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ESTIMATION OF HETEROTIC COMPONENTS FOR GROWTH AND LIVABILITY TRAITS IN A CROSSBREEDING EXPERIMENT OF SAUDI CHICKENS WITH WHITE LEGHORN

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***ABSTRACT**: A crossbreeding experiment involving Baladi Saudi (S) and White Leghorn (L) chickens was carried out in El-Qassim region in Saudi Arabia to evaluate the growth performance and livability traits of the resulting crossbreds. Data of bi-weekly body weights, daily gains in weight and livabilities were collected on 1281 chicks from the age of 0 to 12 weeks. The genetic model of Dickerson was used to estimate the heterotic components of this experiment in terms of heterosis (H^I) and direct (G^I) and maternal breed (G^M) additive effects. Chicks of L breed had superior performance in body weights ($P<0.001$) and daily gains in weight ($P<0.01$ or $P<0.001$) and livability traits studied compared to the S chicks. Crossing of S chickens with L ones was associated with significant positive direct heterosis for some growth traits especially those weights and gains of early ages (0-6 weeks), while at later ages of 8-12 weeks, crossbred chickens recorded negative H^I for the same traits. Heterotic effects decreased generally with advance of chick's age. The percentages of H^I ranged from 1.7 to 3.0% for body weights and gains at early ages of 0-6 weeks, while they ranged from -3.1 to 0.0% at later ages (6-12 weeks). In contrast to that found in body weights and gains, estimates of H^I for livability were mostly negative during the early ages of 0-4 weeks, while at later ages of 6-12 weeks they were positive and significant and ranged from 2.8 to 4.2%. Under hot climatic conditions, additive maternity (G^M) for studied traits was generally significant and in favour of the S breed since chicks produced from LxS matings had better growth and livability traits than those* *produced from SxL matings. The direct additive effects significantly affected most weights and gains. L-sired chicks had high direct additive effects (G^I) compared to the S-sired chicks for all growth and livability traits studied.*

INTRODUCTION

Crossbreeding between standard breeds and Saudi chickens raised under the hot conditions of Saudi Arabia is not widely carried out. To date, publications concerning crossbreeding of local chickens with standard breeds (e.g. White Leghorn) seem to be not available. Direct and maternal heterosis, maternal and direct additive effects from crossbreeding experiments including Saudi chickens were expected to be important especially for growth performance and egg production. In hot climate countries, White Leghorn breed was found to exhibit an outstanding maternal ability (Jain *et al*, 1981; Jain and Choudhary, 1984; Al-Sobayel, 1985). To get crossbred layers including Saudi blood, it was necessary to investigate their growth rates up to sexual maturity, which in turns affects their weights and ages at which they lay the first egg. Therefore, this study was conducted to evaluate the importance of heterosis, maternal and direct additive effects on growth and livability traits in a crossbreeding experiment involving local Saudi and White Leghorn chickens. Data collected for egg production on crossbred hens will be published later.

MATERIAL AND METHODS

A crossbreeding experiment was carried out in the poultry farm of the Research Center of the Agricultural Experiments (RCAE), College of Agriculture and Veterinary Medicine, King Saud University, Saudi Arabia. This experiment started in January 1997 and is still running with the data of egg production being collected.

Breeding plan:

Chicks used in this study represent one local breed (Baladi Saudi, S) and one exotic breed (White Leghorn, L). Two parental stocks of S (600 chicks) and L (400 chicks) were taken from the Poultry Farm of the College of Agriculture at Riyadh, King Saud University. Details and description of general features of the two breeds raised under conditions of Saudi Arabia are reported by Al-Sobayel (1985). Chicks of the parental stock were raised up to the age of five months in the rearing house. At the beginning of the crossbreeding experiment (October, 1997), breeding hens of each of the two breeds were randomly divided into two breeding groups. The first group of hens of each of the two breeds was artificially mated with cocks from their own breed, while the second group was artificially mated with cocks from the other breed. Consequently, eggs of four mating groups of LxL, SxS, LxS, and SxL were collected and placed in two hatches. Throughout the two hatches, each cock was allowed to sire all his chicks from the same dams, i.e. separate cocks were used in each of the four breed groups. The distribution of breeding hens and cocks and number of chicks hatched in the four genetic groups are presented in Table 1. Two subsequent hatches were obtained during November and December 1997.

Management and feeding:

All chicks of one-day old were wing-banded and floor brooded and reared in closed houses up to the age of 16 weeks (11 chicks per 1 m^2). Temperature was controlled using separate electric heaters and air-conditioners, while the ventilation was controlled using electric extractor fans. Chicks were vaccinated against New Castle disease via the drinking water during the first week (strain Hitchner) and at 8 weeks (strain Lassota) and they were regularly vaccinated thereafter every three months. All chicks were subjected to the same managerial, hygienic and climatic conditions. They were treated and medicated similarly and regularly.

At the age of 5 months, pullets were individually housed in breeding pens in three-tier batteries equipped with feeding hoppers and drinking nipples. The pedigreed eggs from each individual hen were collected and recorded regularly.

During the brooding and rearing periods, all chicks were fed *ad-libitum* using a standard starter ration (21% crude protein and 12.1 MJ Metabolizable energy per kg of feed) up to 8 weeks of age and a finisher ration (14% crude protein and 11.1 MJ Metabolizable energy per kg of feed) thereafter up to 18 weeks.

Data and statistical analysis:

Data on body weights of 1281 chicks over two hatches were taken at 0, 2, 4, 6, 8, 10 and 12 weeks (W0, W2, W4, W6, W8, W10 and W12, respectively). Daily gains measured included gains at intervals of 0-2 (G2), 2-4 (G4), 4-6 (G6), 6-8 (G8), 8-10 (G10), and 10-12 (G12) weeks of age, respectively. The livability traits were also measured at intervals of 0-2 (L2), 2-4 (L4), 4-6 (L6), 6-8 (L8), 8-10 (L10) and 10-12 (L12) weeks of age, respectively. Livability percentages were subjected to arc-sin transformation to approximate normal distribution before being analysed. Data of all growth traits and livabilities were analysed using the following sire-dam model (Harvey, 1990):

$$Y_{ijklmn} = \mu + B_i + S_{ij} + D_{ijk} + H_l + A_m + (BH)_{il} + (BA)_{im} + (HA)_{lm} + e_{ijklmn}$$

Where:

Y_{ijklmn} = The observation on the ijklmnth hatched chick
μ = The overall mean
B_i = The fixed effect of the ith breed group
S_{ij} = The random effect of the jth sire nested within the ith breed group
D_{ijk} = The random effect of the kth dam nested in the random effect of the jth sire nested within the ith breed group
H_l = The fixed effect of the lth hatch (i=1,2)
A_m = The fixed effect of the mth sex
BH_{il}, BA_{im} and HA_{lm} = All possible interactions
e_{ijklmn} = The random deviation particular to the nth chick, *i.e.* NID $(0, I\sigma^2_e)$.

Pedigrees of sires and dams were not available in the data, therefore the relationship coefficient inverse matrix (A^{-1}) was not included in the model. Breed group was tested against sires within breed group, while sires were tested against dams within sires. Other fixed effects were tested against the remainder. HARVEY's least-squares and maximum likelihood computer program (Harvey, 1990) was used. The mixed model equations (MME) of the sire-dam model (in matrix notation) described above were:

$$\begin{bmatrix} X'R^{-1}X & X'R^{-1}Z_S & X'R^{-1}Z_d \\ & Z_S'R^{-1}Z_S + I\sigma^2_e/\sigma^2_s & Z_S'R^{-1}Z_d \\ & & Z_d'R^{-1}Z_d + I\sigma^2_e/\sigma^2_d \end{bmatrix} \begin{bmatrix} \beta \\ U_S \\ U_d \end{bmatrix} = \begin{bmatrix} X'R^{-1}Y \\ Z_S'R^{-1}Y \\ Z_d'R^{-1}Y \end{bmatrix}$$

Where:

Y = nx1 vector of observed growth or livability trait; n= number of records.

β = px1 vector of fixed effects of breed group, hatch and sex and all possible interactions; p= number of levels for fixed effects.

$\mathbf{U_s}$ or $\mathbf{U_d}$ = qx1 vector of random effects of sire or dam; q= number of levels for random sire or dam effects.

$\mathbf{Z_s}$ or $\mathbf{Z_d}$ = Design incidence matrix of order nxp, which relates records to random sire or dam effects.

e = nx1 vector of random error.

σ^2**s**, σ^2**d**, and σ^2**e** = variance components for sire, dam and remainder, respectively,

I = identity matrix corresponding to **n** observations, and often $\mathbf{I}\sigma^2\mathbf{e} = \mathbf{R}$.

Genetic model and estimation of crossbreeding effects:

Heterotic components (maternal breed additive, direct additive and direct heterosis) for different growth and livabilities traits were estimated according to Dickerson's methodology (Dickerson, 1992). Such a genetic model permits the derivation of a selected set of linear contrasts, *i.e.* direct additive effect, maternal breed additive effect and direct heterotic effect were estimated as:

Direct heterosis contrast:

H^I_{LxS} in units = [(L x S + S x L) - (L x L + S x S)]

H^I_{LxS} in percentage = {[(LxS + SxL) - (LxL + SxS)]/(LxL + SxS)}x 100

Maternal breed effect (dam-breed effect):

(G^M_L - G^M_S) = [(S x L) - (L x S], *i.e.* reciprocal crosses differences or breed genetic maternal effect.

Direct additive effect:

(G^I_L-G^I_S)= {[(L x L)+(L x S)] - [(S x S)+(S x L]}, *i.e.* Breed group of sire differences.

Where $\mathbf{G^I}$ and $\mathbf{G^M}$ represent direct additive and maternal additive effects, respectively, of the subscripted genetic group. Each single degree of freedom contrast was tested for significance with the Student's t-test.

RESULTS AND DISCUSSION

Genetic-groups comparison

Genetic-group least-squares means and contrasts among purebreds for growth traits and livabilities are presented in Table 2. The LxL genetic group resulted in heavier body weights and gains ($P<0.001$) compared to the SxS matings. In comparison of growth performance of S and L chickens raised in Saudi Arabia, Al-Sobayel (1985) found that Baladi chicks showed higher weights and gains at the early ages (0-8 weeks), while Leghorn chicks showed higher rates of growth at the later ages (12-16 weeks). The linear contrasts given in Table 2 evidenced that breed of L had superior performance in body weights ($P<0.001$) and daily gains in weight ($P<0.01$ or $P<0.001$) compared to the S chickens. These results were expected and reflect that L used in this study may became more adapted to the conditions of Saudi Arabia since several generations of this breed were produced locally. More investigations are needed in this respect. Significant differences of 6.0, 9.5, 25.7, 52.3, 88.2, 121.2 and 136.3 grams were in favour of L breed at 0, 2, 4, 6, 8, 10 and 12 weeks of age, respectively. The same trend was observed for most daily gains and livability traits.

Direct heterosis (H^I)

Estimates of direct heterosis (H^I calculated in actual units and percentages) for growth and livability traits are presented in Table 3. These estimates indicate that heterosis had a little effect on the variations of body weights and gains, while it had a considerable effect on the livability traits in most cases. However, estimates of H^I indicated also that crossing of L and S chickens was generally associated with an existence of heterotic effects on some growth traits, especially those weights measured at early ages (2-6 weeks) and livabilities of later ages (6-12 weeks). These results may be an encouraging factor for the poultry producers in Saudi Arabia to cross their native breeds with the exotic Leghorn. This observation was also reported in the other results obtained from crossing of local chickens with the exotic ones in our Arabian area (Hanafi *et al*, 1977; Abd El-Gawad *et al*, 1979; Kosba *et al*, 1981; Hanafi *et al*, 1991). In India, results of crossing native breeds with other exotic ones (*e.g.* Aggarwal *et al*, 1978; Sharma, 1978; Singh *et al*, 1982) also showed varying degrees of heterosis for body weights at different ages.

For body weights and gains (Table 3), estimates of heterosis showed that heterotic effects decreased generally with advance of chick 's age. Percentages of heterosis for body weights and gains were positive for the early ages, while they were negative at the later ages. At the early ages (0-6 weeks), the positive percentages of H^I ranged from 1.7 to 3.0%, while at later ages (6-12 weeks) the negative estimates ranged from -3.1 to 0.0 %. High common environmental effects of the dam that appearing in early ages of growth might be had negative non-additive effects at the later stages of growth. In Egypt, Hanafi *et al.* (1991) from a 4x4 diallel crossing experiment showed that crossing between exotic breeds (New Hampshire and Plymouth Rock) with two local Egyptian ones (Dandarawi and Silver Montazah) was usually associated with an existence of heterotic effects on body weights at 4, 8, 12 and 16 weeks of age; estimates of H^I ranged from 8.2% to 24.9% for different ages. In contrast to that found for body weights and gains, estimates of heterosis for livability traits showed a reversible trend where the significant positive estimates were recorded at the later ages (6-12 weeks), while negative and insignificant estimates were recorded at the early ages (0-4 weeks); heterosis percentage for livability was 0.5% at 0-4 weeks and ranged from 2.8 to 4.2% at 6-12 weeks of age.

Maternal breed effect (G^M)

The estimates of G^M (expressed as contrasts for the differences between the two reciprocal crosses) for growth and livability traits are presented in Table 4. The contrasts for body weights and gains were statistically significant and they were mainly in favour of the S breed. The estimates obtained (Table 4) showed that additive breed maternity had a meaningful effect on the variations of body weights (especially at the late ages of 4-10 weeks). Bahie El-Deen *et al.* (1998) observed an evidence for the significant maternal effects on body weights and gains.

Under hot climatic conditions, the favourable maternity recorded for the S breed may be attributable to better pre-ovipositional maternal effects in terms of oviductal factors such as egg size, egg weight, shell quality and yolk composition (Aggrey and Cheng, 1994). Also, the S breed may have better pre-hatching maternity in terms of prenatal growth and embryo survival and immunities transmitted to the hatched chicks relative to the L breed. The common environmental effects of the full-sib families become the determining factor in this respect. Viability is an example of these specific maternal environmental effects that persisted almost through the growth period of the chick.

The G^{M}% [i.e. percentages of G^{M} contrast relative to ½(SS+LS)] were moderate for body weights and daily gains in weight and small for livability traits (Table 4). These percentages were mostly in favour of the S breed and they ranged from 1.0 to 7.2 % for body weights, 2.1 to 12.1% for daily gains in weight and from 1.3 to 3.7 % for livability traits. Also, chicks of the LxS matings had generally better growth performance and livability traits than those from the SxL matings. These notations gave an indication to that S breed could be used as a dam-breed to get heavier weights and higher livability rates. However, the insignificant additive breed maternal effects on most livability traits indicated that both breeds of the present study could be used as breed of dam under the conditions of Saudi Arabia. Hanafi *et al.* (1991) reported that White Plymouth ranked first in maternal ability for body weights, followed by Silver Montazah, Dandarawi and New Hampshire in a 4x4 diallel crossing experiment.

Direct additive effect (G^{I})

Results of G^{I} for growth and livability traits are presented in Table 5. The linear contrasts of sire additive effects for all body weights and gains (from 0-12 weeks of age) were highly significant ($P<0.001$), *i.e.* a considerable contribution of sire-breed effect in the inheritance of these traits was recorded in favour of the L breed. Results of Bhushan and Singh (1995) confirmed also this trend. In crossbreeding experiment using two lines of quails in Egypt, Bahie El-Deen *et al.* (1998) stated that direct additive effects on body weights and gains from 2 to 6 weeks of age were important for most growth traits studied. For most livability traits, limited and insignificant differences in direct additive effects between the two breeds were observed. In general, L-sired chicks had higher values of direct additive effects than S-sired chicks for all growth and livability traits.

The G^{I}% [i.e. percentages of G^{I} contrast in grams relative to ½(LL+LS)] for all body weights and daily gains studied were moderate and they ranged from 4.9 to 10.2 % for body weights and from 3.5 to 14.6 % for daily gains in weight (Table 5). On the other hand, these percentages for livability traits were low for most age-intervals studied (except G2) and they ranged from 0.3 to 3.3%. The observed direct additive effects of the L breed on growth traits (body weights and gains) from hatching up to 12 weeks of age lead to suggest that L chickens could be used as a terminal sire-breed in any crossbreeding program.

Conclusion

The estimates of direct additive (G^I) and maternal breed additive (G^M) lead to the conclusion that it is preferable to use White Leghorn as a sire-breed and Baladi Saudi as a dam-breed in any crossbreeding stratification system in Saudi Arabia to obtain crossbred hens characterized by high growth rate and early sexual maturity associated with an early age to lay the first egg.

Table (1): Number of cocks, hens and chicks hatched in the four breed-groups of the study

Mating group+	Cocks	Hens	Chicks hatched 1st hatch	Chicks hatched 2nd hatch
L x L	31	72	179	86
S x S	43	102	157	171
L x S	39	94	154	202
S x L	42	85	80	252
Total	155	353	570	711

+ L = White Leghorn; S = Saudi; Breed of cock listed first.

Table (2): Purebred and crossbred means (±SE) for growth traits and livabilities

		Purebred groups			Crossbred groups	
		Leghorn	Saudi		LXS	SXL
Trait	Symbol	Mean±SE	Mean±SE	Contrast±SE[a]	Mean±SE	Mean±SE
Body weight (grams):						
0 day	**W0**	35.5±0.4	29.5±0.32	6.04 ±1.6***	32.0± 0.32	32.4± 0.4
2 weeks	**W2**	122±1.5	113±1.2	9.5±1.2***	120±1.2	118±1.4
4 weeks	**W4**	269±4.1	243±3.3	25.7±3.9***	268±3.2	256±3.8
6 weeks	**W6**	451±5.5	398±4.5	52.3±5.0***	443±4.3	421±5.1
8 weeks	**W8**	658±8.1	570±6.7	88.2±7.3***	637±6.3	593±7.6
10 weeks	**W10**	876±10	755±8.6	121.2±9.4***	838±8.2	791±9.8
12 weeks	**W12**	1074±13	938±10.8	136.3±10.9***	1018±10.4	994±12.6
Daily gain in weight (grams):						
0-2 weeks	**G2**	6.2±0.10	5.9±0.08	0.25±0.08**	6.3±0.08	6.1±0.1
2-4 weeks	**G4**	10.5±0.24	9.3±0.20	1.14±0.25***	10.5±0.19	9.8±0.2
4-6 weeks	**G6**	12.9±0.29	11.0±0.25	1.89±0.31***	12.5±0.23	12.0±0.3
6-8 weeks	**G8**	14.8±0.27	12.3±0.23	2.56±0.28***	13.9±0.21	12.3±0.3
8-10 weeks	**G10**	15.6±0.29	13.2±0.25	2.36±0.28***	14.4±0.23	14.1±0.3
10-12 weeks	**G12**	13.9±0.35	12.9±0.30	1.01±0.41**	12.8±0.28	13.5±0.3
Livability (%):						
0-2 weeks	**L2**	100±0.38	99.8±0.3	0.32±0.04NS	100±0.3	98.8±0.3
2-4 weeks	**L4**	98.0±1.0	99.3±0.8	-1.25±0.12NS	99.4±0.8	97.3±0.9
4-6 weeks	**L6**	95.4±1.5	92.9±1.2	2.50±0.17NS	99.0±1.2	97.2±1.4
6-8 weeks	**L8**	95.4±1.5	92.9±1.2	2.52±0.17NS	98.8±1.2	97.2±1.4
8-10 weeks	**L10**	95.4±1.5	92.9±1.2	2.52±0.17NS	98.8±1.2	97.2±1.4
10-12 weeks	**L12**	92.3±1.8	90.0±1.5	2.31±0.22NS	95.4±1.5	92.0±1.8

[a] Leghorn mentioned first.

NS= Non-significant; *=P<0.05; **=P<0.01; ***=P<0.001.

Table (3): Estimates of direct heterosis (H^I) for growth and livability traits

Trait[a]	Direct heterosis contrast		
	Units ±SE	%[b]	Significance
Body weight (grams):			
W0	-0.59±0.2	-0.9	**
W2	3.29±1.7	1.4	*
W4	11.89±2.7	2.3	*
W6	14.28±6.8	1.7	*
W8	2.68±10.1	0.2	NS
W10	-2.02±12.9	0.0	NS
W12	-0.22±15.2	0.0	NS
Daily gain in weight (grams):			
G2	0.28±0.12	2.3	*
G4	0.60±0.36	3.0	NS
G6	0.62±0.42	2.6	NS
G8	-0.85±0.39	-3.1	*
G10	-0.34±0.40	-1.2	NS
G12	-0.59±0.57	-2.2	NS
Livability (%):			
L2	-0.96±0.06	-0.5	NS
L4	-0.52±0.16	-0.3	NS
L6	7.87±0.24	4.2	***
L8	7.66±0.24	4.1	***
L10	7.66±0.24	4.1	***
L12	5.11±0.32	2.8	*

[a] Traits as defined in Table 2.
[b] H^I %= [H^I in units / parents]x100
NS= Non-significant: *=P<0.05; **=P<0.01; ***=P<0.001.

Table (4): Estimates of maternal additive effects (G^M) for growth and livability traits

Trait[a]	Maternal additive contrast		
	Units ±SE	%[b]	Significance
Body weight (grams):			
W0	0.31±0.01	1.0	*
W2	-2.33±1.20	2.0	*
W4	-12.4±3.79	4.8	***
W6	-21.6±4.73	5.1	***
W8	-43.8±6.96	7.2	***
W10	-47.9±8.89	6.0	***
W12	-24.6±10.5	2.5	**
Daily gain in weight (grams):			
G2	-0.19±0.08	8.8	*
G4	-0.72±0.25	7.3	**
G6	-0.54±0.29	3.0	*
G8	-1.59±0.27	12.1	***
G10	-0.29±0.27	2.1	NS
G12	0.77±0.39	6.0	*
Livability (%):			
L2	-1.33±0.04	1.3	***
L4	-2.15±0.16	2.2	*
L6	-1.78±0.17	1.9	NS
L8	-1.54±0.17	1.6	NS
L10	-1.54±0.17	1.6	NS
L12	-3.44±0.22	3.7	NS

[a] Traits as defined in Table 2.
[b] G^M %= [G^M in units / average of **SS+LS** breed groups]x100
NS= Non-significant; *=P<0.05; **=P<0.01; ***=P<0.001.

Table (5): Estimates of direct additive effects (G^I) on growth and Livability traits

Trait[a]	Sire additive contrast		
	Units ±SE	%[b]	Significance
Body weight (grams):			
W0	2.87±0.01	8.5	***
W2	5.91±0.86	4.9	***
W4	19.1±2.72	7.1	***
W6	36.9±3.43	8.3	***
W8	66.0±5.04	10.2	***
W10	84.5±6.45	9.8	***
W12	80.4±7.57	7.7	***
Daily gain in weight (grams):			
G2	0.22±0.06	3.5	***
G4	0.93±0.18	8.9	***
G6	1.22±0.21	9.6	***
G8	2.08±0.19	14.6	***
G10	1.32±0.20	8.8	***
G12	1.12±0.29	8.4	***
Livability (%):			
L2	0.83±0.03	0.8	**
L4	0.45±0.08	0.5	NS
L6	2.14±0.12	2.2	NS
L8	2.03±0.12	2.1	NS
L10	2.03±0.12	2.1	NS
L12	2.87±0.16	3.1	NS

[a] Traits as defined in Table 2.
[b] G^I %= [G^I in units / average of LL+LS breed groups]x100
NS= Non-significant; *=P<0.05; **=P<0.01; ***=P<0.001.

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الملخص العربى

تقدير مكونات قوة الخلط لبعض صفات النمو والحيوية فى تجربة لخلط الدجاج السعودى مع دجاج اللجهورن الأبيض

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أجريت تجربة خلط بين الدجاج البلدى السعودى واللجهورن الأبيض في منطقة القصيم بالمملكة العربية السعودية لتقييم بعض صفات وزن الجسم والزيادة اليومية في الوزن والحيوية في الخلطان الناتجة. وقد تم تقييم هذه الصفات وراثيا من عمر الفقس وحتى عمر ١٢ أسبوع لعدد ١٢٨١ كتكوت. استخدم النموذج الوراثي لد يكرسون Dickerson Model لتقدير قوة الخلط المباشرة والتأثيرات التجمعية الأبوية والتأثيرات الأمية لسلالة الأم.

تفوقت سلالة اللجهورن في معدلات نموها وحيويتها مقارنة بسلالة البلدى السعودى. صاحب الخلط بين البلدى السعودى وسلالة اللجهورن تفوق طفيف موجب في قوة الخلط المباشرة لبعض صفات النمو خاصة الأوزان والزيادة اليومية في الوزن عند الأعمار المبكرة (من الفقس حتى عمر ٦ أسابيع)، في حين سجلت الكتاكيت الخليطة قوة خلط سالبة لهذه الصفات عند الأعمار المتأخرة (٨-١٢ أسبوع). ومن ثم يمكن القول بأن قوة الخلط لصفات النمو المدروسة تناقصت بتقدم الكتكوت في العمر. وقد تراوحت نسب قوة الخلط بين ١,٧ - ٣% لصفات الوزن والزيادة في الوزن عند الأعمار المبكرة فى حين تراوحت هذه النسب بين -٣,١ إلى ٣٠.٠% عند الأعمار المتأخرة. وعلى عكس ما تم الحصول عليه في صفات وزن الجسم والزيادة اليومية في الوزن فإن نسب قوة الخلط لأغلب صفات الحيوية كانت سالبة خلال فترة النمو المبكرة (من عمر الفقس حتى ٤ أسابيع) في حين أصبحت هذه القيم موجبة ومعنوية عند الأعمار المتأخرة (٦-١٢ أسبوع) حيث تراوحت قيم قوة الخلط بين ٢,٨ إلى ٤,٢%. تحت ظروف المناخ الحار كان للتأثير التجمعى لسلالة الأم تأثيرا معنويا

على معظم الصفات المدروسة وفي صالح الدجاج السعودى حيث أظهرت الكتاكيت الناتجة من تلقيح ذكور اللجهورن مع إناث البلدى السعودى تفوقا ملحوظا عن تلك الكتاكيت الناتجة من التلقيح المعاكس. تأثرت معنويا معظم أوزان الجسم ومعدلات الزيادة اليومية بالتأثير التجمعى الأبوى. وقد تفوقت الكتاكيت الناتجة من ذكور سلالة اللجهورن فى التأثير التجمعى الأبوى مقارنة بالكتاكيت الناتجة من ذكور البلدى السعودى. أشارت نتائج التأثيرات التجمعية الأبوية والتأثيرات التجمعية الأمية لسلالة الأم بأنه من المفضل استخدام ذكور سلالة اللجهورن كديوك وإناث الدجاج السعودى كسلالة أمية في نظم تخطيط برامج الخلط في المملكة العربية السعودية وذلك للحصول على دجاجات خليطة تتميز بمعدلات نمو عالية ونضج جنسى مبكر بالإضافة إلى عمر مبكر عند وضع أول بيضة.