Heterotic Effects and Additive Components for Growth Traits in a Crossing Scheme between Fayoumi and Acclimatized Rhode Island Red Chicken

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Received: *6/9/2009*

Abstract: Data of the present study were obtained on a total of 261 chicks, (123 straight-bred and 138 cross-bred), produced from two breeds, one exotic, Rode Island Red (RIR) and the other is the native and improved (Selected for heavier body weight at 8 wks) Fayoumi (FA) as well as their reciprocal crosses. The study aimed at the evaluation of the direct and maternal additive, direct and individual heterotic effects as well as the non-genetic factors (hatch and sex) affecting body weight (BW) and gain in weight (WG) traits from 4 up to 16 wk of age. Tests of significance revealed that Breed group did not affect BW and WG significantly at most age stages except at 4 wk for body weight and 8-12 wk of age for Gain in weight. Sex proved highly significant effects on BW and WG at all studied ages and age stages. Insignificant differences were observed for the effect of hatch on most body weight traits except 16 wks of age while significance was observed for the effect of hatch on WG at 12-16 and 14-16 wk. Sex X hatch interaction exerted significance influence on gain in weight at 8-12 and 4-16 wk. The estimates of direct heterosis were generally positive on body weight and gain in weight except that for the later at 4-8 wk. Direct and maternal additives, generally showed non-significant negative trends on body weight and gain in weight at all age studied.

Keywords: Rode Island Red; Fayoumi; Crossing; Heterosis; Direct and Maternal Additive.

INTRODUCTION

Since poultry production plays an important role in the food sector, it may be worthwhile to investigate the possible contribution of native fowls to the meat and egg production industries and whether they still possess a beneficial role to play in the future or not. The main purposes of crossing is to produce superior crosses (*i.e* make use of hybrid vigor) to improve fitness and fertility traits and to combine different characteristics in which the crossed breeds are premium (Willham and Pollak 1985; Hanafi and Iraqi 2001 and Afifi *et al.*, 2002; Iraqi *et al.*, 2005). Crossbreeding is one of the expeditious existing tools available to breeders in favor of improving several traits in farm animals mostly in the course of utilizing the non-additive genetic variance Therefore, this study was conducted to evaluate body weight and gain in weight traits genetically from four up to sixteen wk of age (at four wk intervals), using diallel crossing involving Rode Island Red and Fayoumi chicken to estimate the importance of some genetic (Mating group, direct and individual heterosis, direct and maternal additive) and non-genetic (Hatch and sex) factors as well on the forementioned traits.

MATERIALS AND METHODS

This experiment was conducted at faculty of agriculture, Suez Canal University, Ismailia, Egypt. Data of 261 chicks, 123 straight-bred and 138 cross bred were produced from a diallel crossing between two breeds, one exotic (Rode Island Red, RIR) and other improved (Selected for heavier body weight at 8 wks) local one (Fayoumi, FA). The breeding plan of parent stock permits the simultaneous production of both straight-bred and crossbred chickens. In the straight-bred groups, cockerels were assigned at random to breed the dams, as in case of cross-bred but with a restriction of avoiding half-sib; full-sib and parent-offspring mating. Single set of males were used, each contained 12 males (6 males/breed), where one male was assigned to a breeding pen at random containing two hens from each chicken breed involved. Progeny of F_1 of all breed groups (4 groups) were produced in two hatches. All trap nested eggs produced from each breeding pen were individually recorded according to breed group and collected daily for a ten days period. On day of hatch, all chicks were wings banded to keep their breed groups. The chicks were floor brooded and reared from hatch up to 16 wks of age at using gas brooders as necessary. The Resultant F_1 chicks were vaccinated against Newcastle disease, Gumboro and Fowl Pox in their respective ages, according to the vaccination program applied in the college farm, medicated and subjected to the same managerial conditions. All chicks up to 16 wk of age were fed standard growing ration containing approximately 18% crude protein and 3000 ME (k.cal/kg.). Feed and water were assigned *ad libitum* all over the experimental period.

Body weight (BW) was recorded to the nearest gram, for each individual bird every four wk stages being 4, 8, 12, 16, wk of age. Gain in weight was computed, as the difference in weight between two consecutive periods, at age spans of 4-8; 8-12; 12-16 and 4-16 wk. General Linear Model procedure of SAS (SAS, 2000) was used for analyzing the data. The linear fixed model adopted for the analysis comprised the effects of mating group (MG, 4 classes); Sex (males and females, hatch (first and second) as well as the first-order (MG X Sex, MG X Hatch, Sex X Hatch) and second-order (MG X Sex X Hatch) interactions.

Crossbreeding effects (direct and individual heterosis, direct and maternal additive) on body weight and gain in weight were derived applying a selected set of linear contrasts on mating group least squares means (Dickerson, 1992) as follow

Pure lines difference:
[(GiRIR + GmRIR) – (GiFA + GmFA)] = (RIRxRIR) – (FAxFA).

Direct heterotic effect:
H^i RIRXFA (Units) = [0.5 X (RIRxFA + FAxRIR) – 0.5 X (RIRxRIR + FAxFA)].

Individual heterotic effect:
H^i RIR X FA (Units)=[(RIRxFA)–0.5 X (RIRxRIR+ FAxFA)].
H^i FA X RIR (Units) = [(FAxRIR) – 0.5 X (RIRxRIR + FAxFA)].

Direct additive effect (i.e. line group of sire differences):
(G^iRIR-G^iFA)={[(RIRxRIR)+(RIRxFA)]–[(FAxFA)+ (FAxRIR)]}.

Maternal additive effect (i.e. reciprocal crosses differences):
(G^mFa - G^mRIR) = [(RIRxFA) – (FAxRIR)].
Where G^i and G^m represent direct and maternal additive effects of the subscript genetic group, respectively.

RESULTS AND DISCUSSION

Mating group (MG):

Differences due to MG were generally insignificant for body weight and gain in weight traits at most age stages except at 4 wk for body weight and 8 - 12 wk of age for Gain in weight. (Table 1). Regarding pure breeds, it was clear that Fayoumi chicks surpassed Rode Island Red in body weight and gain in weight in all ages except at 4-8 wk of Gain in weight. The Superiority of FA over their RIR contemporaries may be due first to that FA chicks were basically selected for 8 wks body weight. Secondly, because the RIR chicks used herein are descendents of many generations subsequent to importing of the standard breed which due to the relaxation of selection and during the process of acclimatization they lose most of their superiority and behave comparable to our native chickens.

These results of body weight in the present study generally agreed with those reported by Abdel-Ghany (1995). In contrast, Saadey *et al.* (2008) reported that the RIR breed had heaviest body weight at 0, 2, 3 and 5 month of age compared to FA mean while RIR showed little insignificant superiority compared with Fayoumi chicks as regard to gain in weight. Khalil *et al.* (1999) reported significant effects (P<0.001) of growth traits between White Leghorn and Saudi chickens. Iraqi *et al.* (2002). Showed that differences were significant (P<0.001) of BW4, DG4, DG8 and DG16 between purebreds (Mandarah and Matrouh).

Concerning crosses, the cross resulted from FA males with RIR females surpassed all RIR males with FA at all ages and stages studied for body weight and Gain in weight, respectively. Abdel-Ghany (1995) reported similar results of body weight pattern for FA males with RIR females while showed that RIR males with FA proved insignificant superior growth compared with FA males with RIR at most age stages of gain in weight traits. Hanafi and Iraqi (2001), Osama and Nazla (2005), and Osama *et al.* (2005), with miscellaneous breed groups and crosses indicated that breed group and crosses effect on body weight at different ages mostly significant and crossbreds were generally superior for most studied traits than purebreds.

Table (1): F-values of least squares analyses of variance of factors affecting body weight and gain in weight from 4 to16 wk of age of Rode Island Red and Fayoumi chicken and their crosses.

Sources of variation	df	Body weight			
		4 wk.	8 wk	12 wk	16 wk
MG	3	5.12**	1.32	3.21	1.61
Sex	1	26.55****	58.04****	59.73****	95.52****
Hatch	1	0.00	0.00	0.89	41.58****
MG * Sex	3	0.44	0.12	0.05	0.97
MG * Hatch	3	1.43	0.24	0.21	0.13
Sex * Hatch	3	2.60	1.44	3.83	3.82
MG * Sex * Hatch	3	0.40	0.27	0.05	1.90
Error MS		1450.00	4498.71	13368.46	34881.77
Sources of variation	**df**	**Gain in weight**			
		4-8 wk	8-12 wk	12-16 wk	4-16 wk
MG	3	0.68	3.28*	0.05	0.96
Sex	1	39.46****	22.00****	32.92****	80.11****
Hatch	1	0.00	1.93	45.46****	43.96****
MG * Sex	3	0.09	0.20	1.19	1.17
MG * Hatch	3	0.19	0.88	0.14	0.37
Sex * Hatch	3	0.15	14.15***	0.73	5.49*
MG * Sex * Hatch	3	0.88	0.53	2.11	2.12
Error MS		2511.14	6652.66	26371.06	33131.20

Error df = 245.
MG = Breeding group.
* = Significance at (P≤ 0.05); ** = Significance at (P≤ 0.01); *** = Significance at (P≤ 0.001); **** = Significance at (P≤ 0.0001).

Table (2): least squares means (grams) and standard error (± SE) of factors affecting body weight and gain in weight from 4 up to 16 wk of age in Rode Island Red (RIR) and Fayoumi (FA) Chicken.

	No	Body weight			
		4 wk	8 wk	12 wk	16 wk
Mating group					
Straight-bred					
RIR	63	170.14±5.54	325.63±10.86	575.31±16.97	971.27±30.53
FA	60	193.75±5.21	341.25±9.81	602.75±15.73	1016.58±31.81
Cross-bred					
RIR * FA	57	182.59±5.71	322.98±8.82	580.61±15.73	967.46±27.41
FA * RIR	81	195.42±3.96	349.20±7.85	637.34±14.26	1055.25±23.96
Sex					
Male	117	202.51± 4.01	376.24±6.98	663.63±12.13	1131.15±20.14
Female	144	172.83±2.90	303.23±4.81	551.97±8.47	905.97±15.47
Hatch					
1st hatch	163	185.34±3.21	335.95±6.07	599.29±9.98	955.83±15.18
2nd hatch	98	187.45±4.32	335.97±7.32	606.58±13.16	1091.89±26.13
Overall mean	261	186.134± 2.57	335.96±4.67	602.03±7.94	1006.92±14.21
	No	**Gain in weight**			
		4-8 wk	**8- 12 wk**	**12- 16 wk**	**4-16 wk**
Straight-bred					
RIR	63	155.49±7.98	249.68±11.62	395.95±25.13	801.13±29.31
FA	60	147.50±6.57	261.50±10.10	413.83±24.23	822.83±29.20
Cross-bred					
RIR * FA	57	140.39±5.02	257.63±9.68	386.84±21.56	784.86±25.52
FA * RIR	81	153.78±6.37	288.15±10.09	417.90±19.96	859.83±23.98
Sex					
Male	117	173.73±5.42	287.39±7.99	467.52±17.52	928.64±19.94
Female	144	130.40±3.37	248.75±6.77	353.99±13.33	733.15±14.84
Hatch					
1st hatch	163	150.61±4.50	263.34±6.89	356.53±11.15	770.48±13.86
2nd hatch	98	148.52±4.79	270.61±8.28	485.31±21.41	904.44±25.59
Overall mean	261	149.82±3.33	266.07±5.30	404.89±11.29	820.78±13.52

‡ Sire breed is preceeding dam breed
RIR = Rhode Island Red; FA = Fayoumi

Sex:

The results presented in table 1 revealed highly significant sex effect (P≤0.001) on body weight and gain in weight at all ages and stages studied. Males tend to be heavier than females at all ages and age stages studied. These results were in agreement with those reported by Burke (1994); Hancock *et al.* (1994); Abdel-Ghany (1995); Mohammed *et al.* (2005); Adedeji *et al.* (2006). Burke (1994); Hancock *et al.* (1994) reported presence of sexual dimorphism in favor of males in the growth performance of studied strain and attributed this trend to differences in hormonal profile, aggressiveness and dominance of males when feeding especially when sexes are reared together. Males being substantially heavier than females that could be due to the effective male growth hormones compared with female hormones (Singh *et al.*, 1982).

Hatch:

Insignificant differences (Table 1) were detected of the effect of hatch on all body weight traits except at 16 wks of age (P≤0.0001) while the results showed that gain in weight was affected significantly (P≤0.05 and P≤0.01) of stages 4-8 and 12-16 wk of age by hatch effect. These results were in disagreement with those reported by Mohammed *et al.* (2005) on body weight and Abdel-Ghany (1995) on body weight and gain in weight at different ages and stages; where they reported a highly significant hatch effect. Though of the insignificance, least squares means presented in table 2, demonstrates that the average of body weights and gain in weight of chicks at most ages and spans studied were heavier in the second than that of the first hatch. These differences among the two hatches especially in gain in weight could be attributed to differences in environmental conditions.

Interactions:

Results for the effect of interactions between MG x Sex, MG x Hatch and MG x Sex x Hatch (Table 1) were generally not significant at most studied ages (body weight) and spans (Gain in weight). On the contrary, Sabra (1990) and Abdel-Ghany (1995) reported highly significant differences due to hatch by sex interaction for body weights at different ages. Significant effect (P≤ 0.05 and P≤0.001)) detected only of interaction of Sex x hatch on gain in weight of 8-12 and 4-16 wk studied spans and this significance is in agreement with those of Abdel-Ghany (1995) and Mohammed *et al.* (2005) who reported an early significant interaction effect at day-old and disappeared thereafter.

However, the insignificant interaction effects may mean comparable response of the different mating groups with the change in sex or hatch. In other words,

main effects of the fixed effects of the model can be discussed unfussy and straightforward and uncomplicated with other effects of the model.

Straight-bred differences:

Results given in table 3 revealed that there was a general trend of superiority for FA chicks as compared with RIR. The results showed that improved FA chicks surpassed (non-significantly; except that at 4 wk of body weight $P \leq 0.01$) acclimatized RIR at all studied ages and spans except that at 4-8 wk for Gain in weight. These results may give attention to that RIR chickens possibly need to be selected under Egyptian conditions to restore back its superiority.

Direct heterotic effect (H^i):

Estimates of direct heterosis (H^i) of body weight between RIR and FA, presented in table 3, were insignificantly positive at most age spans studied. H^i absolute values ranged between 1.91 g. (8 wks) to 37.02 g. (16 wks). The respective gain in weight values ranged from -2.79 (4-8 wks) and 32.31 (4-16 wks). However, the positive and significant H^i ($P \leq 0.05$) values were detected merely for gain in weight at 8-12 and 4-16 wk interval ages. Howbeit, this negative direct heterosis might be attributable to directional dominance of genes affecting this trait. The findings of insignificant, though positive, heterotic effects may lead us to verify that non-additive crossbreeding effects may be of little importance for improving growth traits (especially Body weight) during the age periods and crossing plan under consideration.

However, Sabra (1990) reported positive and high magnitude of heterosis for (average 20.4%) body weights at different ages from crossing between local breeds (Silver Montazah and Dandarawi). Iraqi *et al.* (2002) indicated that crossing between Mandarah x Matrouh strains were generally positive and of high significance for body weights (average 30.6%) and gain in weight (average 39.7%). Osama *et al.* (2005) noted the presence of positive heterosis percentages for the cross Gimmizah x Bandara at all ages studied (Wo, W4, W8 and W12) except at 16 wk of age on body weight. Osama and Nazla (2005) reported that the estimates of direct heterosis for body weight at different ages for the cross between Gimmizah and Bandara chickens showed positive heterotic effects on body weight at hatch, 8 and 12 wk. Saadey *et al.* (2008) showed that crosses between Sinai x White Leghorn had positive and high heterotic percentage at all ages, except of at 2 and 3 month of age. In the contrary, Hanafi and Iraqi (2001) reported that heterosis effect was non significant for body weight at 8 wk for crosses between New Hampshire, White Cornish, White Plymouth Rock and White Leghorn.

Nevertheless, most of the reviewed studies showed that body weights of crossbred chickens at different ages were associated with positive heterotic effects for growth traits (Khalil *et al.*, 1999; Sabri *et al.*, 2000). This probably due to that non-additive gene effects in their tested chicken breeds are responsible for the manifestation of greater ratios of direct heterosis. Falconer (1989) showed that a cross between two base populations would show heterosis if they differ in the frequency of genes affecting a given trait. The same author also added that the negative sign of heterosis could be attributed in some cases to the nature of the measurement (*i.e.* if the trait is expressed in another way such as the reciprocal of the present the heterosis would be positive in sign). This non-additive genetic effect is expected to be enhanced more by using reciprocal recurrent selection between the breeds in the current crossbreeding plan.

Individual heterosis:

Estimates of individual heterosis of (RIR_{males} X $FA_{females}$) and (FA_{males} X $RIR_{females}$) are presented in table 3. Individual heterosis estimates were insignificant and ranged from -4.45 (8 wks.) to 7.99 (16 wks) of body weight and ranged between -3.29 (4-8 wk) to 9.16 (4-16 wks) for gain in weight. On the Other hand, individual heterosis estimates for FA_{males} X $RIR_{females}$ proved significance and ranged from 5.88 (4 wks) to 29.03 (16 wks) for body weight while the ranged from 0.49 (4-8 wks) to 23.15 (4-16 wks) for gain in weight. These Results revealed the superiority of FA males over RIR ones as regard to body weight and gain in weight at most studied ages. These results may suggest the use of FA chicks as sire breed in the crossbreeding strategy designated to establish native chicks for meat production.

Direct additive effect (G^i):

Crossing not only takes advantage of characters with considerable non-additive genetic variations (i.e. dominance and epistasis), but also exploits differences in additive effects (i.e. differences in average performance between populations as a deviation from the overall mean) between populations (Ahmed, 2003). On the level of loci responsible for a given trait, complementarily between additive effects of genes occupying these loci play an important role in the manifestation of G^i.

The results of G^i presented in table 3, revealed non-significant negative trends of RIR direct additive on body weight at Most ages studied except at 4 wk (significant negative ($P \leq 0.001$) for body weight and 4-8 wk (non-significant positive) for gain in weight. The estimates of G^i ranged from -16.64 (16 wk) to -8.33 (4 wks) of body weight while gain in weight estimates ranged from -7.44 (4-16 wks) to 0.88 (4-8 wks). These results leads to that FA breed could be used as a sire line to improve body weight and gain in weight. These results suggest that additive effects are of trivial importance in improving growth traits during the age spans and using the chicken breeds considered herein.

Significant breed of sire effect was reported by Khalil *et al.* (1999) and Iraqi *et al.* (2002). Results of Bahie El-Deen *et al.* (1998) with two lines of Quails and their crosses raised in Egypt reported a trend of relatively higher G^i. In crossing of Saudi chickens with White Leghorn, Khalil *et al.* (1999) found that percentages of G^i were Positive and ranged from 4.9 to 10.2% for body weights and from 3.5 to 14.6% for daily gains in weight. Iraqi *et al.* (2002) found this percentage to be 2.54% for body weights from 12 - 16 wk of age.

Table (3): Linear functions, (±SE) of straight-bred differences and crossbreeding effects pertaining body weight and gain in weight traits from 4 up to 16 wk of age in Rode Island Red (RIR) and Fayoumi (FA) Chicken and their crosses.

Estimate	Body weight			
	4 wk	8 wk	12 wk	16 wk
Straight-bred differences				
RIR *vs*, FA	-11.36±3.59**	-5.83±6.32	-9.40±10.90	-12.24±17.60
Direct Heterosis (H^i):				
RIR-FA	4.71± 5.12	1.91±9.03	29.36±15.57	37.02±25.14
Individual heterosis‡				
RIR- FA	-1.16±3.42	-4.45±6.03	4.06±10.40	7.99±16.80
FA –RIR	5.88±2.85*	6.36±5.02	25.29±8.64**	29.03±13.96*
Direct additive(G^i):	-9.21±2.56***	-8.33±4.51	-15.31±7.78	-16.64±12.57
Maternal additive(G^m):	-7.04± 3.66	-10.82±4.51	-21.23±11.11	-21.04±17.95
Estimate	**Gain in weight**			
	4-8 wk	**8- 12 wk**	**12- 16 wk**	**4-16 wk**
Straight-bred differences				
RIR *vs*, FA	5.53± 4.72	-3.58±7.69	-2.84±15.30	-0.88±17.15
Direct Heterosis (H^i):				
RIR-FA	-2.79±6.75	27.44±10.98*	7.67±21.86	32.31±24.51*
Individual heterosis‡				
RIR-FA	-3.29±4.51	8.52±7.34	3.93±14.60	9.16±16.37
FA –RIR	0.49±3.74	18.92±6.10**	3.74±12.14	23.15±13.61**
Direct additive(G^i):	0.88±3.37	-6.99±5.49	-1.33±10.93	-7.44±12.25
Maternal additive(G^m):	-3.78±4.82	-10.41±7.84	0.19±15.61	-13.99±17.49

RIR = Rhode Island Red; FA = Fayoumi,
‡ Sire breed is preceding dam breed
* = Significance at (P≤ 0.05); ** = Significance at (P≤ 0.01); *** = Significance at (P≤ 0.001).

Maternal additive effect (G^m):

Maternal effect (G^m) consists mainly from additive maternal and cytoplasmic inheritance. Denoting G^m in terms of complimentarily effect, certain crosses may show much more G^m than others depending upon the extent to which the crossed populations differ in reproductive performance along with production characters. Therefore, this type of effect relies on the direction of the crossing (Ahmed, 2003).

The results of G^m presented in table 3 revealed non-significant negative trends of maternal additive at all ages studied except 12-16 wk interval (non-significant positive) for gain in weight. The estimates of maternal additive effect ranged from -21.23 (12 wks) to -10.82 (4&8 wks) for body weight and were from -13.99 (4-16 wks) to 0.19 (12-16 wks). These results leads to that RIR breed could be used as a dam line in crossing process to improve growth traits.

Bhushan and Singh (1995) and Osama and Nazla (2005) with different breeds confirmed also this trend of insignificantly negative trivial importance of G^m on growth traits of chickens. However, the later results were in divergence with the findings of Khalil *et al.* (1999), sabri *et al.* (2000); Iraqi *et al.* (2002); Osama and Nazla (2005) and Saadey *et al.* (2008) who showed that maternal effects influenced significantly (P<0.05, P<0.01 and P<0.001) body weight and daily gain in weight of chickens. Also, Iraqi *et al.* (2002) found Percentages of G^m for body weights at early ages (averaged 5.23% for weight from hatch to 8 weeks) were higher than those at later ages (averaged 2.83% for weight from 12 to 16 weeks).

CONCLUSION

Results proved that additive effects are of trivial importance in improving growth traits during the age spans from 4-16 wk of age when crossing RIR and FA. As regard to non-additive component, results revealed the superiority was for FA males over RIR ones at most ages.

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قوة الهجين والمكونات المضيفة لصفات النمو فى خطة تهجين بين دجاج الفيومى والرود أيلاند الأحمر المتأقلم على ظروفنا المحلية

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البيانات الحالية مأخوذة على عدد كلى ٢٦١ كتكوت (١٢٣ كتكوت من الأنواع النقية و١٣٨ من الخلطان) ناتجة من التهجين بين نوعين من الدجاج أحدهما قياسى وهو الرودأيلاند الأحمر والأخر محلى محسن (فيومى منتخب لوزن الجسم عند عمر ٨ أسابيع). هدفت الدراسة إلى تقييم التأثير المضيف الأمى والمباشر وكذا قوة الهجين المباشرة والفردية بالإضافة لبعض التأثيرات غير الوراثية (تاريخ الفقس والجنس) والمؤثرة على صفات وزن الجسم والزيادة فى وزن الجسم للفترة من ٤ إلى ١٦ أسبوع من العمر.

أظهر إختبار المعنوية أن مجموعة التربية لم تؤثر معنويا على وزن الجسم ما عدا عند ٤ أسابيع من العمر لوزن الجسم وللفترة من ٨-١٢ أسبوع للزيادة فى وزن الجسم. كان للجنس تأثيرات عالية المعنوية على وزن الجسم والزيادة فى وزن الجسم عند كل الأعمار المدروسة. لم تتضح المعنوية لتأثير تاريخ الفقس على معظم صفات وزن الجسم ماعدا عند ١٦ أسبوع من العمر بينما وضحت المعنوية لتأثير تاريخ الفقس على الزيادة فى وزن الجسم عند الفترات المتأخرة من ١٢-١٦ و١٤-١٦ أسبوع من العمر. أظهر التداخل بين الجنس و تاريخ الفقس تأثيرا معنويا على الزيادة فى وزن الجسم عند الفترات ٨-١٢ ، ٤-١٦ أسبوع من العمر.

تقديرات قوة التهجين المباشرة كانت عموما موجبة على وزن الجسم والزيادة فى وزن الجسم ما عند الفترة من ٤-٨ أسابيع من العمر. بينما أظهر التأثيران المضيفان المباشر والأمى عموما إتجاه سالب غير معنوى على وزن الجسم والزيادة فى وزن الجسم عند أغلب الأعمار المدروسة.