP could be used to improve body weight and F% traits (Table 4).

General combining ability (GCA)

The GCA was only significantly different (P<0.01) for body weight traits (Table 5), which are in agreement with findings of Singh et al. (1983), Hanafi et al., 1991 and Sabri et al. (2000) for body weight traits. This indicated that additive gene effect was very high on body weights and very low for reproductive traits (Table 5).

Results in Table 6 show NH gave the highest estimates of GCA for BWSM, F% and H% traits. Therefore, we can conclude that NH had higher additive gene effects than the other purebreds. On the contrary, the WC had the lowest estimates of GCA for BWSM and H% traits and the highest EM1% and EM3% traits.

Estimates of GCA ranged from –360.98 to 240.38 gm for body weights, -5.32 to 8.94% for fertility, -6.22 to 5.82% for hatchability and from –4.58 to 4.643% for embryonic mortality.

Maternal ability (MA)

Effect of MA was significantly (P<0.01) different for BWSM and non-significant for the other studied traits (Table 5). Hanafi et al. (1991) and Khalil et al. (1999) and Sabri et al. (2000) showed significant effect of MA on body weights. Moreover, El-Gendy (2000) found that significant effect (P<0.01) of MA on fertility and hatchability traits.

Estimates of MA were the highest in WP and WC for body weight traits, and it was the highest in WL for most reproductive traits. Thus, we can conclude that dams of WP and WC had the best mothering ability to improve body weight, while dams of WL could be considered to improve most of reproductive traits. The MA effect was the lowest performing of NH for BWSM (-119.72 gm) and EM2% (1.94%). However, MA effect of WC was the lowest for F% (-10.62%) and H% (-3.88%) and it was the highest effect for EM1% (1.9%) as shown in Table 6.

Table 6. Least-squares constants (Con.) and standard errors (SE) for factors affecting productive and reproductive traits.

Item⁺	BW8	BWSM	Fertility %	Hatch %	Embryonic mortality %		
					1st WK	2nd WK	3rd WK
	Con.±S.E.	Con.±S.E.	Con.±S.E.	Con.±S.E.	Con.±S.E.	Con.±S.E.	Con.±S.E.
$\hat{\mu}$:	678.2±9.76	2034.9±26.4	77.31±2.13	59.95±1.66	18.31±1.05	4.64±0.74	20.06±1.39
Heterosis:							
Pure	1.67±19.5	68.64±52.7	-0.58±4.56	1.20±3.56	-0.56±2.26	-0.18±1.60	-0.53±2.98
Cross	-1.67±11.3	-68.64±30.4	0.58±2.40	-1.20±1.88	0.56±1.19	0.18±0.84	0.53±1.57
Purebreds:							
NH	-231.11±32.7	-285.01±88.3	-13.49±7.21	-6.37±5.63	7.53±3.57	3.48±2.53	0.73±4.71
WP	151.58±48.6	258.00±131	-3.89±10.2	4.45±7.96	-0.79±5.06	-4.46±3.57	-4.30±6.67
WC	263.73±70.6	683.09±191	8.19±10.2	2.45±7.96	-7.89±5.06	-0.57±3.57	0.68±6.67
WL	-184.20±30.6	-656.08±82.6	9.20±10.2	-0.53±7.96	1.15±5.06	1.55±3.57	2.89±6.67
GCA:							
NH	-42.49±14.8	240.38±39.9	8.94±3.22	5.82±2.52	-4.58±1.60	1.44±1.13	0.71±2.11
WP	72.19±14.6	177.71±39.4	-5.32±3.22	-1.39±2.52	0.67±1.60	-3.82±1.13	-3.39±2.11
WC	52.25±24.1	-360.98±65.2	-2.79±4.16	-6.22±3.25	4.64±2.06	0.37±1.46	2.49±2.72
WL	-81.94±14.5	-57.11±39.3	-0.83±3.22	1.79±2.52	-0.73±1.60	2.00±1.13	0.19±2.11
MA:							
NH	7.07±20.7	-119.72±55.8	-0.35±4.56	0.47±3.56	0.22±2.26	1.94±1.60	-2.86±2.98
WP	9.48±21.1	-565.38±56.9	4.89±4.56	0.58±3.56	1.20±2.26	0.59±1.60	2.53±2.98
WC	4.62±40.0	751.75±108	-10.62±5.89	-3.88±4.6	1.90±2.92	0.57±2.06	-1.76±3.85
WL	-21.18±19.4	-66.65±52.4	6.09±4.56	2.82±3.56	-3.33±2.26	-3.10±1.60	2.08±2.98
SCA:							
NH-WP	0.27±22.1	198.83±59.6	-0.38±5.10	1.43±3.98	-0.97±2.53	-2.77±1.79	0.20±3.33
NH-WC	-0.85±41.5	196.00±112	6.55±7.21	1.45±5.63	-2.33±3.57	4.72±2.53	3.49±4.71
NH-WL	0.57±22.6	-394.83±61.0	-6.17±5.10	-2.89±3.98	3.30±2.53	-1.95±1.79	-3.69±3.33
WP-WC	0.57±44.2	-394.83±119	-6.17±7.21	-2.89±5.63	3.30±3.57	-1.95±2.53	-3.69±4.71
WP-WL	-0.85±21.6	196.00±58.4	6.54±5.10	1.46±3.98	-2.33±2.53	4.72±1.79	3.49±3.33
WC-WL	0.27±40.0	198.83±108	-0.37±7.21	1.43±5.63	-0.97±3.57	-2.77±2.53	0.20±4.71
Reciprocal:							
NH-WP	-16.83±33.1	312.90±89.3	-0.38±7.21	-1.34±5.63	-1.92±3.57	0.69±2.53	1.21±4.71
WP-NH	16.83±29.7	-312.90±80.1	0.38±7.21	1.34±5.63	1.92±3.57	-0.69±2.53	-1.21±4.71
NH-WC	22.80±58.7	-310.35±159	0.24±10.2	-0.75±7.96	2.59±5.06	-1.33±3.57	3.81±6.67
WC-NH	-22.80±58.7	310.35±159	-0.24±10.2	0.75±7.96	-2.59±5.06	1.33±3.57	-3.81±6.67
NH-WL	-5.97±30.9	-2.55±83.4	0.14±7.21	2.09±5.63	-0.67±3.57	0.63±2.53	-5.03±4.71
WL-NH	5.97±33.1	2.55±89.3	-0.14±7.21	-2.09±5.63	0.67±3.57	-0.63±2.53	5.03±4.71
WP-WC	-17.78±63.8	549.14±172	4.02±10.2	-4.67±7.96	-3.04±5.06	0.01±3.57	3.58±6.67
WC-WP	17.78±61.1	-549.14±165	-4.02±10.2	4.67±7.96	3.04±5.06	-0.01±3.57	-3.58±6.67
WP-WL	0.95±30.6	-236.24±82.6	-4.40±7.21	3.32±5.63	1.12±3.57	0.68±2.53	-2.36±4.71
WL-WP	-0.95±30.6	236.24±82.6	4.40±7.21	-3.32±5.63	-1.12±3.57	-0.68±2.53	2.36±4.71
WC-WL	5.03±43.2	238.79±117	4.26±10.2	-5.41±7.96	-0.45±5.06	-1.31±3.57	7.39±6.67
WL-WC	-5.05±106	-238.79±286	-4.26±10.2	5.41±7.96	0.45±5.06	1.31±3.57	-7.39±6.67

⁺NH= New Hampshire; WP= White Plymouth Rock; WC= White Cornish; WL= White Leghorn.

Specific combining ability (SCA)

Effect of SCA was significantly (P<0.01) different for BWSM and EM3% traits (Table 5). Similarly, Singh et al. (1983), Hanafi et al., 1991 and Sabri et al. (2000) showed the same result for body weight traits. Estimates of SCA presented in Table 6 showed that crosses of NH-WP and NH-WC were superior for BWSM, while NH-WC crossbred was superior for reproductive traits. These crosses had the highest and positive estimates of SCA. The WP-WC crossbred had the lowest SCA for BWSM, F% and H% traits, and the highest embryonic mortality percentages. These results indicate that NH could be crossed advantageously with WP to improve body weight and with WC to reduce embryonic mortality.

Reciprocals or sex-linked effect (SL)

The BW8 and reproductive traits were found to be non-significantly affected by sex-linked (Table 5). Consequently, an advantage may be obtained by using certain breeds (as either male or female parents) in crossbreeding program. Similarly, some studies (Amrit, 1978; Sharma, 1978; Sabri et al., 2000) reported non-significant differences in body weight due to SL effects.

On the contrary, many findings (i.e. Manglik et al., 1980; Singh et al., 1983; Hanafi et al., 1991) showed significant differences in reciprocal crosses for body weight. However, our results showed in Tables 5&6 indicate significant effects of SL for BWSM. Thus, the sex-linked genes were of major important in affecting body weights, consequently, the choice of sire breed and dam breed would be important in planning crossbreeding programs. It is clear that NH-WC, WP-WC and WL-WP crossbreds had the highest and positive estimates of SL for BW8, BWSM and F% traits, respectively, while the WL-WC had the best estimates of SL for both H% and embryonic mortality (Table 6). These crosses were superior compared to their reciprocals at most traits, which reflect the existence of better maternal ability for these crossbreds.

CONCLUSION

1- Based on heterotic effect, NH as sire breed and WP as dam breed could be used to produce commercial crosses superior for traits of body weight and F%, while NH as sires and WL as dams could be used to produce commercial strains superior for reproductive traits.
2- Most effects of purebred, GCA, MA, SCA and SL were significantly different for body weight traits, while the only SCA effect was significantly ($P<0.01$) different for embryonic mortality percentages. This reflects an important of genetic and non-additive genetic effects for body weights and only non-additive genetic effects for reproductive traits in chickens.
3- Generally, crossbreds were relatively superior to purebreds for F% trait, which prove that F% could be improved by crossing.

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تقييم الأنواع الأصيلة وقوة الهجين وقدرة التوافق العامة والخاصة وتأثير الأمومة والارتباط بالجنس لبعض الصفات الإنتاجية والتناسلية فى الدجاج

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استخدمت أربعة أنواع من الدجاج هى النيوهامبشير والكورنيش الأبيض والبليموث روك الأبيض واللجهورن الأبيض فى تجربة خلط تبادلى ٤x٤ ، حيث تم اختيار ١٦ ديك & ١٢٨ دجاجة عشوائيا من كل نوع لاستخدامهم كسلالة أب وسلالة أم – على التوالى. وقد سجلت بيانات ٤٧١ طائر (٧٨ ديك ، ٣٩٣ دجاجة) وبيانات ٣٣٥٦ بيضة (تم تفريخهم فى خمسة تفقيسات) وذلك لدراسة قوة الهجين وتأثير كل من الأنواع الأصيلة وقدرتى التوافق العامة والخاصة والمقدرة الأمية والتزاوجات العكسية (أو التأثير المرتبط بالجنس). درست صفات وزن الجسم عند عمر ٨ أسابيع ، وعند عمر النضج الجنس ، كما درس أيضا صفات التناسل مثل صفات نسبة الخصوبة والفقس والنفوق الجنينى فى الأسبوع الأول والثانى والثالث من فترة التفريخ. وقد أوضحت النتائج مايلى:

١- كانت الاختلافات بين مجاميع الأنواع معنوية (١%) لكل الصفات المدروسة فيما عدا صفة النفوق الجنينى عند الأسبوع الثالث من التفريخ.

٢- أظهرت الخلطان بصفة عامة تفوقا ملحوظا عن الأنواع النقية لمعظم الصفات المدروسة.

٣- أعطى الخليط الناتج من ذكور النيوهامبشير واناث البليموث روك أعلى قوة هجين لصفات وزن الجسم والخصوبة ، بينما أعطى الخليط الناتج من ذكور النيوهامبشير واناث اللجهورن أعلى قوة هجين موجبة لصفة نسبة الفقس ، وأعلى قوة هجين سالبة لنسبة النفوق الجنينى خلال فترة التفريخ. وعلى العكس أعطى الخليط الناتج من البليموث روك والكورنيش الأبيض أقل تقدير لقوة الهجين.

٤- كان تأثير كل من الأنواع النقية وقدرة التوافق العامة والخاصة والارتباط بالجنس معنويا (١%) على وزن الجسم ، بينما كانت قدرة التوافق الخاصة فقط معنوية (١%) لصفة النفوق الجنينى عند الأسبوع الثانى من التفريخ.

٥- كانت قدرة التوافق العامة لسلالة النيوهامبشير أعلى لصفات وزن الجسم والخصوبة والفقس ، بينما كانت أقل لصفة النفوق الجنينى فى الأسبوع الأول من التفريخ عن الأنواع النقية الأخرى.

٦- كانت المقدرة الأمية لسلالة الكورنيش أعلى تأثيرا لوزن الجسم وأقل تأثيرا لصفتى الخصوبة والفقس عن الأنواع النقية ، بينما كانت سلالة اللجهورن أعلى تقديرا للتأثير الأمى لمعظم صفات التناسل.

٧- أعطى الخليط الناتج من ذكور النيوهامبشير واناث البليموث روك أعلى قدرة توافق خاصة لصفة وزن الجسم عند عمر النضج الجنسى ، والخليط الناتج من ذكور النيوهامبشير و إناث الكورنيش أعلى قدرة توافق خاصة لصفات التناسل.

٨- أعطت الخلطان الناتجة من النيوهامبشير والكورنيش ، والبليموث روك والكورنيش ، واللجهورن والبليموث روك أعلى تقديرات موجبة لتأثير الارتباط بالجنس لصفات وزن الجسم عند عمر ٨ أسابيع ، عند عمر النضج الجنسى وصفة الخصوبة– على التوالى ، بينما كان الخليط الناتج من ذكور اللجهورن و اناث الكورنيش الأفضل تقديرا لتأثير الارتباط بالجنس لصفات الفقس والنفوق الجنينى.

٩- مما سبق يمكن استنتاج أن ذكور النيوهامبشير واناث البليموث روك تصلح لتكوين خلطان تجارية متميزة فى صفات النمو والخصوبة ، بينما ذكور النيوهامبشير واناث اللجهورن تصلح لتكوين خلطان تجارية متميزة فى صفات التناسل.