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GENETIC AND NON-GENETIC ASPECTS OF EARLY GROWTH TRAITS IN NEW ZEALAND ROMNEY SHEEP

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ABSTRACT

The aim of the present study was to analyze the effect of genetic and non-genetic factors on the early growth traits of New Zealand Romney sheep. Early growth data of 1629 lambs (863 males and 766 females), progenies of 20 rams and 905 ewes, were used to test the factors affecting birth weight (BW), adjusted weight for 90 days (W90) and average daily gain from birth to weaning (ADG) using the general linear model of SAS software **(SAS, 2000)**. The fixed effects were the year of birth, the parity of ewe, the gender of lamb and the type of birth. Bi-interactions between the fixed effects were included in the statistical model. The co-variance components, direct *(h^2_a)* and maternal *(h^2_m)* heritabilities, and genetic *(r_G)* and phenotypic *(r_P)* correlations among the studied traits were estimated using MTDFREML (**Boldman *et al*., 1995**).

Year of birth had no effect on all the studied traits. The parity of ewe proved significant effect ($P < 0.01$) on both W90 and ADG. The gender of lamb and type of birth contributed significantly ($p < 0.001$) to the variation of the studied traits. The parity of ewe interacted with gender of lamb to significantly ($P < 0.01$) affect ADG and also interacted with type of birth to significantly affect BW ($P < 0.001$), W90 ($P < 0.001$) and ADG ($P < 0.05$). Significant effects were observed on BW ($P < 0.05$), W90 ($P < 0.001$) and ADG ($P < 0.01$) due to the interaction between gender of lamb and type of birth.

The estimates of h^2_a for BW, WW and ADG were 0.15 ± 0.02, 0.08 ± 0.03 and 0.16 ± 0.05, respectively; however, the corresponding estimates of h^2_m for these traits were 0.30 ± 0.02, 0.20 ± 0.02 and 0.16 ± 0.05, respectively. The additive genetic variance *(σ^2_a)* for BW, WW and ADG were 0.106, 1.419 and 0.0004, respectively, and the corresponding maternal genetic variance *(σ^2_m)* for these traits were 0.213, 6.535 and 0.0004, respectively. The estimates of environmental variance *(σ^2_p)* were 0.357, 11.289 and 0.0012 for BW, WW and ADG, respectively, which contributed to the higher proportion of total phenotypic variance for all these traits.

According to these findings, it is important to consider the role of various environmental factors in New Zealand Romney sheep production, since they affected the early growth performance of lambs. The low to moderate estimates of h^2_a for early growth traits indicate to the possibility of improving them using traditional or genomic selection. Furthermore, selection for any of the studied traits would be expected to have a large effect on the other growth traits as a result of their moderately positive genetic correlations.

Keywords: *Romney sheep, heritability, additive, maternal, environmental effects.*

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INTRODUCTION

Romney sheep is one of the most important sheep breeds in New Zealand. They are raised for meat and wool production and are distributed in all areas of the north and south islands. Ways to increase meat production of sheep, in any system, are achieved by producing more lambs per ewe and increasing growth performance of the lambs (**Baneh *et al.*, 2010**). The first objective can be achieved by increasing ewe productivity, including lambing rate and frequency, whereas the second objective requires enhancing growth performance and survival of lambs **(Miraei-Ashtiani *et al.*, 2007)**.

Early growth traits are important factors influencing the profitability of any sheep meat production enterprise, whereas animals with higher early growth rate are less affected by unfavorable environmental factors than animals with lower early growth rate (**Přibyl *et al.*, 2008**), therefore these traits have to be included in any breeding program.

These traits are influenced by many factors including additive genetic effects, maternal genetic effects and environmental factors which affect both the lambs and their ewes **(Ghafouri-Kesbi *et al.*, 2008; Farokhad *et al.*, 2010)**. Adjustments of data for non-genetic factors, such as year and/or season of birth, parity of ewe, type of birth, gender of lamb and location are necessary to obtain reliable estimates for important economic traits and to increase the accuracy of selection of breeding animals (**Thiruvenkadan *et al.*, 2011**). In addition, effective breeding plan could be achieved through the knowledge about inheritance of the economically important traits. Therefore, estimating co-variance components, direct (h^2_a) and maternal (h^2_m) heritabilities and genetic *(r_G)* and phenotypic *(r_p)* correlations among early growth traits is required to formulate optimum breeding objectives and implement an effective genetic improvement program.

Little information is available on genetic and non-genetic factors affecting growth traits of New Zealand Romney sheep. **Baker *et al.* (1979)** cited that type of birth and gender of lamb were the largest sources of variation for weaning weight (WW) and also found that the h^2 estimate for WW in Romney sheep was 0.08. The h^2 estimates were 0.10 and 0.06 for WW in male and female of Romney sheep, respectively **(Parratti, 1989)**.

The present study was designed for the genetic and non-genetic evaluation of the New Zealand Romney sheep breed with the following objectives: 1) to investigate the influence of environmental factors and their bi-interactions on early growth traits; 2) to estimate the co-variance components, direct and maternal heritabilities and genetic and phenotypic correlations among early growth traits.

MATERIALS AND METHODS

Data Collection

Data and pedigree information of the period from 2006 to 2012, for Romney sheep were collected from a commercial flock, located in the south island of New Zealand and were granted by the Gene Marker Laboratory, Faculty of Agriculture and Life Sciences, Lincoln University, New Zealand. The data were 1629 lamb records (863 males and 766 females) born from 20 rams and 905 ewes. Data included pedigree information (lamb, ram and ewe code), birth information (date of birth, gender of lamb and type of birth) and performance records of birth weight (BW), adjusted weight at 90 days (W90) and average daily gain from birth to weaning (ADG). Breeding season is normally in autumn (from February to late May) and usually starts with a 'silent' cycle. The selected rams and ewes are divided into mating groups depending on their pedigree to avoid inbreeding. Ewes are joined in a pen with a single ram in a group of 40-50 ewes. After the mating period, groups of ewes are separated from rams and kept as one group until lambing. The lambing season usually starts in August to October. Lambs suckle until weaning at about 90 days.

Statistical analysis

Estimation of non-genetic factor effects

Data were analyzed using the general linear model (GLM) procedure of SAS software (SAS, 2000), to estimate the effect of year of birth, parity of ewe, gender of lamb and type of birth and their bi-interactions on three early growth traits: BW, W90 and ADG. The mathematical model used to analyze the three early growth traits can be written as follows:

$$Y_{ijklm} = \mu + Y_i + P_j + G_k + B_l + YP_{ij} + YG_{ik} + YB_{il} + PG_{jk} + PB_{jl} + GB_{kl} + e_{ijklm}$$

Where:

Y_{ijklm} = the observed records on the traits,

μ = the overall mean,

Y_i = the fixed effect of ith year of birth, i = 1, …6,

P_j = the fixed effect of jth parity of ewe: j= 1, …5,

G_k = the fixed effect of kth gender of lamb, k = 1, 2,

B_l = the fixed effect of nth type of birth, l = 1, 2, 3,

YP_{ij} = the interaction between ith year of birth and jth parity of ewe,

YG_{ik} = the interaction between ith year of birth and kth gender of lamb,

YB_{il} = the interaction between ith year of birth and lth type of birth,

PG_{jk} = the interaction between jth parity of ewe and kth gender of lamb,

PB_{jl} = the interaction between jth parity of ewe and lth type of birth,

GB_{kl} = the interaction between kth gender of lamb and lth type of birth and

e_{ijklm} = Random error; assumed N.I.D. $(0, \sigma^2_e)$.

Estimation of genetic parameters

Estimates of co-variance components, direct and maternal heritabilities and genetic and phenotypic correlations were estimated using the Multiple Trait Derivative-Free Restricted Maximum Likelihood (MTDFREML) program of **Boldman *et al.* (1995)**. The animal model included the significant fixed factors at $P \leq 0.05$ as well as the significant bi-interactions at $P \leq 0.20$.

The animal model in matrix notation as follow**:**

Model 1: $Y_1 = X\beta_1 + Z_a a + Z_m m + Z_c c + e$

Model 2: $Y_2 = X\beta_2 + Z_a a + Z_m m + Z_c c + e$

Where:

Y_1 = Vector of observations (BW),

Y_2 = Vector of observations (W90 and ADG),

X = incidence matrix for the fixed effects and their bi-interactions,

β_1 = Vector of fixed effects and interactions (gender of lamb, type of birth, parity of ewe × gender of lamb, parity of ewe × type of birth and gender of lamb × type of birth),

β_2= Vector of fixed effects and interactions (parity of ewe, gender of lamb, type of birth, year of lambing × gender of lamb, parity of ewe × gender of lamb, parity of ewe × type of birth),

Z = incidence matrix for random effects,

a, m and c = Vector of random effects: additive genetic effect (σ^2_a), maternal genetic effect (σ^2_m) and environmental effect (σ^2_e), and

e = Vector of residual effects; assumed N.I.D. $(0, I\sigma^2_e)$.

RESULTS AND DISCUSSION

Means and standard errors

The obtained results showed that, he means and standard errors of BW, W90 and ADG were 5.97 ± 0.02 kg, 36.81 ± 0.11 kg and 342.61 ± 1.17 gm/d, respectively. **Morris *et al.* (1996)**

worked on New Zealand Romney sheep and reported that the mean and SD for live body weights at birth and weaning were 4.10 ± 0.76 and 28.7 ± 3.1 kg, respectively. On the same breed, the mean of live body weights at birth and weaning were 4.32 and 28.71 kg, respectively **(Morris *et al.*, 2000)**.

Effect of non-genetic factors

Least square means (LSM) and effects of non genetic factors on early growth traits are presented in Table (1).

The parity of ewe showed significant effect ($P < 0.01$) on W90 and ADG. In general, W90 and ADG increased from the first to the fourth parity and thereafter decreased substantially. The lower values of pre-weaning growth traits for lambs born to younger ewes may attributed to the relative competition of nutrients between the still growing ewes and the developing foetus (**Thiruvenkadan *et al.*, 2011).** Also the depression in these traits for lambs born after the fourth parity may be due to the ewe's tooth decay that results in grazing problems followed by decreasing milk production and maternal care for lambs **(Mousa *et al.*, 2013).** Similar significant effects for parity of ewe on the body weights at early stage of age were observed by **Mousa *et al.* (2006); Thiruvenkadan *et al.* (2011); Shokrollahi and Zandieh (2012)** and **Simeonov *et al.* (2015).**

There were highly significant ($P < 0.001$) effects for gender of lamb on all traits. Male lambs have higher values for BW, W90 and ADG in comparison with female lambs. The differences in body weights between male and female lambs might be due to the differences in endocrine system between the two genders **(Swenson and Reece, 1993)**. The gender difference is consistent with results from other investigations (**ElWakil *et al.*, 2009; Shokrollahi and Zandieh, 2012**; **Mousa *et al.*, 2006 & 2013)**.

All studied traits were highly significant ($P < 0.001$) influenced by type of birth. The obtained results indicated that, single born lambs had heavier BW, W90 and ADG than multiple born lambs. The growth advantage of single born might result from its lower competition to milking and supply from the ewe in gestation period than the multiplex **(Mousa *et al.*, 2013)**. This result is in agreement with the results of **Roshanfekr *et al*. (2011); Shokrollahi and Zandieh (2012)**; **Mousa *et al.* (2006 & 2013) and Simeonov *et al.* (2015),** in Arabi, Kurdish, Egyptian Farafra and Blackhead Pleven breeds of sheep, respectively.

No associations were found between year of birth and all the studied traits. Our results are inconsistence with the results obtained by **ElWakil *et al.* (2009)**; **Roshanfekr *et al*. (2011); Shokrollahi and Zandieh (2012); Mousa *et al.*, (2006 & 2013) and Simeonov *et al.* (2015)** in the Egyptian Barki, Arabi, Kurdish, Egyptian Farafra and Blackhead Pleven breeds of sheep, respectively.

Effects of bi-interaction between non-genetic factors

The obtained results from bi- interactions between the fixed effects are presented in Table (2).

The interactions of year of birth with the rest of fixed factors were not significant.

The parity of ewe interacted with the gender of lamb to significantly ($P < 0.05$) affect only ADG. However, the interaction of parity of ewe with type of birth significantly affected all the studied traits. The main effect of parity of ewe shows a direct influence on W90 and ADG due to the changes of amount of ewe's milk production and indirect influence on BW due to the changes of in ewe's maturation. Thus different estimates were obtained for different combinations of parity of ewe with gender of lamb and type of birth for these traits. These results are partially agreed with the results of **Baneh *et al.* (2009)** on Ghezel sheep and **Akhtar *et al.* (2012)** in on Buchi sheep and disagreed with the results of **Fadare et al. (2015)** on West African dwarf sheep.

Table 1. Least square means and effects of non-genetic factors on early growth traits in New Zealand Romney sheep.

Non-genetic factor	Number of records	Early growth traits		
		BW (kg)	W90 (kg)	ADG (gm)
Year				
2006	80	5.92 ± 0.09	36.43 ± 0.48	339.06 ± 4.93
2007	93	5.77 ± 0.07	35.89 ± 0.48	334.61 ± 4.87
2008	140	5.86 ± 0.07	35.92 ± 0.41	333.92 ± 4.22
2009	164	6.08 ± 0.06	37.69 ± 0.36	351.26 ± 3.86
2010	201	5.99 ± 0.05	36.98 ± 0.28	344.31 ± 2.86
2012	951	5.99 ± 0.02	36.87 ± 0.15	343.11 ± 1.55
Significance		ns	ns	ns
Parity of ewe				
1	868	5.90 ± 0.02	$36.14^{b} \pm 0.15$	$335.97^{b} \pm 1.57$
2	409	6.04 ± 0.04	$36.85^{b} \pm 0.24$	$342.36^{b} \pm 2.53$
3	194	6.02 ± 0.06	$38.47^{a} \pm 0.30$	$360.64^{a} \pm 2.99$
4	131	6.15 ± 0.08	$39.14^{a} \pm 0.30$	$366.55^{a} \pm 3.00$
5	27	6.16 ± 0.19	$34.44^{c} \pm 0.71$	$314.13^{c} \pm 6.93$
Significance		ns	**	**
Gender				
Male	863	$6.266^{a} \pm 0.02$	$39.90^{a} \pm 0.09$	$373.77^{a} \pm 0.98$
Female	766	$5.654^{b} \pm 0.03$	$33.33^{b} \pm 0.13$	$307.50^{b} \pm 1.40$
Significance		***	***	***
Type of Birth				
1	397	$6.41^{a} \pm 0.04$	$38.81^{a} \pm 0.22$	$359.97^{a} \pm 2.32$
2	1076	$5.92^{b} \pm 0.02$	$36.45^{b} \pm 0.13$	$339.31^{b} \pm 1.38$
3	156	$5.26^{c} \pm 0.07$	$34.16^{c} \pm 0.40$	$321.14^{c} \pm 4.07$
Significance		***	***	***

BW: birth weight; W90: adjusted weight for 90 days; ADG: average daily gain from birth to weaning; Means of the same trait with the same letter do not significantly ($P < 0.05$) differ from each other; NS: refers to non significance; *: refers to significance at ($P < 0.05$); ** refers to significance at ($P < 0.01$); *** refers to significance at ($P < 0.001$).

Significant interactions between gender of lamb and type of birth existed here for BW ($P < 0.05$), W90 ($P < 0.001$) and ADG ($P < 0.01$). These interactions were inconsistence with the findings of **Hussain (2006)**; **Iram (2008)** and **Farmnullah (2011)** on Thalli sheep, Lohi sheep and Kajili sheep, respectively.

Genetic parameters of the studied traits

Estimates of co-variance components for early growth traits are presented in Table (3). The estimates of σ^2_a were nearly half the estimates of σ^2_m which indicate to the importance of maternal effects on the traits of concern. Also the estimates of σ^2_a were found to account for small proportions and the estimates of σ^2_e were found to account for large proportions of the σ^2_p for all the studied traits. This result reflects the importance of σ^2_e than σ^2_a which is possibly due to uterine capacity, feeding level at late gestation, and maternal behavior of the ewe. Reasonably higher maternal genetic effects than additive genetic effects were also observed by **El-Awady *et al.* (2011) and Mousa *et al.* (2013)** for BW and the results obtained by **El-Awady *et al*. (2011)** for WW.

The covariances between additive and maternal genetic effects (σ_{am}) were positive but not important for BW (0.03) and ADG (3.12), and slightly more considerable for W90 (1.26). **Miraei-Ashtiani *et al*. (2007)** and **Mousa *et al.* (2013)** reported lower covariances between additive and maternal genetic effects, which were -0.06 and -0.04 for BW and -0.06 and -2.90 for WW, respectively.

Table 2. P-values of bi-interactions between non-genetic factors on the early growth traits of New Zealand Romney sheep.

Interaction	Trait		
	BW	W90	ADG
Year of birth			
× parity of ewe	0.852	0.918	0.869
× gender of lamb	0.366	0.375	0.141
× type of birth	0.306	0.454	0.603
Parity of ewe			
× gender of lamb	0.053	0.062	0.009
× type of birth	0.001	0.003	0.015
Gender of lamb			
× type of birth	0.015	0.001	0.004

BW: birth weight; W90: adjusted weight for 90 days; ADG: average daily gain from birth to weaning.

The estimates of h^2_a, h^2_m, r_G and r_p between the studied traits are shown in Table (4). The presented results showed that the estimates of h^2_a for BW and WW were nearly half the estimates of h^2_m, indicating the importance of maternal genetic effects in sheep which contribute to the dependence of lambs on their mother`s milk until the time of weaning **(Bradford, 1972)**. In a rare study, **Morris *et al.*, (1996)** worked on the New Zealand Romney sheep and reported that the h^2 estimates for BW and WW were 0.29 ± 0.05 and 0.11 ± 0.05, respectively. **Meyer (1992)** suggested that models not considering maternal genetic effects

Table 3. Co-variance components for early growth traits in New Zealand Romney sheep.

Parameter	BW (kg)	W90 (kg)	ADG (gm/d)
σ^2_a (Additive variance)	0.11	1.43	35.12
σ^2_m (Maternal variance)	0.21	3.36	36.13
σ_{am} (Additive maternal covariance)	0.03	1.26	3.12
σ^2_e (Environmental variance)	0.36	11.09	119.32
σ^2_p (Total phenotypic variance)	0.71	17.16	193.40
σ^2_e/σ^2_p (Environmental proportion of total variance)	0.51	0.64	0.61

BW: birth weight; W90: adjusted weight for 90 days; ADG: average daily gain from birth to weaning.

Table 4. Direct and maternal heritabilities (diagonal) and genetic (above diagonal) and phenotypic (below diagonal) correlations between early growth traits in New Zealand Romney sheep.

Trait	BW	W90	ADG
BW	0.15 ± 0.05 (D) 0.30 ± 0.02 (M)	0.385 (D) 0.355 (M)	0.120 (D) 0.131 (M)
W90	0.483**	0.08 ± 0.03 (D) 0.20 ± 0.02 (M)	0.797 (D) 0.836 (M)
ADG	0.381**	0.867**	0.18 ± 0.05 (D) 0.18 ± 0.05 (M)

BW: birth weight; W90: adjusted weight for 90 days; ADG: average daily gain from birth to weaning; **correlation is significant at ($P < 0.01$); D: direct; M: maternal.

could result in substantial higher estimates of σ^2_a and h^2_a. Also the estimates of h^2_a and h^2_m for BW were higher than their corresponding estimates for WW.

The decrease in the estimates of both h^2_a and h^2_m by age is consistence with the results of **El-Awady *et al*. (2011) and Mousa *et al.*, (2013)**, and inconsistence with the results of **ElWakil *et al.* (2009)**.

Generally, the obtained results fell in the range reported in the literature for different breeds of sheep maintained at different locations and regions of the world. The range of h^2_a estimates for these traits in literature varied substantially from 0.004 in Barbary sheep **(Bedhiaf *et al.*, 2000)** to 0.94 in Hissardale sheep **(Chaudhry and Shah, 1985** for BW; from 0.007 in Barbary sheep **(Bedhiaf *et al.*, 2000)** to 0.81 in Multibreed meat sheep **(Lobo et al., 2009)** for WW and from 0.12 in Crossbreed sheep **(Hall *et al.*, 1995)** to 0.15 in Romanov sheep **(Maria *et al.*, 1993)** for ADG. Likewise, the estimates of h^2_m ranged from 0.02 in Dorper sheep **(Neser *et***

***al.*, 2001)** to 0.65 in Sangsari sheep **(Miraei-Ashtiani *et al.*, 2007)** for BW, from 0.01 in Ghazel sheep to 0.48 in Dorper sheep **(Assan *et al.*, 2011)** for WW and from 0.01 in Romanov sheep **(Maria *et al.*, 1993)** to 0.07 in Crossbreed sheep **(Hall *et al.*, 1995)** for ADG.

Estimates of r_G and r_P between early growth traits in the current study were positive and moderate. The direct r_G for BW with both WW and ADG were 0.385 and 0.120, respectively, however, the maternal r_G among these traits were 0.355 and 0.131, respectively. The estimates of r_P between the studied traits were positive and generally moderate to high (0. 381 to 0.957). In this study, the estimates of r_G were higher than those reported by **El-Awady *et al*. (2011)** in Egyptian Rahmani lambs and lower than those reported by **ElWakil *et al.* (2009); Roshanfekr *et al*. (2011); Prakash *et al*. (2012)** in Egyptian Barki, Kermani and Malpura breeds of sheep, respectively. The higher estimates for r_G and r_P indicate that selection for any of these traits could result in reasonable genetic improvement for the other traits.

CONCLUSION

It could be concluded that the environmental factors have a main source of variation for early growth traits; therefore through better feeding and management, there are ample chances of improvement in performance traits. The estimates of heritabilities and co-variance components of the studied traits proved the importance of maternal effect, hence, to achieve an optimum genetic progress for early growth traits, both additive and maternal components of variance must be considered. Early growth traits have been reported as moderately heritable traits; therefore, they could be genetically improved using traditional or genomic selection. Furthermore, the moderate positive genetic correlations among these traits indicate that selection for any trait could improve the other traits.

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العوامل الوراثية والغير وراثية لصفات النمو في المرحلة المبكرة من العمر لأغنام الرومني النيوزيلندية

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اجريت هذه الدراسة للتعرف على تأثير العوامل الوراثية والغير وراثية على أوزان الجسم في مرحلة النمو المبكر لحملان الرومني النيوزيلندية.

استخدمت في هذه الدراسة سجلات النسب وأوزان الجسم لعدد 1629 حمل، منسبة لعدد 20 من الكباش و 905 من النعاج، تم ولادتهم في الفترة من (2006 – 2012) بإحدى المزارع الواقعة بالجزيرة الجنوبية لدولة نيوزيلندا.

تم دراسة تأثير كل من عام الولادة، ترتيب الولادة، جنس الحمل، نوع الولادة وكذلك التداخلات الثنائية فيما بينهم على وزن الجسم عند الميلاد، وزن الجسم عند 90 يوم، معدل النمو من الميلاد للفطام، وذلك باستخدام برنامج SAS 2000

كما تم استخدام برنامج MTDFREML لتقدير مكونات التباين والتغاير وكذلك المعالم الوراثية للصفات المدروسة، حيث تم استخدام نموذج الحيوان الاحصائي الذي تضمن كل من التأثيرات العشوائية، التأثيرات الثابتة ذات التأثير المعنوي عند مستوى 0.05 والتداخلات الثنائية ذات التأثير المعنوي عند مستوى 0.20 .

أوضحت النتائج أن:

1. عام الولادة لم يكن له تاثير معنوى على الصفات المدروسة، بينما كان ترتيب الولادة له تأثير معنوى عند مستوى 0.01 على كلا من الوزن عند 90 يوم ومعدل النمو من الميلاد للفطام، في حين كان لجنس الحمل ونوع الولادة تأثيرا عالي المعنوية عند مستوى 0.001 على كل الصفات المدروسة .

2. التداخل بين ترتيب الولادة وجنس الحمل أثر معنويا على معدل النمو من الميلاد للفطام. التداخل بين ترتيب الولادة ونوع الولادة أثر معنويا على كل من الوزن عند الميلاد ، الوزن عند عمر 90 يوم ، معدل النمو من الميلاد للفطام ، بينما أثر التداخل بين جنس الحمل ونوع الولادة معنويا على كل من الوزن عند الميلاد ، الوزن عند عمر 90 يوم ، معدل النمو من الميلاد للفطام.

أظهرت نتائج نموذج الحيوان أن:

1. المكافئات الوراثية المباشرة كانت (0.15 ، 0.08 ، 0.18) والمكافئات الوراثية الأمية كانت (0.30 ، 0.20 ،0.18) وذلك لصفات وزن الجسم عند الميلاد، وزن الجسم عند عمر 90 يوم ، معدل النمو من الميلاد للفطام على التوالي. وكان من الواضح أن المكافئات الوراثية الأمية أعلى من المكافئات الوراثية المباشرة لأوزان الجسم عند الميلاد وعمر 90 يوم.

2. التباينات الأمية كانت أعلى من التباينات المباشرة لوزن الجسم عند الميلاد ووزن الجسم عند عمر 90 يوم ، كما أن مكونات التباين البيئية مثلت نسبة 50% من التباين الكلي لوزن الجسم عند الميلاد وارتفعت لتصبح 64% من التباين الكلي لوزن الجسم عند عمر 90 يوم.

3. معامل الارتباط الوراثي المباشر ما بين الوزن عند الميلاد والوزن عند عمر 90 يوم متوسطه (0.385).

ومن هذه الدراسة يتضح:

1. أهمية تأثير بعض العوامل الغير وراثية على صفات النمو في المرحلة المبكرة من العمر خاصة ترتيب الولادة ، جنس الحمل ، نوع الولادة.

2. أهمية التأثيرات الأمية على النمو في هذه المرحلة العمرية.

3. التحسين لوزن الجسم عند الميلاد سوف يؤدي الى زيادة وزن الجسم عند عمر 90 يوم.