Chapter 4

RESULTS

4. RESULTS

4.1 Growth performance

Data on birth weight, weaning weight or 90 – day weight and the post weaning weights at 180, 270 and 360- days of age was analysed for the body weight development of the various genotypes at the different age groups.

4.1.1 Least square analysis of variance for birth weight and subsequent body weights

An analysis of variance model with 2 – way and 3 – way interaction was used to analyse the effects of the year of birth, genotype, sex, type of birth and parity of birth on the body weights of all the genotypes under study from birth to 360-days old. Variance due to regression effect of offspring weight on ewe weight at parturition and on offspring birth weight were also estimated to correct for the above effect on relevant traits. The results for the regression effect, main effects, two-way and three-way interaction effects of the analysis was tabulated in Table 4.1.

The overall results showed that the effect of the year of birth was significant for birth weight ($P<0.01$) and for the 180-days ($P<0.001$) weight. Low significant difference for the effect of genotype was revealed for birth weight ($P<0.05$) and weight at 270 days old ($P<0.05$). The effect of sex was found to be significant for the weight at 270 days only while the effect of the type of birth was significant for the weight at birth ($P<0.001$), 90-days ($P<0.001$) and 180-days ($P<0.05$) old. No significant difference was found for the effect of parity of birth on birth weight and the subsequent body weights under study.

Table 4.1 Least square analysis of variance for the body weights of the various genotypes at different age groups

Source of variation	Birth Weight		90- days		180 – days		270 – days		360 - days	
	df	Mean Square Values	df	Mean Square Values	df	Mean Square Values	df	Mean Square Values	df	Mean Square Values
+ Regression 1	1	4.58***	1	40.39***	1	46.50**	1	36.43*	1	109.64**
++ Regression 2	-	-	1	157.24***	1	128.31***	1	117.76***	1	174.10***
Year of birth (YOB)	7	0.58**	7	7.30	7	25.17***	7	12.05	7	15.33
Genotype (G)	6	0.46*	6	4.29	6	10.78	6	21.92*	6	20.91
Sex (S)	1	0.17	1	9.72	1	12.36	1	68.77**	1	31.23
Type of birth (T)	1	4.45***	1	59.73***	1	31.99*	1	20.66	1	1.47
Parity of birth (P)	2	0.26	2	3.07	2	8.25	2	6.52	2	8.62
Genotype x Year of birth	17	0.26	16	3.32	16	11.30	16	9.81	16	12.60
Genotype x Sex	6	0.11	6	3.33	6	14.65*	6	25.23*	6	35.87*
Genotype x Type of birth	5	0.33	5	5.94	5	22.13**	5	19.11	5	15.45
Genotype x Parity of birth	10	0.30	10	1.81	10	10.28	10	10.93	10	7.03
Year of birth x Genotype x Sex	14	0.10	13	2.52	12	4.23	11	5.33	11	18.91
Year of birth x Genotype x Type of birth	8	0.14	8	6.32	8	7.95	8	16.36	8	13.21
Year of birth x Genotype x Parity of birth	17	0.12	17	4.04	16	8.01	16	9.38	16	9.78
Genotype x Sex x Type of birth	5	0.12	5	1.18	5	5.23	5	9.01	5	8.44
Genotype x Sex x Parity of birth	8	0.18	7	1.03	7	2.44	7	6.53	7	12.49
Sex x Type of birth x Parity of birth	4	0.10	4	6.96	4	5.03	4	5.93	4	10.23
Error	306	0.18	289	3.68	242	6.82	240	9.19	240	10.71

+ Regression of offspring weight on ewes weight at parturition
++ Regression of offspring weight on birth weight

*	P ≤ 0.05
**	P ≤ 0.01
***	P ≤ 0.001

The two-way interaction between the effect of genotype and sex showed a significant difference for the post-weaning weights at the age of 180 ($P<0.05$), 270 ($P<0.05$) and 360-days ($P<0.05$). The interaction effect between the genotype and the type of birth was significant for the weight at 180 days ($P<0.05$) only.

High significant effect ($P<0.001$) for the effect of regressing the weights of the offspring at 90, 180, 270 and 360 days old on their birth weight was shown in Table 4.1. Similarly, regression effect for the offsprings' body weights to the weights of their ewes at parturition was revealed to be significant for birth weight ($P<0.001$), weaning weight at 90-days of age ($P<0.001$), and the post-weaning weights at 180 ($P<0.01$), 270 ($P<0.05$) and 360 days ($P<0.01$).

The three-way interactions did not show any significant difference for three sources of variation of all the weights at the various age groups. This could be due to the variation among the effects of the different sources of variation in the model used. Since the two factor interaction had shown significant effect for two sources of variation, namely for the interaction effect between genotype and sex and the interaction effect between genotype and type of birth, the data was reanalysed using a different model involving only the main effects and two-way interaction only.

The new model involved only two-factor interaction and the results were presented to show the differences between the major effects like the year of birth, genotype, sex, type of birth, parity of birth and the two-factor interactions between them such as the interaction between the effects of genotype x year of birth, genotype x sex, genotype x type of birth and genotype x parity of birth. The results discussed the effects of the various factors on birth weight, weaning weight (90-day weight) and post-weaning weights (180, 270 and 360 days).

4.1.2 Birth weight

4.1.2.1 Least square analysis of variance for birth weight

Table 4.2 shows the analysis of variance for the main effects and two-way interactions for the various genotypes under study at birth.

The main effects of the year of birth ($P \leq 0.01$), genotype ($P \leq 0.05$), sex ($P \leq 0.05$), type of birth ($P \leq 0.001$) and parity of birth ($P \leq 0.05$) were found to be significant on the birth weights of the genotypes. However there was no significant effect found on the interaction effects between genotype x year of birth, genotype x sex, genotype x type of birth and genotype x parity of birth. The interaction effects between genotype x year of birth, genotype x sex, genotype x type of birth, and genotype x parity of birth were also not significant when the data was analysed earlier using the three-way analysis of variance (Table 4.1).

The regression effects for the birth weights of the lambs on the weights of their ewes at parturition were very highly significant ($P \leq 0.001$), as expected.

4.1.2.2 Effect of genotypes on birth weight

The genotypes involved in the evaluation of growth performances were the purebred Cameroon hair sheep, purebred Thai Long Tail wool sheep, their first, second and third filial crosses (F_1, F_2, F_3) and the reciprocal backcrosses of the first filial generation (F_1) to the Thai Long Tail parents, BC_1 (F_1 male x Thai Long Tail female) and BC_2 (Thai Long Tail male x F_1 male).

The effect of genotypes on the birth weight was found to be significant ($P<0.05$) (Table 4.1 and Table 4.2). The overall mean for the birth weight of all the genotypes

Table 4.2 Least square analysis of variance for birth weights

Sources of Variation	Degrees of freedom	Sum of Squares	Mean Squares	F–Values
Regressions				
Ewe's weight at parturition	1	9.00	9.00	50.91***
Year of birth	7	3.90	0.56	3.15**
Genotype	6	2.63	0.44	2.48*
Sex	1	0.85	0.85	4.83*
Type of birth	1	20.85	20.85	117.96***
Parity of birth	3	0.89	0.30	1.67*
Genotype x Year of birth	17	4.99	0.29	1.66
Genotype x Sex	6	1.10	0.18	1.04
Genotype x Type of birth	5	1.45	0.29	1.64
Genotype x Parity of birth	15	3.07	0.20	1.16
Error	404	71.41	0.18	

Significance levels

*	=	$P \leq 0.05$
**	=	$P \leq 0.01$
***	=	$P \leq 0.001$

involved in this study was 2.84 ± 0.04 kg (Table 4.3). The overall means for the birth weights of the lambs studied with the effect of sex, the type of birth and the parity of birth is tabulated in Table 4.3 and Figure 4.1.

Table 4.4 and Figure 4.2 show the least square means for all the genotypic groups. The results showed that the BC_1 genotype had the highest mean birth weight of 2.83 ± 0.08 kg while the F_2 genotype had the lowest (2.48 ± 0.05 kg). The rankings of the birth weights of the genotypes in descending order were 2.83 ± 0.08, 2.82 ± 0.04, 2.74 ± 0.08, 2.72 ± 0.07, 2.68 ± 0.04, 2.52 ± 0.16 and 2.48 ± 0.05 kg with respect to the BC_1, Thai Long Tail , F_3, BC_2, F_1, Cameroon and F_2.

The mean birth weight of the F_1 (2.68 ± 0.04 kg) was the intermediate of that of the parental genotypes while the F_2 crossbreds from the second filial generation showed a lower birth weight (2.48 ± 0.05 kg) than the F_1. However the F_3 crossbreds of the third filial generation had the highest birth weight (2.74 ± 0.08 kg) in comparison to that of the F_1's and the F_2's .

The backcrosses were also found to have higher birth weights than the purebred Cameroon, with the BC_1 having higher birth weight than the Cameroon and the Thai Long Tail while the BC_2's birth weight was the intermediate of their purebred grandparents (Table 4.4). The backcrosses between the F_1 male x Thai Long Tail female (BC_1) revealed higher birth weights than their parental F_1 and Thai Long Tail while the BC_2 showed birth weight higher than one of their parental genotypes, the F_1 crossbred. The birth weight difference between the BC_1 and the BC_2 crossbreds was only 0.11 kg. Except for the F_3, the backrosses were shown to have higher birth weights than the F_1 and the F_2's (Figure 4.2).

Table 4.3 Overall Least square means and std. errors for birth weights

Parameters	Number of observations	Least square means ± std. errors (kg)
Overall mean	493	2.84 ± 0.04
By sex		
Male	259	2.76 ± 0.04[a]
Female	234	2.61 ± 0.04[b]
By type of birth		
Single	376	2.96 ± 0.03[a]
Twins	111	2.41 ± 0.05[b]
By parity of birth		
First parity	195	2.83 ± 0.06[a]
Second parity	153	2.85 ± 0.06[a]
Third parity	90	2.81 ± 0.10[a]

Difference in superscripts a and b shows significant difference in least square means

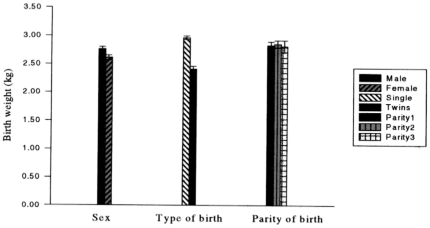

Figure 4.1 Least square means and std. errors of the birth weights by the effects of sex, type of birth and parity of birth

Table 4.4 Least square means and std. errors of the birth weights for the various genotypes

Genotypes	Least square means ± std. errors of birth weights (kg)
Cameroon (C)	2.52 ± 0.16^{cd} (8)
Thai Long Tail (TLT)	2.82 ± 0.04^{a} (112)
$\mathbf{F_1}$ (C x TLT)	2.68 ± 0.04^{bc} (176)
$\mathbf{F_2}$ (F_1 x F_1)	2.48 ± 0.05^{d} (92)
$\mathbf{F_3}$ (F_2 x F_2)	2.74 ± 0.08^{ab} (29)
$\mathbf{BC_1}$ (F_1 (male) x TLT (female))	2.83 ± 0.08^{a} (35)
$\mathbf{BC_2}$ (TLT (male) x F_1 (female))	2.72 ± 0.07^{ab} (40)

Difference in superscripts a, b, c and d shows significant difference in the least square means

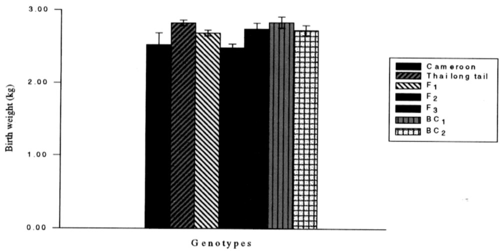

Figure 4.2 Least square means and std. errors of the birth weights of the various genotypes

4.1.2.3 Effect of sex on birth weight

Sex has a significant ($P \leq 0.05$) effect on the mean birth weights of the genotypes (Table 4.2). The Least Square means showed that the males were heavier at birth than the females (Table 4.3). The birth weights of the males and the females were 2.76 ± 0.04 and 2.61 ± 0.04 kg respectively. The results from this study revealed that the males were 0.15 kg or 5.75% heavier than the females.

The least square analysis of variance for birth weight (Table 4.2) showed that the interaction effect between the genotypes and the sex on the birth weight was not significant. However, the males from all the genotypes were found to be heavier than the females at birth (Table 4.5 and Figure 4.3), with the exception of the F_2 females, which were about 0.02 kg heavier than the F_2 males. The Thai Long Tail males were the heaviest at birth followed by the BC_1, F_3, F_1, BC_2, Cameroon and F_2. On the other hand the birth weight of the BC_1 females were the heaviest followed by that of the BC_2, Thai Long Tail, F_1, F_3, F_2 and Cameroon.

Their birth weight were 2.99 ± 0.06, 2.90 ± 0.10, 2.86 ± 0.11, 2.75 ± 0.05, 2.74 ± 0.10, 2.60 ± 0.22 and 2.47 ± 0.07 kg for the males, and 2.75 ± 0.12, 2.69 ± 0.10, 2.66 ± 0.06, 2.61 ± 0.05, 2.61 ± 0.12, 2.49 ± 0.07 and 2.43 ± 0.22 kg for the females in descending order respectively (Table 4.5 and Figure 4.3).

4.1.2.4 Effect of the type of birth on birth weight

Comparison on the effect of the type of birth was only done between the single and the twins lambs only. The triplets and quadruplets were not considered in this study due to their frequency at birth being very low in this project. Not all genotypes had incidence of multiple births.

Table 4.5 Least square means and std. errors of the birth weights by the effects of genotypes and sex

Genotypes	Least square means ± std. errors of birth weights (kg)
Cameroon (C)	
Male	2.60 ± 0.22 (4)[c]
Female	2.43 ± 0.22 (4)[d]
Thai Long Tail (TLT)	
Male	2.99 ± 0.06 (60)[a]
Female	2.66 ± 0.06 (52)[c]
F_1 (C x TLT)	
Male	2.75 ± 0.05 (93)[b]
Female	2.61 ± 0.05 (83)[c]
F_2 (F_1 x F_1)	
Male	2.47 ± 0.07 (48)[d]
Female	2.49 ± 0.07 (44)[d]
F_3 (F_2 x F_2)	
Male	2.86 ± 0.11 (15)[ab]
Female	2.61 ± 0.12 (14)[c]
BC_1 (F_1 (male) x TLT (female))	
Male	2.90 ± 0.10 (20)[a]
Female	2.75 ± 0.12 (15)[b]
BC_2 (TLT (male) x F_1 (female))	
Male	2.74 ± 0.10 (19)[b]
Female	2.69 ± 0.10 (21)[b]

Difference in superscripts a, b, c and d shows significant difference in the least square means

Figure 4.3 Least square means and std. errors of the birth weights by the effects of genotypes and sex

Table 4.6 Least square means and std. errors of the birth weights by the effects of genotypes and type of birth

Genotypes	**Least square means ± std. errors of birth weights by the type of birth (kg)**
	Birth weight
Cameroon (C)	
Singles	2.64 ± 0.17 (8)^{cd}
Twins	–
Thai Long Tail (TLT)	
Singles	2.91 ± 0.05 (78)^{b}
Twins	2.65 ± 0.08 (34)^{c}
$\mathbf{F_1}$ (C x TLT)	
Singles	2.95 ± 0.04 (153)^{b}
Twins	2.41 ± 0.11 (20)^{d}
$\mathbf{F_2}$ (F_1 x F_1)	
Singles	2.73 ± 0.06 (70)^{c}
Twins	2.40 ± 0.10 (22)^{d}
$\mathbf{F_3}$ (F_2 x F_2)	
Singles	3.11 ± 0.14 (12)^{ab}
Twins	2.52 ± 0.11 (17)^{d}
$\mathbf{BC_1}$ (F_1 (male) x TLT (female))	
Singles	3.17 ± 0.09 (31)^{a}
Twins	2.36 ± 0.23 (4)^{d}
$\mathbf{BC_2}$ (TLT (male) x F_1 (female))	
Singles	3.24 ± 0.10 (24)^{a}
Twins	2.45 ± 0.12 (10)^{d}

Difference in superscripts a, b, c and d shows significant difference in the least square means

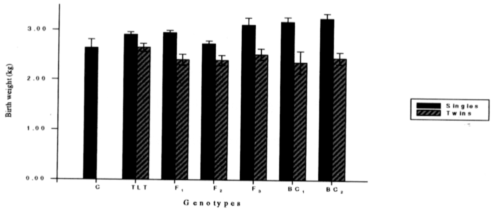

Figure 4.4 Least square means and std. errors of the birth weights by the effects of genotypes and type of birth

The type of birth was found to have a very high significant ($P \leq 0.001$) effect on the birth weights of the various genotypes (Table 4.2). Table 4.3 shows that the single lambs were 0.55 kg or 22.8% heavier than the twins at birth. The Least square means of the birth weights of the single lambs and the twins were 2.96 ± 0.03 and 2.41 ± 0.05 kg respectively. It was also found that the number of animals born as single lambs were 376 compared to 112 twins.

Table 4.6 and Figure 4.4 show that all the Cameroon lambs were born as singles. Data for Cameroon lambs born as twins were not available because the Cameroon genotype that was imported and bred in the farm produced only single lambs during the course of this study. Therefore, data for twins were not presented for the Cameroon hair sheep for this effect.

The interaction effect between the genotypes and the type of birth was shown by the least square analysis of variance (Table 4.1 and Table 4.2) to be not significant for birth weight. In all the genotypic groups being compared, the singles were found to have higher birth weights than the twins (Figure 4.4). The range for the singles was 2.64 kg for the lightest to 3.24 kg for the heaviest lambs. Table 4.6 and Figure 4.4 showed that the ranking of the birth weights for the single lambs by the genotypes and the type of birth was the BC_2 (3.24 ± 0.10 kg), BC_1 (3.17 ± 0.09 kg), F_3 (3.11 ± 0.14 kg), F_1 (2.95 ± 0.04 kg), Thai Long Tail (2.91 ± 0.05 kg), F_2 (2.73 ± 0.06 kg) and Cameroon (2.64 ± 0.17 kg). On the other hand, the rankings for the birth weights of the twins in descending order were Thai Long Tail (2.65 ± 0.08 kg), F_3 (2.52 ± 0.11 kg), BC_2 (2.45 ± 0.12), F_1 (2.41 ± 0.11 kg), F_2 (2.40 ± 0.10 kg) and BC_1 (2.36 ± 0.23 kg). Except for the F_2 lambs, the other crossbreds that were born as single lambs were heavier than the singles born by their Cameroon and Thai Long Tail parental genotypes, while the crossbred twins were all lighter than the purebred twins born from their Thai long Tail parent (Figure 4.4).

When the first, the second and the third filial generations crossbreds were compared, the F_3 crossbred lambs that were born as singles were the heaviest compared to the F_1 and the F_2. The F_1 singles were heavier at birth than the F_2 but lighter than the F_3 singles. The birth weights were 3.11 ± 0.14, 2.95 ± 0.04 and 2.73 ± 0.06 kg for the F_3, F_1 and F_2 singles respectively while for the twins, their birth weights were 2.52 ± 0.11, 2.41 ± 0.11 and 2.40 ± 0.10 kg for the F_3, F_1 and F_2 respectively in descending order. In the backcrosses animals, BC_2 singles and twins were heavier than the BC_1's, with birth weights of 3.24 ± 0.10 kg and 3.17 ± 0.09 kg respectively for the singles; and 2.45 ± 0.12 kg and 2.36 ± 0.23 kg respectively for the twins, of the BC_2 and the BC_1 genotypes respectively.

4.1.2.5 Effect of the parity of birth on birth weight

Only lambs born from the first, second and the third parities were included in this comparison to ensure comparison between the genotypic groups.

The parity of birth was found to have a significant ($P \leq 0.05$) effect on the birth weights (Table 4.2). The overall results in Table 4.3 showed that lambs born in the second parity were found to have the highest birth weight when compared to the first and the third. The second parity lambs were 0.02 kg heavier than the first parity lambs and 0.04 kg heavier than the third parity lambs. Their birth weights were 2.85 ± 0.06, 2.83 ± 0.06 and 2.81± 0.10 kg respectively for the second, first and the third parity respectively. The birth weights of the lambs born in the third parity group was the lightest when compared to the animals born in the first and second parities.

The interaction effect on the birth weight between the genotypes and the parity of birth was earlier shown to be not significant (Table 4.2).

Table 4.7 Least square means and std. errors of the birth weights by the effects of genotypes and parity of birth

Genotypes	**Parity**	**Least square means ± std. errors of birth weights by parity of birth (kg)**
Cameroon (C)	1	2.79 ± 0.35 (2)^{b}
	2	2.79 ± 0.28 (3)^{b}
	3	2.74 ± 0.35 (2)^{bc}
Thai Long Tail (TLT)	1	2.82 ± 0.07 (54)^{b}
	2	3.03 ± 0.10 (29)^{a}
	3	3.01 ± 0.12 (16)^{a}
F_1 (C x TLT)	1	2.85 ± 0.07 (48)^{b}
	2	2.92 ± 0.06 (61)^{a}
	3	2.84 ± 0.08 (38)^{b}
F_2 (F_1 x F_1)	1	2.67 ± 0.07 (53)^{c}
	2	2.65 ± 0.10 (27)^{c}
	3	2.47 ± 0.16 (10)^{c}
F_3 (F_2 x F_2)	1	2.75 ± 0.12 (17)^{b}
	2	2.61 ± 0.15 (11)^{c}
	3	3.13 ± 0.15 (2)^{a}
BC_1 (F_1 (male) x TLT (female))	1	3.08 ± 0.15 (11)^{a}
	2	2.91 ± 0.19 (7)^{a}
	3	2.93 ± 0.16 (10)^{a}
BC_2 (TLT (male) x F_1 (female))	1	2.81 ± 0.16 (10)^{b}
	2	3.04 ± 0.12 (17)^{a}
	3	2.52 ± 0.14 (13)^{c}

Difference in superscripts a, b and c shows significant difference in the least square means

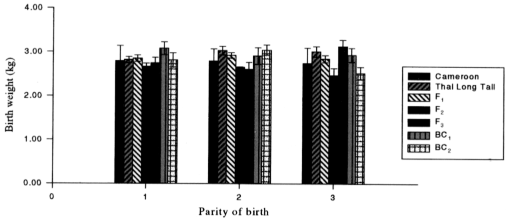

Figure 4.5 Least square means and std. of the birth weights by the effects of genotypes and parity of birth

Lambs born in the second parity were mostly found to have the highest birth weight in comparison to lambs born in the first and third parities except in the case of the F_2, F_3 and BC_1 (Table 4.7). In Cameroon, the least square means of the birth weights of the first and the second parity lambs were the same (2.79 ± 0.35 kg and 2.79 ± 0.28 kg) while the third parity lambs were 0.05 kg lighter (2.74 ± 0.35 kg). The second parity lambs from the Thai Long Tail, F_1 and BC_2 genotypes had the highest birth weight than the second and the third, while the first parity lambs showed the highest birth weight in the F_2 and the BC_1. The third parity lambs were the heaviest at birth in the F_3 genotype only (Table 4.7 and Figure 4.5).

Amongst the genotypes, the highest birth weight was found for the third parity lambs in the F_3 (3.13 ± 0.50 kg) while the lowest was of the third parity lambs from the F_2 crossbreds (2.47 ± 0.16 kg).

4.1.2.6 Effect of the year of birth on birth weight

The year of birth had a significant ($P<0.05$) effect on the mean birth weight (Table 4.2). However the interaction effect between the genotypes and the year of birth was not significant.

The least square means of the birth weights of the genotypes showed that the birth weights were represented with respect to the year the genotypes were produced, therefore they were not represented in all the sub-classes (Table 4.8).

However, from this study, it could be observed that the birth weights of all the genotypes studied were represented only in the year of 1995 where the Thai Long Tail showed the highest birth weight followed by the BC_1, F_1, BC_2, F_2, F_3 and Cameroon. Their respective birth weights in this year were 2.92 ± 0.25, 2.88 ± 0.12, 2.66 ± 0.19, 2.58 ± 0.09, 2.44 ± 0.08, 2.43 ± 0.25 and 2.13 ± 0.46 kg (Table 4.8).

Table 4.12 Least square means and std. errors of the weaning weights by the effects of genotypes and sex

Genotypes	Least square means ± std. errors of weaning weights (kg)
Cameroon (C)	
Male	11.12 ± 1.10 (4)^{de}
Female	11.03 ± 1.10 (4)^{e}
Thai Long Tail (TLT)	
Male	14.26 ± 0.29 (60)^{a}
Female	12.89 ± 0.32 (50)^{c}
$\mathbf{F_1}$ (C x TLT)	
Male	13.64 ± 0.25 (92)^{b}
Female	12.15 ± 0.28 (81)^{d}
$\mathbf{F_2}$ (F_1 x F_1)	
Male	13.31 ± 0.35 (43)^{b}
Female	12.64 ± 0.37 (39)^{cd}
$\mathbf{F_3}$ (F_2 x F_2)	
Male	13.10 ± 0.58 (14)^{bc}
Female	11.94 ± 0.63 (12)^{d}
$\mathbf{BC_1}$ (F_1 (male) x TLT (female))	
Male	13.65 ± 0.50 (20)^{ab}
Female	12.07 ± 0.57 (15)^{d}
$\mathbf{BC_2}$ (TLT (male) x F_1 (female))	
Male	14.00 ± 0.55 (16)^{a}
Female	11.89 ± 0.53 (18)^{d}

Difference in superscripts a, b, c, d and e shows significant difference in the least square means

Figure 4.8 Least square means and std. errors of the weaning weights by the effects of genotypes and sex

The birth weights in general peaked up in 1996 for the F_1 (3.14 ± 0.43 kg) and the F_2 (3.55 ± 0.31 kg). In 1997, the birth weights of the Thai Long Tail, F_3 and BC_2 peaked up to 3.52 ± 0.31 kg, 3.51 ± 0.32 kg and 3.52 ± 0.31 kg respectively. Except for the year 1996, the birth weights of the F_2 genotype were comparatively lower than the F_1. There seemed to be a discrepancy in the birth weights shown by the least square means for the year 1996 and 1997 but it could probably be due to the very small sample sizes analysed during these two years.

The Cameroon lambs that were produced in 1994 had the heaviest birth weight of 2.58 ± 0.26 kg when compared to the Cameroon produced in 1992 (2.52 ± 0.31 kg), 1993 (2.45 ± 0.31 kg) and 1995 (2.13 ± 0.46 kg). The heaviest Thai Long Tail was produced in 1997 (3.52 ± 0.31 kg) while the lightest birth weight was for the lambs born in 1990. The birth weights of the Thai Long Tail improved every year except for a decrease of 0.02 kg in 1995. The mean birth weight of the F_1 was at the highest in 1996 (3.14 ± 0.43 kg) for the only one animal produced and the lowest was in 1994 (2.61 ± 0.08 kg). The F_2 lambs were found to have the heaviest birth weight in 1996 (3.55 ± 0.31 kg) and the lightest in 1997 (2.15 ± 0.25 kg). The heaviest F_3 lambs were produced in 1996 (2.73 ± 0.09 kg) and the lightest (2.43 ± 0.25 kg) in 1995. The highest mean birth weight for the BC_1 was obtained from the lambs born in 1994 (2.89 ± 0.15 kg) and the lambs born in 1993 had the lowest birth weight (2.68 ± 0.12 kg). The BC_2 lambs that were produced in 1997 had the highest mean birth weight (3.52 ± 0.31 kg) when compared to the year 1995 where the lambs weighed the lowest (2.58 ± 0.09 kg).

Table 4.8 showed some inconsistency in the birth weights of the Thai Long Tail (1997), F_1, F_2 (1996) and F_3, BC_2 (1997) genotypes during the seven years' study. This could be due to the fact that the F_1 parents were selected for less wool, which might have reduced the birth weights in the F_2. This selection for hairy parents was not so drastic in the F_2 for the production of the F_3. Another factor that could influence the birth weight and fluctuated birth weights of the genotypes would be because of the management problem and the nutrition of the parents especially the expecting ewes. Thus the number of lambs born for the year for the various genotypic groups would depend on the genotype required for the study and the limited maximum number of animals in the flock.

4.1.2.7 Regression of lamb birth weights on ewe's weight at parturition

Regression on lamb birth weight on ewe's body weight was obtained in the least square analysis of variance (Table 4.1) to correct the effect of ewe weight on offspring weight.

Table 4.1 and Table 4.2 show that the effect of regressing the birth weights of the lambs on the weights of the ewes at parturition were very highly significant ($P \leq 0.001$). The regression estimate for the birth weights of the lambs on ewes' weights at parturition was 0.04 ± 0.01 and this value was also very highly significant ($P \leq 0.001$). Thus it was justified that prior to analyzing the main effect and the interaction effect, it was necessary to remove the variances due to the above regression effect.

4.1.2.8 Regression of lamb weight at later ages on birth weight

Correction for the effect of birth weight on subsequent body weights (Table 4.1) was done to correct for the variation in birth weight caused by ewe body weight at parturition, which reflected the age of the ewe and its nutritional status at the time of pregnancy. Regression effects were significant all through the analysis.

4.1.3 Weaning weight (90-days weight)

4.1.3.1 Least square analysis of variance for weaning weight

The least square analysis of variance for weaning weights or at the age of ninety days old for the various genotypes was tabulated in Table 4.9.

The results showed the interaction effects of the year of birth and the type of birth were very highly significant ($P \leq 0.001$) on the weaning weight of the genotypes, while highly significant ($P \leq 0.01$) effects were also revealed for the sex effect and the interaction effects between the genotypes and the type of birth. Other main effects such as the effects of genotypes and the parity of birth, as well as the interaction effects between the genotype and the year of birth, genotype and sex, and genotype and the parity of birth were not significant.

The least square analysis of variance (Table 4.9) also revealed very high significant effects on the regression of offspring weight on ewes weight at parturition ($P \leq 0.001$) and the regression of offspring weight on their birth weight ($P \leq 0.001$). The same result was also revealed using the three-way analysis of variance (Table 4.1).

In comparison to the three-way least square analysis of variance in Table 4.1, only the effect of the type of birth was found to be significant. Thus the two-way least square analysis of variance showed more significant effects from lesser sources of variation than the three- factors least square analysis of variance. Therefore the following result on the weaning weight would be based on the result from the two-factor least square analysis of variance.

Table 4.9 Least square analysis of variance for weaning weights

Sources of Variation	Degrees of freedom	Mean Squares
+ **Regression 1**	1	58.60***
++ **Regression 2**	1	216.23***
Year of birth	7	37.72***
Genotype	6	1.43
Sex	1	33.50**
Type of birth	1	249.46***
Parity	3	3.23
Genotype x Year of birth	16	5.91
Genotype x Sex	6	3.69
Genotype x Type of birth	5	14.47**
Genotype x Parity of birth	14	2.19
Error	383	3.82

+ Regression of offspring weight on ewes weight at parturition

++ Regression of offspring weight on birth weight

Significance levels

* = $P \leq 0.05$

** = $P \leq 0.01$

*** = $P \leq 0.001$

4.1.3.2 Interaction effect of genotype and type of birth on weaning weights

The analysis of variance (Table 4.9) showed that the interaction effect between genotype and type of birth on weaning weight was significant. The main effect of the type of birth was highly significant ($P \leq 0.001$) although there was no significant effect of genotype on the weaning weight. Since genotype x type of birth was significant, the results will present the weaning weights of the genotypes within the type of birth.

At weaning, the single lambs were significantly ($P \leq 0.001$) heavier than the twins (Table 4.10 and Figure 4.6) with weaning weights of 14.23 ± 0.17 and 11.16 ± 0.27 kg respectively. The twin lambs were 22.82% lighter than the single lambs.

The interaction effect showed that all the singles from the various genotypes under study were significantly heavier than their twin counterparts (Table 4.11 and Figure 4.7). The result also revealed that the single lambs from the BC_2 genotype were the heaviest at weaning followed by single lambs from the BC_1, F_3, Thai Long Tail, F_1, F_2 and Cameroon. The weights of the singles in descending order were 15.70 ± 0.53, 15.21 ± 0.46, 15.09 ± 0.70, 14.76 ± 0.28, 14.56 ± 0.20, 14.51 ± 0.30 and 11.95 ± 0.86 kg respectively (Table 4.11 and Figure 4.7). Single lambs from the backcross animals had the highest weaning weights when compared to the other genotypes, Cameroon, Thai Long Tail and the three filial generations (F_1, F_2 and F_3).

The twins from the Thai Long Tail and the F_1 genotypes had the same weaning weights (12.20 ± 0.44 and 12.20 ± 0.57 kg respectively) and were the heaviest at weaning. The BC_1 twins were the third heaviest followed by the BC_2, F_2, F_3 and Cameroon genotypes, with weaning weights of 10.86 ± 1.22, 10.65 ± 0.68, 10.74 ± 0.57 and 10.26 ± 0.65 kg respectively.

Table 4.10 Overall least square means and std. errors for weaning weights

Parameters	Number of observations	Least square means ± std. errors (kg)
Overall mean	468	13.92 ± 0.03
By sex		
Male	249	13.30 ± 0.23[a]
Female	219	12.09 ± 0.24[b]
By type of birth		
Single	363	14.23 ± 0.17[a]
Twins	102	11.16 ± 0.27[b]
By parity		
First parity	195	13.95 ± 0.33[a]
Second parity	153	13.45 ± 0.30[a]
Third parity	90	13.29 ± 0.48[a]

Difference in superscripts a and b shows significant difference in the least square means

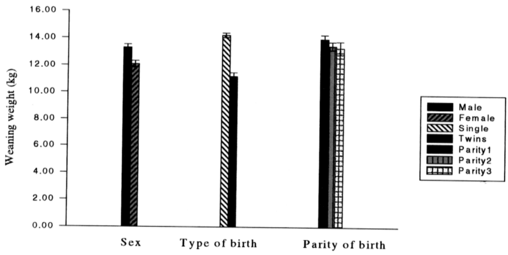

Figure 4.6 Least square means and std. errors of the weaning weights by the effects of sex, type of birth and parity of birth

Table 4.11 Least square means and std. errors of the weaning weights by the effects of genotypes and type of birth

Genotypes	Least square means ± std. errors of weaning weights (kg)
Cameroon (C)	
Singles	11.95 ± 0.86 (8)[c]
Twins	–
Thai Long Tail (TLT)	
Singles	14.76 ± 0.28 (77)[b]
Twins	12.20 ± 0.44 (33)[c]
F_1 (C x TLT)	
Singles	14.56 ± 0.20 (150)[b]
Twins	12.20 ± 0.57 (20)[c]
F_2 (F_1 x F_1)	
Singles	14.51 ± 0.30 (64)[b]
Twins	10.74 ± 0.57 (18)[d]
F_3 (F_2 x F_2)	
Singles	15.09 ± 0.70 (12)[ab]
Twins	10.26 ± 0.65 (14)[d]
BC_1 (F_1 (male) x TLT (female))	
Singles	15.21 ± 0.46 (31)[a]
Twins	10.86 ± 1.22 (8)[c]
BC_2 (TLT (male) x F_1 (female))	
Singles	15.70 ± 0.53 (21) [a]
Twins	10.65 ± 0.68 (9)[d]

Difference in superscripts a, b, c and d shows significant difference in the least square means

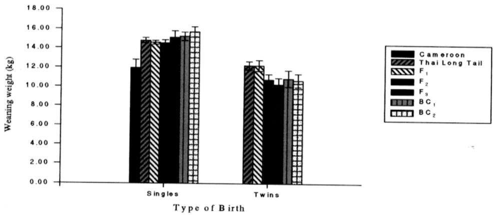

Figure 4.7 Least square means and std. errors of the weaning weights by the effects of genotypes and type of birth

Weaning weight differences between the singles and the twins for the Thai Long Tail, F_1, F_2, F_3, BC_1 and BC_2 genotypes were 2.56, 2.36, 3.77, 4.83, 4.35 and 5.05 kg respectively. The differences varied significantly ($P \leq 0.01$) between the sexes of the same genotype. Due to the absence of twins in the Cameroon, the comparison of the twins did not include the Cameroon genotype.

The effect of genotype was not significant on the weaning weights of the animals under study (Table 4.9) although the effect of genotype was found to be significant ($P \leq 0.05$) at birth (Table 4.2). This indicates birth weight in this study did not correctly reflect the weaning weight.

A comparison of the least square means of the weaning weights showed that the purebred Cameroon hair sheep had the lowest weaning weight (11.08 ± 0.79 kg) while the purebred Thai Long Tail wool sheep had the highest (13.58 ± 0.22 kg) and the difference was significant ($P \leq 0.01$). The second heaviest genotype at weaning was the F_2 (12.98 ± 0.26 kg) followed by the BC_2 (12.95 ± 0.39 kg), F_1 (12.89 ± 0.20 kg), BC_1 (12.86 ± 0.39 kg), F_3 (12.52 ± 0.43 kg) and Cameroon (11.08 ± 0.79 kg) respectively.

The lambs from the second filial generation showed higher weaning weight than the lambs from the first and the third filial generation. The ranking was F_2, F_1 and F_3 with the weights of 12.98 ± 0.26 kg, 12.89 ± 0.20 kg and 12.52 ± 0.43 kg respectively. The differences were very small and not significant. When compared to the backcrosses, the results showed that the weaning weight of the F_2 genotype (12.98 ± 0.26 kg) was higher than that of the BC_1 (12.86 ± 0.39 kg) and the BC_2 (12.95 ± 0.39 kg). The weaning weight of the F_1 genotype (12.89 ± 0.20 kg) was higher than the BC_1 (12.86 ± 0.39 kg) and lower than the BC_2 (12.95 ± 0.39 kg) genotype.

The backcrosses, BC_1 and BC_2 had weaning weights lower than the Thai Long Tail and significantly ($P \leq 0.05$) higher than the Cameroon. The weaning weight of the BC_2 genotype (12.95 ± 0.39 kg) was higher than the BC_1 (12.86 ± 0.39 kg) but the difference between the weights (0.09 kg) was not significant. The weights of the backcrosses were not significantly different from the weights of the F_1, F_2 and the F_3 crossbreds.

Generally, the weights of the crossbreds were an intermediate of the weights of the Cameroon hair sheep and the Thai Long Tail wool sheep parents at weaning.

4.1.3.3 Effect of sex on weaning weight

At the weaning age of 90 days old the least square means and the standard errors (Table 4.10) for the weaning weight between the sexes were 13.30 ± 0.23 kg for the males and 12.09 ± 0.24 kg for the females. The difference between the weaning weights of the sexes was 1.21 kg

The effect of sex was significantly high ($P \leq 0.01$) for the weaning weights of the genotypes. However the interaction effect between the genotype and sex was not significant (Table 4.9).

In Table 4.12 and Figure 4.8, it could be seen that all the males from all the genotypes were heavier than the females. The males were found to be 10.01% heavier than the females at weaning. The ranking of the males weaning weights in descending order was 14.26 ± 0.29, 14.00 ± 0.55, 13.65 ± 0.50, 13.64 ± 0.25, 13.31 ± 0.35, 13.10 ± 0.58 and 11.12 ± 1.10 kg for the Thai Long Tail, BC_2, BC_1, F_1, F_2, F_3 and Cameroon genotypes respectively. The ranking for the weaning weights of the females in descending order was 12.89 ± 0.32, 12.64 ± 0.37, 12.15 ± 0.28, 12.07 ± 0.57, 11.94 ± 0.63, 11.89 ± 0.53 and 11.03 ± 1.10 kg for the Thai Long Tail, F_2, F_1, BC_1, F_3, BC_2 and Cameroon genotypes respectively.

Table 4.12 Least square means and std. errors of the weaning weights by the effects of genotypes and sex

Genotypes	Least square means ± std. errors of weaning weights (kg)
Cameroon (C)	
Male	11.12 ± 1.10 (4)[de]
Female	11.03 ± 1.10 (4)[e]
Thai Long Tail (TLT)	
Male	14.26 ± 0.29 (60)[a]
Female	12.89 ± 0.32 (50)[c]
$\mathbf{F_1}$ (C x TLT)	
Male	13.64 ± 0.25 (92)[b]
Female	12.15 ± 0.28 (81)[d]
$\mathbf{F_2}$ (F_1 x F_1)	
Male	13.31 ± 0.35 (43)[b]
Female	12.64 ± 0.37 (39)[cd]
$\mathbf{F_3}$ (F_2 x F_2)	
Male	13.10 ± 0.58 (14)[bc]
Female	11.94 ± 0.63 (12)[d]
$\mathbf{BC_1}$ (F_1 (male) x TLT (female))	
Male	13.65 ± 0.50 (20)[ab]
Female	12.07 ± 0.57 (15)[d]
$\mathbf{BC_2}$ (TLT (male) x F_1 (female))	
Male	14.00 ± 0.55 (16)[a]
Female	11.89 ± 0.53 (18)[d]

Difference in superscripts a, b, c, d and e shows significant difference in the least square means

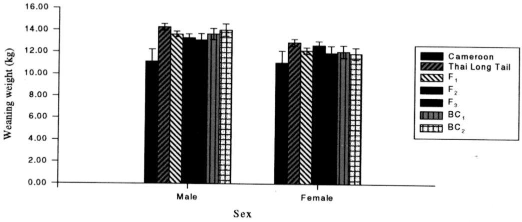

Figure 4.8 Least square means and std. errors of the weaning weights by the effects of genotypes and sex

The least square means in Table 4.12 and Figure 4.8 showed that Thai Long Tail males were the heaviest (14.26 ± 0.29 kg) at weaning while the Cameroon males were the Cameroon females the lightest (11.12 ± 1.10 kg). The weight differences between the Thai Long Tail with Cameroon males and Thai Long Tail with Cameroon females were 3.14 ($P \leq 0.01$) and 1.86 kg respectively. Thai Long Tail males were 0.26 kg, 0.61 kg, 0.62 kg, 0.95 kg ($P \leq 0.05$), 1.16 kg ($P \leq 0.05$) heavier than the BC_2, BC_1, F_1, F_2 and F_3 males while the Thai Long Tail females were 0.25 kg, 0.74 kg, 0.82 kg, 0.95 kg, 1.00 kg and 1.86 kg heavier than the F_2, F_1, BC_1, F_3, BC_2 and Cameroon females respectively.

Comparison between the F_1, F_2 and F_3 showed that the weaning weights of the F_1 males were higher than the F_2 and the F_3 males (13.64 ± 0.25, 13.31 ± 0.35 and 13.10 ± 0.58 kg respectively). On the other hand the F_1 females showed the second highest weaning weights (12.15 ± 0.28 kg) after the F_2 (12.64 ± 0.37 kg), the highest, and the F_3 (11.94 ± 0.63 kg) the lowest. Therefore for the three filial generations the F_1 males and the F_2 females were the heaviest at weaning. However the F_1 males were ranked fourth while the F_2 females the second when compared with respect to the heaviest genotype by sex at weaning (Table 4.12 and Figure 4.8).

Within the backcross animals, for the BC_2 genotype males were 0.35 kg heavier than the BC_1 males. In contrast, the BC_2 females were 0.18 kg lighter than the BC_1 females. The BC_1 males and females weight were 13.65 ± 0.50 and 12.07 ± 0.57 kg respectively while for the BC_2 the respective weights were 14.00 ± 0.55 and 11.89 ± 0.53 kg (Table 4.12).

4.1.3.4 Effect of the parity of birth on weaning weight

The parity of birth and the interaction effects between genotypes and the parity of birth had no significant effect on the weaning weights of the genotypes (Table 4.9).

The results from this study showed that the first parity lambs were the heaviest at weaning in comparison to the second and the third parity lambs (Table 4.10) although there was no significant difference between these three parity. The weaning weights for the first, second and the third parity lambs were 13.95 ± 0.33, 13.45 ± 0.30 and 13.29 ± 0.48 kg respectively, in descending order from the heaviest to the lightest. The first parity lambs were 0.50 kg heavier than the second and 0.66 kg heavier than the third parity lambs, while the lambs of the second parity were 0.16 kg heavier than the lambs from the third parity.

In the Thai Long Tail, F_2, BC_1 and BC_2 genotypes, the trend followed the above observation (Table 4.13). In the Cameroon genotype, lambs born from the second parity were the heaviest at weaning, while for the F_1 and the F_3 genotypes; lambs from the third parity of birth were the heaviest at weaning in. Amongst the first parity lambs the ranking for the highest weaning weights was the BC_2 (15.24 ± 1.09 kg), Thai Long Tail (15.15 ± 0.35 kg), BC_1 (14.89 ± 0.73 kg) and F_2 14.17 ± 0.35 kg). The Cameroon was the only genotype that had the heaviest lamb of the second parity. The heaviest lambs in the third parity of birth was from the F_1 (14.44 ± 0.40 kg) and lambs from the F_3 genotype were the lightest (13.98 ± 0.41 kg)(Table 4.13 and Figure 4.9).

Comparison between the genotypes showed that (Table 4.13) the first parity lambs from the BC_2 genotype had the highest weaning weight (15.24 ± 1.09kg) while the first parity lambs from the Cameroon genotype had the lowest weaning weight (11.35 ± 1.71 kg).

Table 4.13 Least- Square Means and standard errors of the weaning weights by the effects of genotypes and parity of birth

Genotypes	Parity of birth	Least square means ± std. errors of weaning weights (kg)
Cameroon (C)	1	11.35 ± 1.71 (2)[c]
	2	12.99 ± 1.40 (3)[b]
	3	12.13 ± 1.71 (2)[b]
Thai Long Tail (TLT)	1	15.15 ± 0.35 (54)[a]
	2	13.51 ± 0.48 (27)[b]
	3	12.08 ± 0.61 (16)[c]
F_1 (C x TLT)	1	13.91 ± 0.36 (48)[a]
	2	14.31 ± 0.31 (61)[a]
	3	14.44 ± 0.40 (38)[a]
F_2 (F_1 x F_1)	1	14.17 ± 0.35 (53)[a]
	2	14.12 ± 0.48 (27)[a]
	3	13.66 ± 0.93 (10)[ab]
F_3 (F_2 x F_2)	1	12.93 ± 0.59 (17)[b]
	2	11.87 ± 0.86 (11)[c]
	3	13.98 ± 0.41 (2)[a]
BC_1 (F_1 (male) x TLT (female))	1	14.89 ± 0.73 (11)[a]
	2	14.29 ± 0.92 (7)[a]
	3	13.29 ± 0.76 (10)[b]
BC_2 (TLT (male) x F_1 (female))	1	15.24 ± 1.09 (10)[a]
	2	13.06 ± 0.61 (17)[b]
	3	13.36 ± 0.73 (13)[b]

Difference in superscripts a, b and c shows significant difference in the least square means

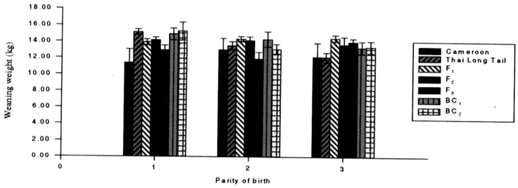

Figure 4.9 Least square means and std. errors of the weaning weights by the effects of genotypes and parity of birth

In general most of the genotypes had the heaviest lambs from the first parity of birth (Thai Long Tail, F_2, BC_1 and BC_2) followed by the third parity (F_1 and F_3) and the second (Cameroon).

4.1.4 Post-weaning weights

4.1.4.1 Least square analysis of variance for post-weaning weights

Least square analysis of variance for post-weaning weight at the age of 180, 270 and 360 days was done and the results are tabulated in Table 4.14.

It was found that the effect of the year of birth was significant at the age of 180 ($P \leq 0.001$), 270 ($P \leq 0.001$) and 360 days ($P \leq 0.01$). Sex of the genotypes had significant effect on the post weaning weights of 180 ($P \leq 0.05$), 270 ($P \leq 0.01$) and 360 ($P \leq 0.01$) days too. The type of birth showed high significant effect on the post weaning weight of 180 days but the degree of significance decreased at the age of 270 days ($P \leq 0.05$) and became not significant at the age of 360 days. Main effects of the genotypes and the parity of birth were found to be not significant on the post weaning weights.

Table 4.14 also shows that the interaction effect between the genotype and sex was significantly high ($P \leq 0.01$) at the age of 180 and 270 days, and the level of significance increased at the age of 360 days ($P \leq 0.001$). On the other hand, the level of significance for the interaction effect between the genotype and sex decreased from $P \leq 0.001$ at 180 days old to $P \leq 0.01$ at 270 days and $P \leq 0.05$ at 360 days old. The interaction effects between the genotype and year of birth, and genotype and parity of birth was not significant for all the post weaning weights at 180, 270 and 360 days.

Regression of the offspring post-weaning weight on their birth weight was very highly significant ($P \leq 0.001$) while the regression of the offspring post-weaning

Table 4.14 Least square analysis of variance for post-weaning weights at the various age groups

Source of Variations	180-days weight		270–days weight		360–days weight	
	d.f	Mean Squares	d.f	Mean Squares	d.f	Mean Squares
+ Regression 1	1	39.56*	1	17.51**	1	75.87**
++ Regression 2	1	193.81***	1	166.54***	1	194.33***
Year of Birth	7	73.78***	7	53.44***	7	32.82**
Genotype	6	14.32	6	19.41	6	22.74
Sex	1	38.28*	1	66.86**	1	100.44**
Type of birth	1	97.54***	1	50.63*	1	28.91
Parity of birth	3	16.29	3	10.06	3	15.11
Genotype x Year of birth	42	6.27	42	5.88	42	6.47
Genotype x Sex	6	29.85***	6	31.77**	6	45.99***
Genotype x Type of birth	6	27.66***	6	25.46**	6	23.21*
Genotype x Parity of birth	18	6.03	18	5.32	14	6.15
Error	329	7.67	296	10.41	296	12.23

\+ Regression of offspring weight on ewes weight at parturition
++ Regression of offspring weight on birth weight

Levels of significance: * $P \leq 0.05$
** $P \leq 0.01$
*** $P \leq 0.001$

weight on the ewes weight at parturition was also significant for the weights at 180 ($P \leq 0.05$), 270 days ($P \leq 0.01$) and 360 days.

The least square analysis of variance (Table 4.14) showed that significant effects of the post weaning weights were only obtained for the effects of the year of birth at 180 days ($P \leq 0.001$), effect of genotype at 270 days ($P \leq 0.05$), effect of sex at 270 days ($P \leq 0.01$), effect of the type of birth at 180 days ($P \leq 0.05$), the interaction effect between the genotype and the type of birth at 180 ($P \leq 0.05$), 270 ($P \leq 0.05$) and 360 days ($P \leq 0.05$); and the interaction effect between the genotype and the type of birth at 180 days ($P \leq 0.01$). Regression effect on the birth weights was significantly high ($P \leq 0.001$) while that on ewes weight at parturition was significant at 180 ($P \leq 0.01$), 270 ($P \leq 0.05$) and 360 day ($P \leq 0.01$).

The following results, which involved the least square means for the effects of genotypes, sex, the type of birth and the parity of birth would refer to the results obtained by the two-way analysis of variance. Due to the most unequal sub class numbers for the data analysed on the year of birth, the least square means for the characters in each year was not estimated. Therefore, the results for the effect of the year of birth was not included in this thesis.

4.1.4.2 Interaction effect of genotype and sex on post-weaning weights

The results from the two-way analysis of variance (Table 4.14) showed that the interaction effect between genotype and sex was significant at the age of 180-days ($P \leq 0.01$), 270-days ($P \leq 0.01$) and 360-days old ($P \leq 0.001$). The main effect of sex on the post weaning weights of the genotypes was significant at the age of 180-days ($P \leq 0.05$), 270-days ($P \leq 0.01$) and 360-days ($P \leq 0.01$) although the effect of genotype was not significant in all the age groups. The least square means of the interaction effect were tabulated in Table 4.16.

The overall least square means between the sexes showed that the post-weaning weights of the males were significantly higher than the females (Table 4.15 and Figure 4.10). The males were 0.76 kg ($P \leq 0.05$), 1.19 kg ($P \leq 0.01$) and 1.46 kg ($P \leq 0.01$) heavier than the females at 180-, 270- and 360-days old respectively. The weights of the males and the females increased 4.71 kg and 4.28 kg from 180- to 270-days but between the age of 270-days to 360-days the difference in weight decreased from 4.71 kg to 4.35 kg in the males and from 4.28 kg to 4.08 kg in the females. The overall post-weaning weights of the males and the females were 18.75 ± 0.34 kg and 17.99 ± 0.36 kg; 23.46 ± 0.39 kg and 22.27 ± 0.39 kg and, 27.81 ± 0.41 kg and 26.35 ± 0.41 kg respectively at 180, 270 and 360-days of age.

Comparison of the post weaning weights between the sexes from the different genotypic groups is tabulated in Table 4.16 and in Figure 4.11. The least square means showed that the males were heavier than the females at the age of 180, 270 and 360 days old except for the Cameroon (180 days), F_2 (180 days, 270 days and 360 days). The BC_2 males had the highest post weaning weights in comparison to the other male counterparts, while the Cameroon males had the lowest.

The ranking of the post-weaning weights at the age of 180-days of the males genotypes, in descending order was BC_2 (21.76 ± 0.82 kg), F_1 (19.79 ± 0.42 kg), Thai Long Tail (19.61 ± 0.51 kg), F_3 (19.12 ± 0.90 kg), BC_1 (18.85 ± 0.74 kg), F_2 (17.66 ± 0.53 kg) and Cameroon (14.47 ± 1.64 kg). The ranking for the females was F_2 (19.01 ± 0.55 kg), BC_2 (18.62 ± 0.79 kg), BC_1 (18.51 ± 0.85 kg), F_1 (18.11 ± 0.44 kg), Thai Long Tail (18.09 ± 0.50 kg), F_3 (17.16 ± 0.94 kg) and Cameroon (16.45 ± 1.64 kg) (Table 4.16 and Figure 4.11). At the age of 270-days and 360-days the BC_2

Table 4.15 Least square means and std. errors of post-weaning weights at the various age groups by the effects of sex, type of birth and parity of birth

	Least square means ± std. errors of post-weaning body weights (kg)		
	180-days	270-days	360-days
Overall mean	19.43 ± 0.38 (411)	23.71 ± 0.43 (406)	27.69 ± 0.45 (406)
By sex			
Male	18.75 ± 0.34[a] (206)	23.46 ± 0.39[a] (202)	27.81 ± 0.41[a] (202)
Female	17.99 ± 0.36[b] (205)	22.27 ± 0.39[b] (204)	26.35 ± 0.41[b] (204)
By type of birth			
Single	19.62 ± 0.26[a] (315)	23.73 ± 0.29[a] (311)	27.56 ± 0.30[a] (311)
Twins	17.13 ± 0.42[b] (92)	22.00 ± 0.46[b] (92)	26.60 ± 0.48[b] (92)
By parity of birth			
First parity	19.51 ± 0.45[a] (173)	23.47 ± 0.48[a] (171)	27.68 ± 0.51[a] (171)
Second parity	18.77 ± 0.41[a] (122)	23.13 ± 0.44[a] (122)	26.89 ± 0.47[a] (122)
Third parity	19.75 ± 0.65[a] (69)	24.16 ± 0.69[a] (68)	27.96 ± 0.73[a] (68)

Difference in superscripts a and b shows significant difference in the least square means

Table 4.16 Least square means and std. errors of post-weaning weights at the various age groups by the effects of genotypes and sex

Genotypes	Least square means ± std. errors of post-weaning weights at various age groups (kg)		
	180-days	270-days	360-days
Cameroon (C)			
Male	14.47 ± 1.64^{d} (4)	19.54 ± 2.02^{d} (3)	25.09 ± 2.10^{c} (3)
Female	16.45 ± 1.64^{cd} (4)	19.33 ± 1.75^{d} (4)	23.08 ± 1.82^{c} (4)
Thai Long Tail (TLT)			
Male	19.61 ± 0.51^{b} (43)	23.68 ± 0.54^{b} (43)	27.51 ± 0.57^{b} (43)
Female	18.09 ± 0.50^{c} (46)	22.02 ± 0.54^{cd} (45)	25.45 ± 0.56^{b} (45)
F_1 (C x TLT)			
Male	19.79 ± 0.42^{b} (69)	24.12 ± 0.45^{b} (68)	29.03 ± 0.47^{a} (68)
Female	18.11 ± 0.44^{c} (71)	22.54 ± 0.47^{c} (71)	26.54 ± 0.49^{bc} (71)
F_2 (F_1 x F_1)			
Male	17.66 ± 0.53^{c} (41)	22.32 ± 0.59^{c} (39)	26.70 ± 0.61^{b} (39)
Female	19.01 ± 0.55^{b} (39)	23.89 ± 0.59^{b} (39)	28.48 ± 0.61^{a} (39)
F_3 (F_2 x F_2)			
Male	19.12 ± 0.90^{b} (13)	23.98 ± 0.96^{b} (13)	28.64 ± 1.00^{a} (13)
Female	17.16 ± 0.94^{c} (12)	20.78 ± 1.00^{d} (12)	24.79 ± 1.04^{c} (12)
BC_1 (F_1 (male) x TLT (female))			
Male	18.85 ± 0.74^{b} (20)	24.00 ± 0.79^{b} (20)	28.10 ± 0.82^{a} (20)
Female	18.51 ± 0.85^{bc} (15)	23.52 ± 0.91^{bc} (15)	28.07 ± 0.95^{a} (15)
BC_2 (TLT (male) x F_1 (female))			
Male	21.76 ± 0.82^{a} (16)	26.61 ± 0.88^{a} (16)	29.64 ± 0.91^{a} (16)
Female	18.62 ± 0.79^{b} (18)	23.78 ± 0.85^{b} (18)	28.01 ± 0.88^{ab} (18)

Difference in superscripts a, b, c and d shows significant difference in the least square means

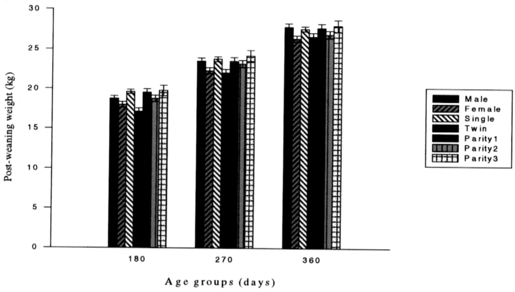

Figure 4.10 Least square means and std. errors of the post-weaning weights at the various age groups

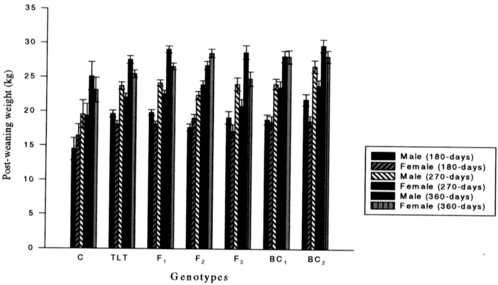

Figure 4.11 Least square means and std. errors of the post-weaning weights by the effects of genotypes and sex

males were the heaviest (26.61 ± 0.88 and 29.64 ± 0.91 kg respectively) followed by the F_1 (24.12 ± 0.45 and 29.03 ± 0.47 kg respectively). The third and fourth heaviest genotypes at 270- and 360-days old were the BC_1 (24.00 ± 0.79 kg) and the F_3 (28.64 ± 1.00 kg) genotype respectively. The F_3 genotype was the fourth heaviest (23.98 ± 0.96 kg) at 270-days old while the BC_1 was the fourth heaviest (28.05 ± 0.82 kg) genotype at the age of 360-days. The Thai Long Tail, F_2 and Cameroon males were the last three lightest genotypes at the age of 270- and 360-days in descending order. Their respective weights were 23.68 ± 0.54, 22.32 ± 0.59 and 19.54 ± 2.02 kg at 270-days and 27.51 ± 0.57, 26.70 ± 0.61 and 25.09 ± 2.10 kg respectively (Table 4.16 and Figure 4.11).

Comparison between the female genotypes (Table 4.16 and Figure 4.11) showed that the F_2 females had the highest post weaning weights while the Cameroon had the lowest. The ranking of their 180-, 270- and 360-days weights by genotypes were the F_2, BC_2, BC_1, F_1, Thai Long Tail, F_3 and Cameroon respectively. Post-weaning weights at 180-, 270- and 360-days of the females were 19.01 ± 0.55, 18.62 ± 0.79, 18.51 ± 0.85, 18.11 ± 0.44, 18.09 ± 0.50, 17.16 ± 0.94 and 16.45 ±1.64 kg; 23.89 ± 0.59, 23.78 ± 0.85, 23.52 ± 0.91, 22.54 ± 0.47, 22.02 ± 0.54, 20.78 ± 1.00 and 19.33 ± 1.75 kg; and 28.48 ± 0.61, 28.07 ± 0.88, 28.01 ± 0.95, 26.54 ± 0.49, 25.45 ± 0.56, 24.79 ± 1.04 and 23.08 ± 1.82 kg respectively. The result also showed that only the F_2 females had higher post-weaning weights than the males of the same genotypes (Table 4.16 and Figure 4.11). Other genotypes generally showed that the males were heavier than the females at the three age groups evaluated. These differences were found to be significant (Table 4.14).

Post-weaning weights at the age of 180-, 270- and 360-days for the various genotypes were not significant. The overall means for the post weaning weights of all the genotypes under study were 19.43 ± 0.38 kg, 23.71 ± 0.43 kg and 27.69 ± 0.45 kg for the age groups of 180, 270 and 360 days respectively (Table 4.15).

The Cameroon genotype remained as the smallest genotype from birth to the age of 360 days. The results (Table 4.15 and 4.11) showed that Cameroon's body weights were of 15.46 ± 1.17, 19.43 ± 1.35 and 24.09 ± 1.41 kg at 180-, 270- and 360-days old respectively, with an increase in body weights of 3.97 kg and 4.56 kg from 180- to 270-days and 270- to 360-days old. The Cameroon sheep was the lightest among all the genotypes studied.

The BC_2 was found to be the heaviest genotype at 180-, 270- and 360-days of age, having the post weaning weights of 20.19 ± 0.58 kg, 25.19 ± 0.62 kg and 28.83 ± 0.65 kg respectively. Comparison between the heaviest and the lightest genotypes revealed that the BC_2, as the heaviest genotype was 4.73, 5.76 and 4.74 kg heavier than the Cameroon at the age of 180-, 270- and 360-days old.

The post-weaning weight of the F_1 genotype, which was the crossbred of the Cameroon and the Thai Long Tail, was found to be greater than that of the parental genotypes. Comparison between the F_1, F_2 and the F_3 genotypes showed that the F_1 was the heaviest in all the three age groups, with the 180-, 270- and 360-days post-weaning weights of 18.95 ± 0.33, 23.33 ± 0.35 and 27.79 ± 0.37 kg respectively. The F_2 genotype was the second heaviest and the F_3 genotype was the lightest amongst the three filial generations. The F_2 was 0.62 kg lighter than the F_1 but 0.19 kg heavier than the F_3 at 180-days old. At 270-days old the F_2 was 0.23 kg lighter than the F_1 but 0.72 kg heavier than the F_3 while at 360-days old the F_2 was 0.20 kg lighter than the F_1 and 0.88 kg heavier than the F_3. The least square means of the post-weaning weights at 180, 270 and 360 days of the F_1, F_2 and F_3 genotypes were 18.95 ± 0.33, 18.33 ± 0.40 and 18.14 ± 0.65 kg; 23.33 ± 0.35, 23.10 ± 0.44 and 22.38 ± 0.69 kg and 27.79 ± 0.37, 27.59 ± 0.45 and 26.71 ± 0.72 kg respectively. The result also showed that the F_1 genotype was heavier than the BC_1 at the age of 180 days while the rest of the post-weaning weights showed that the BC_1 and the BC_2 genotypes were heavier than the F_1.

The average pooled weights of the three filial generations genotypes (F_1, F_2 and F_3) at 180-, 270- and 360-days of age were 18.47 ± 0.46, 22.94 ± 0.49 and 27.36 ± 0.51 kg respectively. Simultaneously the average pooled weights of the backcrosses (BC_1 and BC_2) were 19.44 ± 0.58, 24.48 ± 0.62 and 28.45 ± 0.65 kg respectively.

4.1.4.3 Interaction effect of genotype and type of birth on post-weaning weights

Comparative performance of the singles included all the genotypes under study but comparison between the twins did not include the Cameroon because of the absence of twins in the genotype.

The results from the analysis of variance showed that the interaction effect between genotypes and the type of birth was significant and the degree of significance decreased from ($P \leq 0.001$) at 180-days to ($P \leq 0.01$) at 270-days and ($P \leq 0.05$) at 360-days old (Table 4.14). The main effect of the type of birth had a very high significant ($P \leq 0.001$) effect on the post weaning weight at 180-days but the degree of significance decreased at 270-days ($P \leq 0.05$) and became not significant at the age of 360-days. On the other hand the main effect of genotype did not show any significant difference in all the age groups studied.

Post-weaning weights of the singles at 180-, 270- and 360-days were analysed for the interaction effect with the genotypic groups. All the singles from the various genotypic groups had higher weaning weights than the twins, except that of the F_1 twins which overtook the weights of F_1 singles at the age of 270-days (24.94 ± 0.96 vs. 23.96 kg) and 360-days (30.26 ± 1.03 vs. 28.03 ± 0.36 kg) respectively (Table 4.17 and Figure 4.12).

Among the single born lambs and amongst all the genotypic groups analysed at the three age groups, the BC_2 singles had the highest post-weaning weights than the

Table 4.17 Least square means and std. errors of the post-weaning weights at the various age groups by the effects of genotypes and the type of birth

Genotypes	Least square means ± std. errors of post-weaning weights at various age groups (kg)		
	180-days	270-days	360-days
Cameroon (C)			
Single	15.97 ± 1.20^{d} (8)	19.57 ± 1.36^{e} (8)	23.42 ± 1.46 (8)
Twins	-	-	-
Thai Long Tail (TLT)			
Single	19.59 ± 0.44^{bc} (60)	23.46 ± 0.47^{c} (59)	26.55 ± 0.50 (59)
Twins	17.66 ± 0.65^{c} (29)	21.69 ± 0.69^{d} (29)	25.63 ± 0.74 (29)
F_1 (C x TLT)			
Single	20.06 ± 0.32^{b} (121)	23.96 ± 0.34^{b} (120)	28.03 ± 0.36 (120)
Twins	20.03 ± 0.90^{b} (16)	24.94 ± 0.96^{b} (16)	30.26 ± 1.03 (16)
F_2 (F_1 x F_1)			
Single	19.65 ± 0.43^{b} (62)	24.05 ± 0.46^{b} (61)	28.03 ± 0.49 (61)
Twins	15.83 ± 0.80^{d} (18)	20.93 ± 0.87^{de} (17)	26.06 ± 0.93 (17)
F_3 (F_2 x F_2)			
Single	21.28 ± 0.98^{ab} (12)	25.74 ± 1.04^{ab} (12)	29.23 ± 1.11 (12)
Twins	15.20 ± 0.94^{d} (13)	19.32 ± 1.00^{e} (13)	24.54 ± 1.07 (13)
BC_1 (F_1 (male) x TLT (female))			
Single	20.31 ± 0.64^{b} (31)	24.84 ± 0.68^{b} (31)	29.29 ± 0.73 (31)
Twins	17.03 ± 1.69^{cd} (8)	23.65 ± 1.80^{bc} (8)	24.32 ± 1.93 (8)
BC_2 (TLT (male) x F_1 (female))			
Single	22.43 ± 0.74^{a} (21)	26.73 ± 0.78^{a} (21)	30.30 ± 0.84 (21)
Twins	18.50 ± 0.94^{c} (9)	24.36 ± 1.00^{b} (9)	28.60 ± 1.07 (9)

Difference in superscripts a, b, c, d and e shows significant difference in the least square means

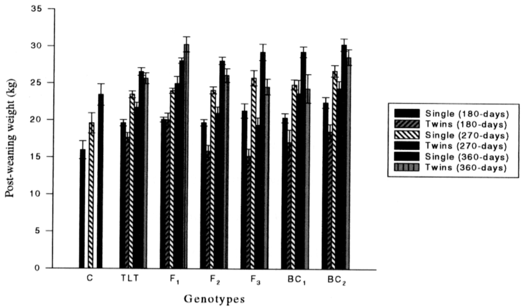

Figure 4.12 Least square means and std. errors of the post-weaning weights by the effects of genotypes and type of birth

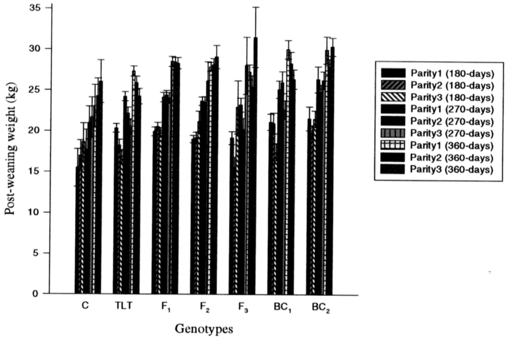

Figure 4.13 Least square means and std. errors of the post-weaning weights by the effects of genotypes and parity of birth

other genotypes under comparison with the 180-, 270- and 360-days weights of 22.43 ± 0.74, 26.73 ± 0.78 and 30.30 ± 0.84 kg respectively. The lightest singles was from the Cameroon genotype, having the post-weaning weights of 15.97 ± 1.20, 19.57 ± 1.36 and 23.42 ± 1.46 kg at the age of 180, 270 and 360 days respectively (Figure 4.12).

The F_1 twins on the other hand were the heaviest twin born lambs among the genotypes at all the three age groups (Table 4.17). At 180, 270 and 360 days of age respectively, the F_1 twins topped the other twins with the weights of 20.03 ± 0.90, 24.94 ± 0.96 and 30.26 ± 1.03 kg Simultaneously, the F_3 twins were the lightest twins at 180-days (15.20 ± 0.94 kg) and 270-days (19.32 ± 1.00 kg) while the BC_2 twins were the lightest at 360-days (24.32 ± 1.93 kg) old.

At 180-days old the ranking of the weights of the singles by genotypes, in descending order was BC_2, F_3, BC_1, F_1, F_2, Thai Long Tail and Cameroon (Table 4.17 and Figure 4.12). At 270-days the ranking was BC_2, F_3, BC_1, F_2, F_1, Thai Long Tail and Cameroon. At 360-days the ranking of the genotypes by weight was BC_2, BC_1, F_3, F_1, F_2, Thai Long Tail and Cameroon.

The ranking for the twins at 180-days weight was the F_1, BC_2, Thai Long Tail, BC_1, F_2 and F_3 (Table 4.17 and Figure 4.12). At the age of 270-days the ranking was the F_1, BC_2, BC_1, Thai Long Tail, F_2 and F_3. At 360-days, the order of ranking changed to the F_1, BC_2, F_2, Thai Long Tail, F_3 and BC_1 respectively.

The main effect of the type of birth on the post-weaning weights showed that the least square means of the weights of the singles in comparison to the twins at 180-, 270- and 360-days old were 19.62 ± 0.26 vs 17.13 ± 0.42; 23.73 ± 0.29 vs 22.00 ± 0.46 and 27.56 ± 0.30 vs 26.60 ± 0.48 kg respectively. Weight differences between the singles and the twins at 180-, 270- and 360-days old were 2.49 ($P \leq 0.001$), 1.73 ($P \leq 0.05$) and 0.96 kg respectively. Between the age of 180- to 270-days and between the age of 270- to 360-days, the weight differences for the singles and the twins were

4.11 and 3.83 kg and 4.87 and 4.60 kg respectively showing a decrease in weight gain as the age increased.

The analysis also revealed a higher number of singles in comparison to the number of twins, for the animals studied in the University of Malaya's farm (Table 4.15).

4.1.4.4 Effect of the parity of birth on post-weaning weights

The parity of birth had no significant effect on the post-weaning weights at 180-, 270- and 360-days of the genotypes. Non-significant interaction effect between the genotype and the parity of birth was also revealed by the least square analysis of variance (Table 4.14).

Least square means and standard errors of the post-weaning weights at the three age groups by their parity of birth are tabulated in Table 4.18. The third parity animals were found to have the highest weights at 180-, 270- and 360-days old followed by animals of the first and third parity respectively. Their respective weights were 19.75 ± 0.65 kg, 24.16 ± 0.69 kg and 27.96 ± 0.73 kg for the third parity, 19.51 ± 0.45 kg, 23.47 ± 0.48 kg and 27.68 ± 0.51 kg for the first and 18.77 ± 0.41 kg, 23.13 ± 0.44 kg and 26.89 ± 0.47 kg for the second parity animals (Table 4.15 and Figure 4.10).

The comparative post-weaning weights between the parity of birth by the age groups were 19.75 ± 0.65 kg, 19.51 ± 0.45 kg and 18.77 ± 0.41 kg at 180-days; 24.16 ± 0.69 kg, 23.47 ± 0.48 kg and 23.13 ± 0.44 kg at 270-days; and 27.96 ± 0.73, 27.68 ± 0.51 and 26.89 ± 0.47 kg respectively for the third, first and the second parity animals. The heaviest genotypes at the age of 180-, 270- and 360-days old was the F_3 genotype that was born at the third parity with the weights of 22.92 ± 3.25, 28.01 ± 3.50 and 31.48 ± 3.69 kg (Table 4.18) respectively.

Table 4.18 Least square means and std. errors of post-weaning weights at the various age groups by the effects of genotypes and parity of birth

Genotypes	Parity	Least square means ± std. errors of post-weaning weights at the various age groups (kg)		
		180-days	270-days	360-days
Cameroon (C)	1	15.51 ± 2.30[c] (3)	17.70 ± 2.48[d] (3)	23.03 ± 2.62[b] (3)
	2	16.98 ± 1.89[c] (2)	20.97 ± 2.03[cd] (2)	24.27 ± 2.14[b] (2)
	3	18.64 ± 2.30[b] (2)	21.64 ± 2.48[c] (2)	26.03 ± 2.61[b] (2)
Thai Long Tail (TLT)	1	20.34 ± 0.53[a] (41)	24.21 ± 0.58[a] (41)	27.29 ± 0.61[a] (41)
	2	18.25 ± 0.71[bc] (22)	22.12 ± 0.76[c] (22)	25.88 ± 0.80[b] (22)
	3	16.88 ± 0.84[c] (15)	20.52 ± 0.90[d] (15)	24.23 ± 0.96[b] (15)
F_1 (C x TLT)	1	19.94 ± 0.54[a] (37)	24.13 ± 0.58[a] (37)	28.48 ± 0.62[a] (37)
	2	20.53 ± 0.49[a] (44)	24.40 ± 0.53[a] (44)	28.41 ± 0.56[a] (44)
	3	19.79 ± 0.59[a] (31)	24.01 ± 0.65[ab] (30)	28.28 ± 0.69[a] (30)
F_2 (F_1 x F_1)	1	19.01 ± 0.47[b] (48)	23.63 ± 0.52[b] (46)	27.83 ± 0.55[a] (46)
	2	19.19 ± 0.65[a] (25)	23.48 ± 0.70[b] (25)	28.10 ± 0.74[a] (25)
	3	21.15 ± 1.25[a] (7)	26.12 ± 2.34[a] (7)	29.04 ± 1.42[a] (7)
F_3 (F_2 x F_2)	1	19.15 ± 0.79[ab] (17)	23.18 ± 0.85[b] (17)	27.19 ± 0.90[ab] (17)
	2	15.56 ± 1.23[c] (7)	20.22 ± 1.33[d] (7)	25.39 ± 1.40[b] (7)
	3	22.92 ± 3.25[a] (2)	28.01 ± 3.50[a] (2)	31.48 ± 3.69[a] (2)
BC_1 F_1 (male) x TLT (female)	1	21.11 ± 0.98[a] (11)	25.08 ± 1.06[a] (11)	29.98 ± 1.12[a] (11)
	2	20.95 ± 1.24[a] (10)	25.95 ± 1.34[a] (10)	28.27 ± 1.41[a] (10)
	3	17.43 ± 1.03[c] (7)	22.60 ± 1.11[b] (7)	26.34 ± 1.17[b] (7)
BC_2 TLT (male) x F_1 (female)	1	21.53 ± 1.46[a] (16)	26.33 ± 1.57[a] (16)	29.94 ± 1.66[a] (16)
	2	19.90 ± 0.82[a] (12)	24.81 ± 0.88[a] (12)	27.89 ± 0.93[a] (12)
	3	21.48 ± 0.98[a] (5)	26.23 ± 1.06[a] (5)	30.32 ± 1.12[a] (5)

Difference in superscripts a, b, c and d shows significant difference in the least square means

Comparison between the genotypes at 180-days old (Table 4.18 and Figure 4.13) by the first parity of birth, showed that the BC_2 crossbreds were the heaviest followed by the BC_1, Thai Long Tail, F_1, F_3, F_2 and Cameroon. Between the genotypes born as the second and third parity of birth, the ranking of their 180-days weights in descending order were BC_1 and F_3, F_1 and BC_2, BC_2 and F_2, F_2 and F_1, Thai Long Tail and Cameroon, Cameroon and Thai Long Tail, and F_3 and BC_1 respectively (Table 4.18).

The ranking for post-weaning weights at 270- and 360-days old for the genotypes born at the first parity, in descending order (Table 4.18 and Figure 4.13) were BC_2 and BC_1; BC_1 and BC_2; Thai Long Tail and F_1; F_1 and F_2; F_2 and Thai Long Tail; F_3 and F_3; and Cameroon. The ranking of the 270- and 360-days weights for the genotypes at the second parity were BC_1 and F_1; BC_2 and BC_1; F_1 and F_2; F_2 and BC_2; Thai Long Tail and Thai Long Tail; Cameroon and F_3; and F_3 and Cameroon respectively. The ranking of the 270- and 360-days weights for the genotypes at the third parity of birth were F_3; BC_2; F_2; F_1; BC_1; Thai Long Tail and Cameroon; and Cameroon and Thai Long Tail in descending order respectively.

4.1.5 Average daily weight gain (ADG) as an indicator for growth performance

4.1.5.1 Least square analysis of variance on the average daily weight gain (ADG) for growth performance

An analysis of variance of the average daily gain of the body weights between birth to the age of ninety days, 90 – 180 days, 180 – 270 days and 270 – 360 days is tabulated in Table 4.19.

Effect of the year of birth was very highly significant on the average daily gain between birth weight to 90-days weight or weaning ($P \leq 0.001$) and between the age of

90 – 180 days ($P \leq 0.001$) but not significant between 180 – 270 and 270 – 360 days of age.

Sex of the genotypes had significant ($P \leq 0.01$), effect on the average daily gain between birth to weaning (90 days old) only while the effect of the type of birth was significant on the average daily gain between birth to weaning ($P \leq 0.001$) and between 90 –180 days ($P \leq 0.05$). The parity of birth had high significant effect on the average daily gain between the age of 90 – 180 days only.

Interaction effects between genotypes and year of birth was significant for 90 – 180 ($P \leq 0.01$) and 180 – 270 ($P \leq 0.05$) days, genotypes and sex for 90 – 180 ($P \leq 0.01$) days, genotypes and the type of birth for birth to 90 days ($P \leq 0.01$). Other main effects and interaction effects did not show any significant difference on the average daily gain between birth to weaning, 90 – 180, 180 – 270 and 270 – 360 days weights.

Least square analysis of variance on the average daily gain for the growth period from birth to 360 days of age was also shown in Table 4.19. The analysis showed that the main effects of the year of birth and sex were significant ($P \leq 0.01$) while the interaction effects were significant for the genotype and sex ($P \leq 0.001$); and genotype and the type of birth ($P \leq 0.05$).

Table 4.19 also shows highly significant effects of the regression of offspring weight on ewes weight at parturition ($P \leq 0.001$) and for the regression of offspring weight on birth weight ($P \leq 0.01$) for the average daily gain from birth to 90-days. The regression effects however became non-significant for the average daily gain between 90 – 180 and between 180 – 270 days old. Low significant difference was later revealed for the regression of offspring weight on ewes weight at parturition on the average daily gain between the age of 270 – 360 days ($P \leq 0.05$).

Table 4.19 Least square analysis of variance on the average daily weight gain (ADG) for the growth performance

Source of variation	Birth – 90 days		90 – 180 days		180 – 270 days		270 – 360 days	
	df	Mean Squares	df	Mean Squares	df	Mean Squares	df	Mean Squares
+ Regression 1	1	0.00700 ***	1	0.000004	1	0.00067	1	0.00266 *
++ Regression 2	1	0.00600 ***	1	0.000052	1	0.00012	1	0.00014
Year of birth	7	0.00473 ***	7	0.00266 ***	7	0.00074	7	0.00090
Genotype	6	0.00023	6	0.00092	6	0.00044	6	0.00050
Sex	1	0.00420 **	1	0.00003	1	0.00039	1	0.00041
Type of birth	1	0.03150 ***	1	0.00280 *	1	0.00096	1	0.00033
Parity of birth	5	0.00078	5	0.00254 ***	5	0.00031	5	0.00023
Genotype x Year of birth	16	0.00076	16	0.00121 **	16	0.00093 *	16	0.00080
Genotype x Sex	6	0.00458	6	0.00183 **	6	0.00023	6	0.00078
Genotype x Type of birth	5	0.00190 **	5	0.00066	5	0.00049	5	0.00094
Genotype x Parity of birth	17	0.00026	17	0.00072	16	0.00025	16	0.00025
Error	395	0.00048	338	0.00037	335	0.00053	335	0.00058

+ Regression of offspring weight on ewes weight at parturition
++ Regression of offspring weight on birth weight

Levels of significance:
* $P \leq 0.05$
** $P \leq 0.01$
*** $P \leq 0.001$

Table 4.20 The average daily weight gain (ADG) for the growth performance by the overall effects of genotype, sex, type of birth and the parity of birth

Sources of variation	**Birth – 90 days**		**90 – 180 days**		**180 – 270 days**		**270 – 360 days**	
	N	**ADG (g)**	**N**	**ADG (g)**	**N**	**ADG (g)**	**N**	**ADG (g)**
Genotype	464	124.19 ± 5.00^{ab}	407	60.79 ± 4.00^{c}	402	47.46 ± 5.00^{abc}	402	44.30 ± 6.00^{ab}
Sex								
Male	220	125.21 ± 3.00^{a}	184	60.72 ± 3.00^{c}	81	49.37 ± 3.00^{ab}	181	46.31 ± 3.00^{ab}
Female	193	114.56 ± 3.00^{b}	179	62.53 ± 3.00^{c}	179	44.21 ± 3.00^{b}	179	41.86 ± 3.00^{b}
Type of birth								
Single	319	128.91 ± 2.00^{a}	278	61.41 ± 2.00^{c}	276	44.82 ± 2.00^{bc}	276	41.54 ± 2.00^{b}
Twins	94	97.67 ± 7.00^{c}	85	97.94 ± 8.00^{a}	84	56.92 ± 7.00^{a}	84	52.13 ± 7.00^{a}
Parity of birth								
First parity	183	124.72 ± 4.00^{a}	161	62.04 ± 4.00^{c}	159	43.85 ± 3.00^{bc}	159	46.78 ± 3.00^{ab}
Second parity	145	119.12 ± 3.00^{b}	124	57.80 ± 3.00^{c}	124	48.68 ± 3.00^{a}	124	41.65 ± 3.00^{b}
Third parity	85	117.45 ± 5.00^{b}	78	70.66 ± 5.00^{b}	77	49.11 ± 3.00^{ab}	77	42.17 ± 5.00^{b}

Difference in superscripts a, b and c within the column indicates significant differences ($P \leq 0.05$)

Presentation of the least square means in the following sections was made following the adjustments for the above significant regressions. Due to unequal subclass numbers represented in the various groups, the results of the least square means for the effect of the year of birth could not be estimated and therefore was not included.

4.1.5.2 Interaction effect between genotype and sex on ADG

The least square analysis of variance showed that the interaction effect between genotype and sex was significant on the average daily weight gain between the age of 90 to 180 days ($P \leq 0.01$), that was just after weaning to about 6 months of age (Table 4.19). The main effect of sex was significant between birth to 90 days while the effect of genotype was not significant in all the age groups studied.

Since the interaction between genotype and sex was significant ($P<0.01$) the average daily weight gain for the males and females from the various genotypic groups was presented in Table 4.21. Comparison between the genotypic groups was done using the Duncan's test and was shown in the tables given. The least square means of the average daily weight gain revealed that between birth to 90 days all the males from all the genotypes under study had significantly higher average daily weight gain than the females, however after 90 days of age the Duncan's test showed that most of the differences were not significant (Table 4.21).

The interaction effect was significant ($P \leq 0.01$) between the age of 90 – 180 days only. Females from the Cameroon, F_1, F_2 and BC_1 had higher daily weight gains than the males while between the ages of 180 to 270 days only the F_2 and BC_2 females gained more weight than the males. Most of the males between the age of 270 to 360

Table 4.21 The average daily weight gain (ADG) for the growth performance by the interaction effect of genotypes and sex

Genotypic groups	Birth – 90 days		90 – 180 days		180 – 270 days		270 – 360 days	
	N	ADG (g)	N	ADG (g)	N	ADG (g)	N	ADG (g)
Cameroon (C)								
Males	4	109.04 ± 14.00^{d}	4	47.92 ± 15.00^{e}	4	46.30 ± 14.00^{bc}	4	58.37 ± 14.00^{a}
Females	4	107.42 ± 14.00^{d}	4	56.27 ± 13.00^{e}	4	27.02 ± 12.00^{d}	4	37.11 ± 12.00^{de}
Thai Long Tail (TLT)								
Males	52	129.75 ± 4.00^{a}	38	57.89 ± 4.00^{d}	38	45.55 ± 4.00^{b}	38	42.51 ± 4.00^{c}
Females	44	120.32 ± 4.00^{b}	40	54.15 ± 4.00^{e}	40	39.98 ± 4.00^{c}	40	32.89 ± 4.00^{e}
F_1 (C x TLT)								
Males	77	132.14 ± 3.00^{a}	58	62.74 ± 3.00^{c}	57	45.81 ± 3.00^{bc}	57	52.03 ± 3.00^{a}
Females	64	119.11 ± 3.00^{b}	54	62.90 ± 4.00^{c}	54	44.92 ± 3.00^{bc}	54	40.86 ± 3.00^{cd}
F_2 (F_1 x F_1)								
Males	43	129.22 ± 4.00^{a}	41	67.16 ± 4.00^{c}	39	48.75 ± 4.00^{abc}	39	45.60 ± 4.00^{a}
Females	39	122.76 ± 4.00^{b}	39	67.93 ± 4.00^{c}	39	50.94 ± 4.00^{abc}	39	47.84 ± 4.00^{ab}
F_3 (F_2 x F_2)								
Males	14	116.50 ± 7.00^{c}	13	64.32 ± 7.00^{c}	13	53.74 ± 7.00^{a}	13	51.30 ± 7.00^{a}
Females	13	102.12 ± 8.00^{d}	12	57.65 ± 8.00^{c}	12	40.05 ± 7.00^{c}	12	44.33 ± 7.00^{bc}
BC_1 F_1 (male) x TLT (female)								
Males	15	131.30 ± 6.00^{a}	15	59.93 ± 7.00^{c}	15	52.38 ± 6.00^{a}	15	41.74 ± 6.00^{cd}
Females	13	117.15 ± 7.00^{c}	13	64.49 ± 7.00^{cd}	13	51.78 ± 7.00^{ab}	13	44.08 ± 7.00^{b}
BC_2 TLT (male) x F_1 (female)								
Males	16	130.55 ± 7.00^{a}	16	85.07 ± 7.00^{a}	16	53.10 ± 6.00^{a}	16	32.59 ± 6.00^{e}
Females	17	111.05 ± 0.07^{c}	17	74.30 ± 6.00^{b}	17	54.75 ± 6.00^{a}	17	45.89 ± 6.00^{a}

Difference in superscripts a, b and c within the column indicates significant differences ($P \leq 0.05$)

days old gained more weight than the females except the F_2, BC_1 and BC_2 males. Differences between the average daily gain of the males and females from the same genotype were mostly not significant.

Interaction effect between genotype and sex was not significant for the age group of 180 – 270 days as well as between 270 and 360 days. All the males from the various genotypic groups except the F_2 males had higher average daily weight gains than the females from the same genotypes. The overall daily weight gains for the males and females were 62.90 ± 6.00 and 57.79 ± 6.00; 68.58 ± 2.00 and 62.38 ± 2.00; 74.56 ± 1.00 and 67.47 ± 1.00; 67.35 ± 1.00 and 72.35 ± 2.00; 71.74 ± 3.00 and 61.09 ± 3.00; 71.91 ± 3.00 and 69.50 ± 3.00 and 74.84 ± 3.00 and 71.11 ± 3.00 g respectively for the Cameroon, Thai Long Tail, F_1, F_2, F_3, BC_1 and BC_2. Within the genotypes, significant differences were found between Thai Long Tail males and females ($P \leq 0.01$), F_1 males and females ($P \leq 0.01$), F_2 males and females ($P \leq 0.05$) and, F_3 males and females ($P \leq 0.01$) and BC_2 males and females. Significant differences could also be observed within the males and females from the different genotypic groups.

Amongst the males of the various genotypes, significant differences were obtained on the average daily weight gain between Thai Long Tail males and F_1 males ($P \leq 0.01$), Thai Long Tail males and BC_2 males ($P \leq 0.05$), F_1 males and F_2 males ($P \leq 0.001$) and, F_2 males and BC_2 males ($P \leq 0.05$). Comparison amongst the females from the different genotypes revealed significance differences between Cameroon females and F_2 females ($P \leq 0.01$), Cameroon females and BC_1 females ($P \leq 0.05$), Cameroon females and BC_2 females ($P \leq 0.05$), Thai Long Tail females and F_1 females ($P \leq 0.05$), Thai Long Tail females and F_2 females ($P \leq 0.001$), Thai Long Tail females and BC_1 females ($P \leq 0.05$), Thai Long Tail females and BC_2 females ($P \leq 0.01$), F_1 females and F_2 females ($P \leq 0.05$), F_1 females and F_3 females ($P \leq 0.05$), F_2 females and

F_3 females ($P \leq 0.001$), BC_1 females and F_3 females ($P \leq 0.05$) and BC_2 females and F_3 females ($P \leq 0.01$).

The overall average daily weight gain of the males and females animals from all the genotype groups was analysed into the age groups of between birth to 90-days, 90 – 180 days, 180 – 270 days and 270 – 360 days. The results in Table 4.20 showed the daily weight gains between the sexes at the five age intervals. The males were found to have significantly higher ($P \leq 0.01$) average daily weight gains than the females from birth to weaning and in all the age intervals studied except between the ages of 90 – 180 days where the females had higher daily weight gain than the males. From 90 – 180 days old, the female lambs average daily gain was 62.53 ± 3.00 g and 1.81 g higher than the males, which had the average daily gain of 60.72 ± 3.00 g.

Females had higher average daily weight gain between 90 to 180 days and slightly higher between birth to 90 days. However the males gained more in the two subsequent periods. During the period from birth to 90 days old, 180 – 270 and 270 – 360 days the males gained 11.21, 5.16 and 4.45 g higher than the females.

The overall average daily gain from birth to 360 days (Table 4.20) for all the genotypes showed that the males were significantly ($P \leq 0.01$) superior than the females in their average daily weight gain. Their average daily gain were 70.27 ± 1.00 g for the males and 65.95 ± 1.00 g for the females. The males therefore gained 4.32 g higher than the females throughout these growth periods.

It is shown in Table 4.19 that the effect of genotype was not significant for all the average daily weight gain between birth to 90, 90 – 180, 180 – 270 and 270 – 360 days. The least square means showed that the overall average daily weight gains for all the genotypes under study between birth to 90 days old, 90 – 180 days, 180 – 270 days, 270 – 360 days and from birth to 360 days were 124.19 ± 5.00, 60.79 ± 4.00, 47.46 ± 5.00 and 44.30 ± 6.00 g respectively. There was a regular decrease in the daily weight gains in subsequent periods from birth to 360 days, which was expected. It could be observed from the differences that the average daily weight gain of the animals' during the four periods studied decreased from birth to 360 days.

In general it could be observed that the BC_2 genotypes had the highest daily weight gain than the other genotypic groups except from birth to 90 days. The F_1 lambs were found to gain the most during the growth period from birth to weaning (at 90-days of age). The daily weight gain of the F_1 for the first ninety days was 127.40 ± 2.98 g. When the other genotypic groups were compared the average daily gains of all the genotypes from birth to 90-days were 127.40 ± 2.34, 127.13 ± 5.28, 126.99 ± 2.98, 126.10 ± 3.11, 119.83 ± 5.03, 109.44 ± 5.48 and 104.99 ± 10.58 g respectively for the F_1, BC_1, Thai Long Tail, F_2, BC_2, F_3 and Cameroon.

Between the age of 90 – 180 days, that was after weaning to about six months old the BC_2 lambs showed the highest average daily weight gain than the other lambs. With the average daily gain of 79.79 ± 4.77 g within the 90 days interval, the BC_2 lambs were 16.98, 17.76, 18.55, 22.38, 24.07 and 27.34 g heavier than the F_1, BC_1, F_3, F_2, Thai Long Tail and the Cameroon.

At this age group it could be observed that only the BC_2 lambs were significantly difference ($P \leq 0.05$) from the other genotypes. The rest of the genotypes were not significantly difference from each other on their daily weight gain which ranged between 52.45 ± 10.45 in the Cameroon to 62.81± 2.49 g in the F_1 lambs.

The BC_2 lambs were again shown to maintain the highest average daily gain than the other lambs between the ages of 180 – 270 days. In descending order, the average daily weight gain of these age groups were 53.92 ± 4.24, 51.97 ± 4.44, 49.99 ± 2.69, 47.24 ± 4.69, 45.34 ± 2.22, 42.62 ± 2.78 and 35.39 ± 8.92 g respectively for the BC_2, BC_1, F_2, F_3, F_1, Thai Long Tail and Cameroon. The differences of the average daily weight gain of the BC_1 and the respective genotypes in descending order were

1.95, 3.93, 6.68, 8.58, 11.30 and 18.58 g. It could be observed that during these age groups the backcross animals (BC_1 and BC_2) gained more weights than the three filial generations (F_1, F_2 and F_3) and the purebreds Cameroon hair sheep and Thai Long Tail wool sheep.

There was a change in the pattern of the average daily weight gains of the genotypic groups between the age of 270 and 360 days (Table 4.22). During this age interval, the animals of three filial generations gained more in comparison to the backcrosses and the purebred parents. Their overall average daily gains were 47.17 ± 3.43 g, 41.02 ± 4.65 g and 41.94 ± 2.62 g respectively for the three filial generations (F_1, F_2, F_3), backcrosses (BC_1, BC_2) and the purebred parents (Cameroon, Thai Long Tail). Comparisons showed that their differences from birth to 90 days were 120.98, 123.48 and 115.99 g; between 90-180 days were 60.49, 70.91 and 54.09 g, and between 180-270 days were 47.52, 52.95 and 39.01 g respectively.

The average daily weight gain between the age of 270 – 360 days, showed that the F_3 genotypes gained the most, followed by the F_2, F_1, Cameroon, BC_1, BC_2 and Thai Long Tail. Their average daily weight gains were 48.04 ± 5.02, 46.92 ± 2.88, 46.55 ± 2.38, 46.39 ± 9.55, 42.64 ± 4.76, 39.39 ± 4.53 and 37.49 ± 2.97 g respectively. The average daily gain for the F_3 genotypes during this period were 1.12, 1.49, 1.65, 5.40, 8.65 and 10.55 g higher than the F_2, F_1, Cameroon, BC_1, BC_2 and Thai Long Tail respectively.

Except for the age interval between 270 to 360 days, the Cameroon was found to have the lowest average daily weight gain amongst the genotypes. However between the age of 270 to 360 days the Cameroon had higher average daily weight gain (46.39 ± 9.55 g) than the Thai Long Tail (37.49 ± 2.97 g), BC_1 (42.64 ± 0.4.76 g) and BC_2 (39.39 ± 4.53 g). The Cameroon gained more weight than the backcrosses BC_1 and BC_2 and the purebred Thai Long Tail at the latter age of their growth period. This

Table 4.22 The average daily weight gain (ADG) for the growth performance of the various genotypic groups

Genotypic groups	Birth – 90 days		90 – 180 days		180 – 270 days		270 – 360 days	
	N	ADG (g)	N	ADG (g)	N	ADG (g)	N	ADG (g)
Cameroon (C)	8	104.99 ± 10.58[a]	8	52.45 ± 10.05[a]	8	35.39 ± 8.92[a]	8	46.39 ± 9.55[b]
Thai Long Tail (TLT)	96	126.99 ± 2.98[b]	78	55.72 ± 3.13[a]	78	42.62 ± 2.78[a]	78	37.49 ± 2.97[a]
F_1 (C x TLT)	141	127.40 ± 2.34[b]	112	62.81 ± 2.49[a]	111	45.34 ± 2.22[a]	111	46.55 ± 2.38[b]
F_2 (F_1 x F_1)	82	126.10 ± 3.11[b]	80	57.41 ± 2.99[a]	78	49.99 ± 2.69[a]	78	46.92 ± 2.88[b]
F_3 (F_2 x F_2)	27	109.44 ± 5.48[a]	26	61.24 ± 5.28[a]	26	47.24 ± 4.69[a]	26	48.04 ± 5.02[b]
BC_1 (F_1 male x TLT female)	28	127.13 ± 5.28[b]	28	62.03 ± 5.00[a]	28	51.97 ± 4.44[a]	28	42.64 ± 4.76[ab]
BC_2 (TLT male x F_1 female)	33	119.83 ± 5.03[ab]	33	79.79 ± 4.77[b]	33	53.92 ± 4.24[a]	33	39.39 ± 4.53[a]

Difference in superscripts a and b within the column indicates significant differences ($P \leq 0.05$)

phenomenon cannot be easily explained as Cameroon is assumed to be the lightest than other groups.

Generally, the Duncan's test showed that in most cases the genotypes were not significantly different from one another on their average daily weight gain. This was revealed as not significant by the least square analysis of variance for the effect of genotype.

4.1.5.3 Interaction effect between genotype and type of birth on ADG

The results from the single lambs and lambs born as twins from all the genotypes except the Cameroon were included in this analysis. There were no twins in the Cameroon genotype, therefore they were not represented.

The results from the least square analysis of variance in Table 4.19 showed that the interaction effect between the genotype and the type of birth were significant during the period between birth to 90 days ($P \leq 0.01$). The main effect of the type of birth on the average daily weight gain were significant between birth to 90 days ($P \leq 0.001$) and 90 – 180 days ($P \leq 0.05$) while the genotype had no significant effect in all the ADG groups.

The least square means of the average daily gains for the interaction effect of the genotypes and the type of birth was tabulated in Table 4.23. There was no twin birth among the Cameroon progeny. It could be seen that the highest daily gain for the Cameroon lambs was achieved between birth to 90 days old (109.37 ± 9.00 g), followed by the gains between the age of 90 – 180 days (51.88 ± 10.00 g), 270- 360 days (45.84 ± 9.00 g) and 180 – 270 days (34.83 ± 9.00 g). The gain became less until the period between 180 – 270 days but increased between the age of 270 – 360 days. This trend could also be observed for the daily weight gain of the F_1

Table 4.23 The average daily weight gain (ADG) for the growth performance by the interaction effect of genotypes and the type of birth

Genotypic groups	Birth – 90 days		90 – 180 days		180 – 270 days		270 – 360 days	
	N	ADG (g)	N	ADG (g)	N	ADG (g)	N	ADG (g)
Cameroon (C)								
Single	8	109.37 ± 9.00^{d}	8	51.88 ± 10.00^{d}	8	34.83 ± 9.00^{e}	8	45.84 ± 9.00^{b}
Twins	-	-	-	-	-	-	-	-
Thai Long Tail (TLT)								
Single	69	135.42 ± 3.00^{a}	55	54.63 ± 4.00^{d}	55	41.04 ± 3.00^{de}	55	33.97 ± 3.00^{c}
Twins	27	108.92 ± 4.00^{d}	23	55.59 ± 5.00^{d}	23	43.02 ± 5.00^{d}	23	43.03 ± 5.00^{b}
F_1 (C x TLT)								
Single	123	128.65 ± 2.00^{c}	98	59.88 ± 3.00^{c}	97	43.86 ± 2.00^{d}	97	44.67 ± 3.00^{b}
Twins	18	108.78 ± 6.00^{d}	14	83.03 ± 7.00^{a}	14	55.00 ± 6.00^{b}	14	59.14 ± 7.00^{a}
F_2 (F_1 x F_1)								
Single	64	132.67 ± 3.00^{a}	62	58.14 ± 3.00^{c}	61	48.77 ± 3.00^{c}	61	44.74 ± 3.00^{b}
Twins	18	93.88 ± 6.00^{e}	18	57.10 ± 7.00^{c}	17	57.79 ± 6.00^{b}	17	57.47 ± 6.00^{a}
F_3 (F_2 x F_2)								
Single	12	130.93 ± 7.00^{b}	12	68.75 ± 8.00^{c}	12	50.00 ± 7.00^{c}	12	36.83 ± 7.00^{b}
Twins	14	88.14 ± 7.00^{e}	13	55.09 ± 7.00^{d}	13	45.71 ± 7.00^{cd}	13	59.23 ± 7.00^{a}
BC_1 (F_1 male x TLT female)								
Single	24	130.19 ± 5.00^{bc}	24	60.64 ± 5.00^{c}	24	47.92 ± 5.00^{c}	24	48.09 ± 5.00^{b}
Twins	4	97.54 ± 13.00^{e}	4	69.10 ± 13.00^{c}	4	73.88 ± 12.00^{a}	4	48.29 ± 12.00^{b}
BC_2 (TLT male x F_1 female)								
Single	20	135.14 ± 6.00^{ab}	20	75.90 ± 6.00^{b}	20	47.42 ± 5.00^{c}	20	36.64 ± 6.00^{b}
Twins	13	88.69 ± 7.00^{e}	13	87.73 ± 8.00^{a}	13	66.10 ± 7.00^{a}	13	45.59 ± 7.00^{b}

Difference in superscripts a, b and c within the column indicates significant differences ($P \leq 0.05$)

(singles and twins), F_3 twins and BC_1 singles.

Comparison between the singles and the twins within the same genotype revealed significant differences in most of the genotypes although some genotypes showed non-significant difference. There were variation between the weights of the singles and the twins between and within the genotypes.

Between birth to weaning (90 days), lambs that were born as single lambs from all the genotypes had greater average daily gain than the twins (Table 4.20). Comparison between the single lambs from the various genotypic groups showed that the Thai Long Tail singles gained the most weight than the BC_2, F_2, F_3, BC_1, F_1 and Cameroon. The average daily weight gain of the Cameroon singles were significantly ($P \leq 0.05$) lower than the Thai Long Tail, F_1, F_2, BC_1 and BC_2.

On the other hand, comparison between the twins from all the genotypes showed that the twin lambs from the Thai Long Tail genotypes had the highest daily weight gain (108.92 ± 4.00 g) followed by that of F_1 (108.78 ± 6.00 g), BC_1 (97.54 ± 13.00 g), F_2 (93.88 ± 6.00 g), BC_2 (88.69 ± 7.00 g) and F_3 (88.14 ± 7.00 g) twins respectively. Significant differences between the twins from within the genotypes were observed and shown in the table.

In general, it was also revealed in Table 4.20 that there was a higher frequency on the incidence of the twins gaining more weight or had higher average daily weight gain than the single lambs (90 – 180 days, 180 – 270 days and 270 – 360 days) except between birth to 90 days where the singles had higher ADG than the twins.

The average daily weight gain of the singles and twin lambs between birth – 90 days, 90 – 180 days, 180 – 270 days and 270 – 360 days was evaluated. The average daily weight gain of the single lambs were significantly higher than the twins between birth to 90 days ($P \leq 0.001$) only, but between the age of 90 – 180 days the average daily weight gain of the twins was significantly higher ($P \leq 0.05$) than the single lambs. The average daily gain of the single and twin lambs during these two age groups were 128.91 ± 2.00 g vs 97.67 ± 7.00 g and 61.41 ± 2.00 g vs 67.94 ± 8.00 g respectively.

Duncan's test showed that the effect of the type of birth was significant in all the age groups however the analysis of variance only showed significant differences on the ADG for birth – 90 days ($P \leq 0.001$), 90 – 180 ($P \leq 0.05$) days. This could probably due to the difference in sub-class numbers within the genotypes.

The ratio of the single and twin lambs was about 3:1 in all the age groups (Table 4.20) under study. The large variation in the number of observation probably had contributed to the differences in the average daily weight gains of the animals when they were compared by their type of birth.

4.1.5.4 Effect of the parity of birth on ADG

The parity of birth was found to have a very high significant ($P \leq 0.01$) effect on the average daily weight gain of the genotypes between the age of 90 – 180 days only. The main effect of the parity of birth was not significant between birth to 90 days, 180 –270 days and 270 – 360 days. The least square analysis of variance also revealed that the interaction effect between the genotypes and the parity of birth was not significant for all the age groups under study. The Duncan's test showed some significant differences between the parity groups within and between the genotypes but mostly the differences were not significant.

The least square means (Table 4.20) showed that the highest average daily weight gained was achieved during the period from birth to 90 days where the first parity lambs gained 124.72 ± 4.00 g, in comparison to the second and the third parity lambs which gained 119.12 ± 3.00 g and 117.45 ± 5.00 g respectively.

The weight gains of the first, second and the third parity lambs generally decreased as the lambs became older except for the first parity lambs which gained more between the age of 270 –360 days (46.78 ± 3.00 g) when compared to their weight gain between the age of 180 – 270 days (43.85 ± 3.00 g)

Within the age groups, the first parity lambs had the highest daily weight gain between birth to 90 days (124.72 ± 4.00 g) and between the age of 270 – 360 days (46.78 ± 3.00 g). The third parity lambs gained the highest weight between the age of 90 –180 days (70.66 ± 5.00 g) and 180 –270 days (49.11 ± 5.00 g). While the second parity lambs gained either the lowest or the intermediate between their first and third parity counterparts within the same age groups.

There was no significant difference on the average daily weight gain due to the interaction between genotype and the parity of birth. The least square means of the daily weight gains for the genotypes by the effect of the parity of birth are presented in Table 4.24.

The result showed that there was no consistency on the effect of parity on the average daily gain during the various age groups and within the genotypes. There were ten incidences where the first parity lambs had the highest daily weight gained when compared to the second and the third parity lambs, while both the second and the third parity lambs showed nine incidences each for gaining the highest weight gain than their counterparts. Similar trend could be observed for the overall weight gain from birth to 360 days.

It could be seen in Table 4.24 that between birth to 90 days, 90 –180 days, 180 –270 and 270 – 360 days, the highest average daily weight gain were found for the first parity lambs from BC_2 genotype (139.37 ± 8.00 g), third parity lambs from the F_3

Table 4.24 The average daily weight gain (ADG) for the growth performance by the interaction effect of genotypes and the parity of birth

Genotypic groups	Birth – 90 days		90 – 180 days		180 – 270 days		270 – 360 days	
	N	ADG (g)	N	ADG (g)	N	ADG (g)	N	ADG (g)
Cameroon (C)								
First parity	3	95.53 ± 19.00^{d}	3	45.93 ± 18.00^{de}	3	24.21 ± 17.00^{b}	3	59.23 ± 18.00^{a}
Second parity	3	113.93 ± 16.00^{c}	3	44.17 ± 15.00^{de}	3	44.06 ± 14.00^{a}	3	36.66 ± 15.00^{b}
Third parity	2	104.25 ± 19.00^{cd}	2	42.02 ± 18.00^{e}	2	33.21 ± 17.00^{ab}	2	48.81 ± 18.00^{ab}
Thai Long Tail (TLT)								
First parity	54	138.18 ± 4.00^{a}	41	59.49 ± 4.00^{c}	41	42.89 ± 4.00^{a}	41	34.22 ± 4.00^{b}
Second parity	26	119.76 ± 5.00^{c}	22	52.44 ± 6.00^{c}	22	43.10 ± 5.00^{a}	22	41.60 ± 5.00^{ab}
Third parity	16	104.88 ± 7.00^{cd}	15	50.15 ± 7.00^{cd}	15	40.63 ± 6.00^{a}	15	41.08 ± 6.00^{b}
F_1 (C x TLT)								
First parity	45	124.35 ± 4.00^{c}	37	67.31 ± 4.00^{b}	37	46.55 ± 4.00^{a}	37	48.29 ± 4.00^{a}
Second parity	59	128.81 ± 4.00^{bc}	44	63.81 ± 4.00^{b}	44	43.24 ± 4.00^{a}	44	44.46 ± 4.00^{a}
Third parity	37	130.37 ± 4.00^{b}	31	$55\ 91 \pm 5.00^{c}$	30	46.93 ± 4.00^{a}	30	47.43 ± 5.00^{a}
F_2 (F_1 x F_1)								
First parity	49	127.28 ± 4.00^{b}	48	54.32 ± 4.00^{d}	46	50.50 ± 4.00^{a}	46	46.64 ± 4.00^{a}
Second parity	26	126.72 ± 5.00^{b}	25	56.77 ± 5.00^{c}	25	47.67 ± 5.00^{a}	25	51.42 ± 5.00^{a}
Third parity	7	121.72 ± 10.00^{c}	7	82.22 ± 10.00^{a}	7	55.56 ± 9.00^{a}	7	32.51 ± 10.00^{b}
F_3 (F_2 x F_2)								
First parity	17	113.02 ± 6.00^{c}	17	68.63 ± 6.00^{b}	17	44.82 ± 6.00^{a}	17	44.64 ± 6.00^{a}
Second parity	8	101.08 ± 10.00^{c}	7	37.97 ± 10.00^{e}	7	51.93 ± 9.00^{a}	7	57.50 ± 9.00^{a}
Third parity	8	125.13 ± 27.00^{bc}	2	99.49 ± 25.00^{a}	2	56.70 ± 24.00^{a}	2	38.40 ± 25.00^{ab}

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

Table 4.24 continued

Genotypic groups	Birth – 90 days		90 – 180 days		180 – 270 days		270 – 360 days	
	N	ADG (g)	N	ADG (g)	N	ADG (g)	N	ADG (g)
BC_1 (F_1 male x TLT female)								
First parity	11	135.33 ± 8.00^{a}	11	69.17 ± 8.00^{a}	11	44.32 ± 7.00^{b}	11	54.32 ± 8.00^{a}
Second parity	7	128.71 ± 8.00^{ab}	7	73.55 ± 8.00^{a}	7	55.92 ± 9.00^{a}	7	25.74 ± 8.00^{c}
Third parity	10	117.47 ± 9.00^{b}	10	45.73 ± 8.00^{b}	10	57.59 ± 7.00^{a}	10	41.49 ± 8.00^{a}
BC_2 (TLT male x F_1 female)								
First parity	5	139.37 ± 8.00^{a}	5	69.43 ± 8.00^{a}	5	53.64 ± 8.00^{a}	5	40.13 ± 8.00^{b}
Second parity	16	114.85 ± 7.00^{b}	16	75.88 ± 6.00^{a}	16	54.82 ± 6.00^{a}	16	34.20 ± 6.00^{b}
Third parity	12	118.35 ± 8.00^{b}	12	68.63 ± 6.00^{a}	12	53.16 ± 7.00^{a}	12	45.49 ± 8.00^{ab}

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

genotype (99.49 ± 25.00 g), third parity lambs from the BC_1 genotype (57.59 ± 7.00 g) and the first parity lambs from the Cameroon genotype (59.23 ± 18.00 g) respectively. The average daily weight gain from birth to 360 days showed that the lambs from the third parity of the F_3 genotype had the highest daily gain while the second parity lambs from the Cameroon genotype had the lowest. Their weight gain were 79.62 ± 10.00 g and 59.87 ± 15.00 g respectively.

In general, variation in the average daily weight gains between and within the genotypes and the type of birth could be observed and the significance differences by the Duncan's test were not shown by the analysis of variance. This could also be attributed to the unequal sub-class numbers when the least square analysis of variance was done to estimate the least square means of the average daily weight gain.

4.1.6 Lamb mortality

The results for lamb mortality in each genotype from 1990 to 1997 were tabulated based on natural death and diseases only. Other causes of mortality such as snake bite, dog bite, injuries, slaughtering for experimental purposes were not included.

Number of lamb mortality in each genotypic group from the year of 1990 to 1997, number of lamb mortality by the age groups and year of birth and number of lamb mortality by genotypes and the age groups are tabulated in Appendix 3, Table 4.25 and Table 4.26.

The results showed that the number of lamb mortality for each group was very low. Throughout the 1990 to 1997 there were only 24 mortalities recorded as a result of natural death between the day of birth (day 1) and day 360.

Table 4.25 Number of lamb mortality by the age groups and the year of birth

Year of birth \ Age (days)	1	2-90	91-180	181-270	271-360	TOTAL
90	0	0	0	0	0	**0**
91	0	0	0	0	0	**0**
92	0	1	2	0	0	**3**
93	0	1	0	0	1	**2**
94	1	1	0	0	0	**2**
95	5	0	0	0	0	**5**
96	1	1	3	2	0	**7**
97	0	1	2	2	0	**5**
TOTAL	**7**	**5**	**7**	**4**	**1**	**24**

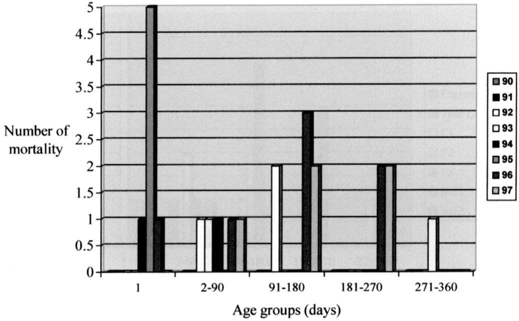

Figure 4.14 Number of lamb mortality by the age groups and the year of birth

Table 4.26 Number of lamb mortality by genotypes and the age groups

Age groups (days) / Genotypes	1	2-90	91-180	181-270	271-360	TOTAL
Cameroon (C)	0	0	0	0	0	**0**
Thai Long Tail (TLT)	0	1	0	0	0	**1**
$\mathbf{F_1}$ (C x TLT)	0	0	1	0	1	**2**
$\mathbf{F_2}$ (F_1 x F_1)	5	2	2	1	0	**10**
F3 (F_2 x F_2)	1	1	4	3	0	**9**
$\mathbf{BC_1}$ (F_1 male x TLT female)	0	0	0	0	0	**0**
$\mathbf{BC_2}$ (TLT male x F_1 female)	1	1	0	0	0	**2**
TOTAL	**7**	**5**	**7**	**4**	**1**	**24**

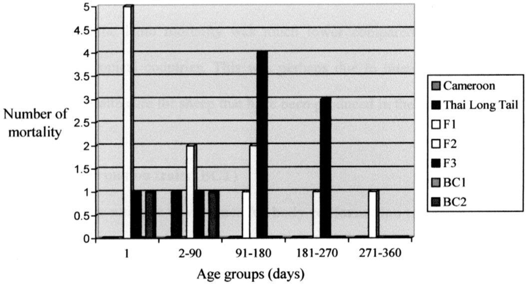

Figure 4.15 Number of lamb mortality by genotypes and the age groups

Appendix 3 showed that no mortality was recorded during 1990 – 1991, followed by 3, 2, 2, 5, 7 and 5 mortalities in 1992, 1993, 1994, 1995, 1996 and 1997 respectively. This is due to increasing numbers of sheep in subsequent years.

When the mortality was classified into various age groups (Table 4.25 and Figure 4.14), it showed that from 1990 to 1997 only seven lambs died on the day of birth, 5 lamb mortalities during pre-weaning, 7 mortalities between the age of 91 – 180 days, 4 deaths between the age of 181 – 270 and only 1 between the age of 271 – 360 days.

Comparison between the genotypes (Table 4.26 and Figure 4.15) revealed that there was no mortality recorded for the Cameroon and BC1 genotypes from 1990 – 1997, 1 for Thai Long Tail (1993 (1)), 2 from the F_1 (1992 (1) and 1993 (1)), 10 F_2 lambs (1992 (2), 1994 (2), 1995 (4), 1996 (2)), 9 F_3 lambs (1996 (5), 1997 (4)) and 2 from the BC_2 (1995 (1), 1997 (1)) genotypes respectively.

In general the lamb mortality was much lower compared to other studies reported earlier in tropical countries. This was perhaps due to intensive management system and proper health care for sheep that have been produced in the farm.

4.2 Body conformation traits (BCT)

4.2.1 Least square analysis of variance for body conformation traits (BCT) at the different age groups

Least square analysis of variance for the effect of genotypes, sex, type of birth and the interaction effect of genotype and sex on height at wither, body length, heart girth and back girth at the age of 90, 180, 270 and 360 days was performed and tabulated. The effects of the interaction between genotype and the type of birth, parity of birth and its interaction with genotype were not included in this thesis because their

Table 4.27 Least square analysis of variance for body conformation traits at the age of 90-days and 180-days

Sources of Variations	d.f	Height at Wither	Body Length	Heart Girth	Back Girth
		Mean Squares			
At 90-days old					
+ **Regression**	1	627.39***	1023.25***	3729.79***	4492.34***
Genotype	6	43.98***	111.10***	61.16***	192.46***
Sex	1	54.03**	0.78	6.94	6.22
Type of birth	1	0.01	8.03	27.32	0.06
Genotype x Sex	6	11.52	6.99	8.83	36.86
Error	382	7.97	13.89	11.71	34.00
At 180-days old					
+ **Regression**	1	1084.69***	1587.52***	2553.33***	2540.41***
Genotype	6	46.05***	54.20**	36.69**	174.35***
Sex	1	105.65**	1.59	8.99	59.01
Type of birth	1	18.75	5.18	0.70	6.29
Genotype x Sex	6	13.00	7.48	13.44	55.17
Error	290	11.83	18.16	20.18	40.19

\+ Regression of the body conformation traits on the weights of the genotypes at the age of 180-days old

Level of significance: * $P \leq 0.05$
** $P \leq 0.01$
*** $P \leq 0.001$

Table 4.28 Least square analysis of variance for body conformation traits at the age of 270-days and 360-days

Sources of Variations	d.f	Height at Wither	Body Length	Heart Girth	Back Girth
		Mean Squares			
At 270-days					
+ **Regression**	1	1105.89***	2304.93***	3132.72***	3979.02***
Genotype	6	97.93***	193.32***	86.63***	193.56***
Sex	1	64.15*	0.77	19.41	73.62
Type of birth	1	5.74	4.02	0.47	4.99
Genotype x Sex	6	5.13	34.65	40.58	94.20
Error	314	15.23	23.14	19.43	38.18
At 360-days old					
+ **Regression**	1	676.23***	1542.64***	2393.11***	3973.97***
Genotype	6	163.21***	196.41***	125.50***	150.10**
Sex	1	73.90	9.76	63.68	42.79
Type of birth	1	1.39	65.17	49.87	59.14
Genotype x Sex	6	11.37	6.33	43.27	114.29
Error	288	21.80	27.53	22.77	44.14

\+ Regression of the body conformation traits on the weights of the genotypes at the age of 270-days and 360-days old

Level of significance: * $P \leq 0.05$
** $P \leq 0.01$
*** $P \leq 0.001$

effects were not significant. Some of the least square means could not be estimated due to small data represented in the different sub-classes. Therefore this study was limited to the main effects related to the body conformation traits only.

Least square analysis of variance on body conformation traits for the effect of genotypes, sex, type of birth and the interaction effect of genotype and sex at the age of 90, 180, 270 and 360 days was tabulated in Table 4.27 and Table 4.28. The results revealed that genotype had highly significant ($P \leq 0.001$) effect on the height at wither, body length, heart girth and back girth of the lambs when they were of 90, 180, 270 and 360-days old respectively.

The effect of sex was significant for the height at wither only and at the age of 90-days ($P \leq 0.01$), 180-days ($P \leq 0.01$) and 270-days ($P \leq 0.01$). Sex of the lambs had no significant effect on the height at wither at the age of 360 days as well as on the body length, heart girth, back girth and the interaction effect between genotype and sex at the age of 90, 180, 270 and 360 days.

The type of birth had also no significant effect ($P>0.05$) on all the body conformation traits at all the age groups studied. Due to the non-significant effect the analysis of variance on the interaction effect between genotype and the type of birth was not performed.

4.2.2 Effect of genotypes on BCT

The least square means of the body conformation traits of the various genotypes at 90, 180, 270 and 360 days were tabulated in Table 4.29 and Table 4.30. Significance differences ($P \leq 0.05$) within the column were tested using the Duncan's test of significance and denoted by the difference in the superscripts shown by the alphabets. Comparative development of the height at wither, body length, heart girth and back girth for all the genotypes were tabulated in Table 4.31 to Table 4.34.

At 90-days of age, the Thai Long Tail lambs were found to have the highest height at wither followed by the BC_1, BC_2, F_1, F_2, F_3 and Cameroon. Their heights were 49.77 ± 0.32, 49.25 ± 0.52, 49.11 ± 0.58, 48.65 ± 0.27, 47.54 ± 0.36, 47.14 ± 0.62 and 47.05 ± 1.04 cm respectively.

The length of the body of the F_3 (50.93 ± 0.82 cm) lambs was the longest followed by the Thai Long Tail (49.92 ± 0.42 cm), F_1 (47.87 ± 0.36 cm), BC_1 (47.41 ± 0.69 cm), BC_2 (47.06 ± 0.77 cm), F_2 (46.60 ± 0.48 cm) and Cameroon (45.49 ± 1.37 cm) respectively.

The circumference of the heart girth and the back girth of the genotypes in descending order were 59.40 ± 0.63 cm (BC_1) and 61.58 ± 1.07 cm (BC_1); 56.90 ± 0.33 cm (F_1) and 61.21 ± 1.29 cm (F_3); 56.46 ± 0.39 cm (Thai Long Tail) and 59.01 ± 0.56 cm (F_1); 56.39 ± 0.44 cm (F_2) and 57.76 ± 0.75 cm (F_2); 56.33 ± 0.75 cm (F_3) and 56.47 ± 1.20 cm (BC_2); 55.75 ± 0.70 cm (BC_2) and 56.03 ± 0.66 cm (Thai Long Tail); and 53.26 ± 1.26 cm (Cameroon) and 55.80 ± 2.15 cm (Cameroon) respectively. The BC_1 and the Cameroon genotypes had lambs with the biggest and the smallest measurements for the heart girth and the back girth respectively.

At the age of 180-days (Table 4.27), the effect of genotype was very significant but within the genotypes there could be observed non-significance differences within the genotypic groups. The Thai Long Tail (55.40 ± 0.49 cm) still had the highest height at wither followed by the BC_2 (54.94 ± 0.71 cm), F_2 (53.14 ± 0.44 cm), F_1 (53.07 ± 0.42 cm), Cameroon (53.01 ± 1.95 cm), BC_1 (52.96 ± 0.65 cm) and F_3 (52.33 ± 0.99 cm) respectively.

Table 4.29 Least square means and std. errors of the body conformation traits of the genotypes at the age of 90-days and 180-days

Genotypes	N	Height at Wither (cm)	Body Length (cm)	Heart Girth (cm)	Back Girth (cm)
At 90-days					
Cameroon	8	47.05 ± 1.04^{c}	45.49 ± 1.37^{c}	53.26 ± 1.26^{d}	55.80 ± 2.15^{c}
Thai Long Tail	85	49.77 ± 0.32^{a}	49.92 ± 0.42^{a}	56.46 ± 0.39^{b}	56.03 ± 0.66^{c}
F_1	163	48.65 ± 0.27^{b}	47.87 ± 0.36^{b}	56.90 ± 0.33^{b}	59.01 ± 0.56^{b}
F_2	76	47.54 ± 0.36^{c}	46.60 ± 0.48^{c}	56.39 ± 0.44^{b}	57.76 ± 0.75^{b}
F_3	21	47.14 ± 0.62^{c}	50.93 ± 0.82^{a}	56.33 ± 0.75^{b}	61.21 ± 1.29^{a}
BC_1	33	49.25 ± 0.52^{a}	47.41 ± 0.69^{b}	59.40 ± 0.63^{a}	61.58 ± 1.07^{a}
BC_2	25	49.11 ± 0.58^{a}	47.06 ± 0.77^{b}	55.75 ± 0.70^{c}	56.47 ± 1.20^{c}
At 180-days					
Cameroon	8	53.01 ± 1.65^{b}	49.88 ± 2.42^{c}	60.73 ± 2.55^{c}	67.64 ± 3.60^{b}
Thai Long Tail	57	55.40 ± 0.49^{a}	54.96 ± 0.61^{a}	63.54 ± 0.64^{b}	67.47 ± 0.90^{b}
F_1	114	53.07 ± 0.42^{b}	52.50 ± 0.52^{b}	65.28 ± 0.55^{a}	70.66 ± 0.77^{a}
F_2	76	53.14 ± 0.44^{b}	52.91 ± 0.54^{b}	64.06 ± 0.57^{b}	67.27 ± 0.83^{b}
F_3	13	52.33 ± 0.99^{b}	53.02 ± 1.22^{a}	63.65 ± 1.29^{b}	67.10 ± 1.82^{b}
BC_1	32	52.96 ± 0.65^{b}	53.80 ± 0.81^{a}	65.73 ± 0.85^{a}	71.99 ± 1.20^{a}
BC_2	26	54.94 ± 0.71^{a}	55.14 ± 0.87^{a}	65.02 ± 0.92^{a}	71.67 ± 1.30^{a}

Difference in superscripts a, b and c within the column indicates significant differences ($P \leq 0.05$)

F_1 = Cameroon x Thai Long Tail
F_2 = F_1 x F_1
F_3 = F_2 x F_2
BC_1 = F_1 (male) x Thai Long Tail (female)
BC_2 = Thai Long Tail (male) x F_1 (female)

Table 4.30 Least square means and std. errors of the body conformation traits of the genotypes at the age of 270-days and 360-days

Genotypes	N	Height at Wither (cm)	Body Length (cm)	Heart Girth (cm)	Back Girth (cm)
At 270-days					
Cameroon	8	53.01 ± 1.64^{d}	51.28 ± 2.03^{d}	64.58 ± 1.86^{c}	71.06 ± 2.60^{c}
Thai Long Tail	75	58.44 ± 0.46^{a}	59.95 ± 0.57^{b}	69.90 ± 0.52^{b}	73.22 ± 0.73^{c}
F_1	130	56.26 ± 0.41^{b}	56.42 ± 0.50^{c}	69.74 ± 0.46^{b}	74.35 ± 0.64^{b}
F_2	69	55.60 ± 0.50^{c}	56.71 ± 0.62^{c}	69.14 ± 0.57^{b}	72.05 ± 0.80^{c}
F_3	12	58.02 ± 1.20^{a}	59.34 ± 1.48^{b}	68.34 ± 1.35^{b}	72.90 ± 1.89^{c}
BC_1	29	57.32 ± 0.75^{b}	56.79 ± 0.93^{c}	71.70 ± 0.85^{a}	75.88 ± 1.20^{b}
BC_2	19	59.65 ± 0.95^{a}	61.89 ± 1.17^{a}	73.45 ± 1.07^{a}	80.53 ± 1.51^{a}
At 360-days					
Cameroon	8	55.39 ± 1.84^{d}	56.20 ± 2.07^{d}	69.61 ± 1.89^{d}	74.35 ± 2.63^{c}
Thai Long Tail	40	60.65 ± 0.75^{b}	61.01 ± 0.84^{b}	77.04 ± 0.77^{a}	80.27 ± 1.07^{a}
F_1	124	58.29 ± 0.50^{c}	59.46 ± 0.56^{c}	75.04 ± 0.51^{b}	79.66 ± 0.71^{b}
F_2	70	59.77 ± 0.59^{b}	59.28 ± 0.66^{c}	72.95 ± 0.60^{c}	76.61 ± 0.84^{c}
F_3	13	61.46 ± 1.42^{b}	64.71 ± 1.59^{a}	73.28 ± 1.45^{b}	77.18 ± 2.02^{b}
BC_1	32	60.31 ± 0.87^{b}	59.37 ± 0.98^{c}	76.02 ± 0.89^{a}	79.52 ± 1.24^{b}
BC_2	23	64.92 ± 0.99^{a}	65.98 ± 1.12^{a}	76.57 ± 1.02^{a}	82.07 ± 1.42^{a}

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

F_1 = Cameroon x Thai Long Tail
F_2 = F_1 x F_1
F_3 = F_2 x F_2
BC_1 = F_1 (male) x Thai Long Tail (female)
BC_2 = Thai Long Tail (male) x F_1 (female)

The BC_2 genotype had the longest body length (55.14 ± 0.87 cm) at the age of 180 days old followed by the Thai Long Tail (54.96 ± 0.61 cm), BC_1 (53.80 ± 0.81 cm), F_3 (53.02 ± 1.22 cm), F_2 (52.91 ± 0.54 cm), F_1 (52.50 ± 0.52 cm) and Cameroon (49.88 ± 2.42 cm).

The BC_1, F_1, BC_2, F_2, F_3, Thai Long Tail and Cameroon had the measurements for the heart girth of 65.73 ± 0.85, 65.28 ± 0.55, 65.02 ± 0.92, 64.06 ± 0.57, 63.65 ± 1.29, 63.54 ± 0.64 and 60.73 ± 2.55 cm respectively. The measurements of the back girth of the genotypes at 180-days of age were 71.99 ± 1.20, 71.67 ± 1.30, 70.66 ± 0.77, 67.64 ± 3.60, 67.47 ± 0.90, 67.27 ± 0.80 and 67.10 ± 1.82 cm for the BC_1, BC_2, F_1, Cameroon, Thai Long Tail, F_2 and F_3, in descending order respectively.

BC_2 genotype was found to be the tallest by the height at wither, at the age of 270-days old (Table 4.27), with the height of 59.65 ± 0.95 cm The second tallest genotype was the Thai Long Tail followed by the F_3, BC_1, F_1, F_2 and Cameroon, with the heights of 58.45 ± 0.46, 58.02 ± 1.20, 57.32 ± 0.75, 56.26 ± 0.41, 55.60 ± 0.50 and 53.01 ± 1.64 cm respectively.

The BC_2 was also the longest genotype at this age with the body length of 61.89 ± 1.17 cm In descending order the genotypes that had their length shorter than the BC_2 were the Thai Long Tail (59.95 ± 0.57 cm), F_3 (59.34 ± 1.48 cm), BC_1 (56.79 ± 0.93 cm), F_2 (56.71 ± 0.62 cm), F_1 (56.42 ± 0.50 cm) and Cameroon (51.28 ± 2.03 cm).

The least square means of the heart girth and the back girth at 270 days showed that the genotypes with the highest and the lowest measurement for the traits in descending order were the BC_2 (73.45 ± 1.07 cm), BC_1 (71.70 ± 0.85 cm), Thai Long Tail (69.90 ± 0.52 cm), F_1 (69.74 ± 0.46 cm), F_2 (69.14 ± 0.57 cm), F_3 (68.34 ± 1.35 cm) and Cameroon (64.58 ± 1.86 cm) for the heart girth; while for the back girth the order was by the BC_2 (80.53 ± 1.51 cm), BC_1 (75.88 ± 1.20 cm), F_1 (74.35 ± 0.64 cm), Thai

Long Tail (73.22 ± 0.73 cm), F_3 (72.90 ± 1.90 cm), F_2 (72.05 ± 0.80 cm) and Cameroon (71.06 ± 2.60 cm) respectively.

At the age of 360 days old (Table 4.30), it was shown that the BC_2 genotype had the highest least square means for the height at wither followed by the F_3, Thai Long Tail, BC_1, F_2, F_1 and Cameroon. Their respective heights in descending order were 64.92 ± 1.00, 61.46 ± 1.42, 60.65 ± 0.75, 60.31 ± 0.87, 59.77 ± 0.59, 58.29 ± 0.50 and 55.39 ± 1.84 cm.

The body length of the BC_2 genotype remained as the longest (65.98 ±1.12 cm) while the second was the F_3 (64.71 ± 1.59 cm) followed by the Thai Long Tail (61.01 ± 0.85 cm), F_1 (59.46 ± 0.56 cm), BC_1 (59.37 ± 0.98 cm), F_2 (59.28 ± 0.66 cm) and Cameroon (56.20 ± 2.07 cm).

The heart girth of the genotypes at 360-days of age in descending order was 77.04 ± 0.77 cm (Thai Long Tail), 76.57 ± 1.02 cm (BC_2), 76.02 ± 0.89 cm (BC_1), 75.04 ± 0.51 cm (F_1), 73.28 ± 1.45 cm (F_3), 72.95 ± 0.60 cm(F_2) and 69.61 ± 1.86 cm (Cameroon) respectively. The BC_2 genotypes again had the biggest back girth measurement in comparison to the Thai Long Tail, F_1, BC_1, F_3, F_2 and Cameroon. In descending order the least square means of their back girth were 82.07 ± 1.42, 80.27 ± 1.07, 79.66 ± 0.71, 79.52 ± 1.24, 77.18 ± 2.02, 76.61 ± 0.84 and 74.35 ± 2.63 cm respectively.

Development of the body conformation traits for all the genotypes was compared from the age of 90 to 360 days and illustrated in the tables and figures . There was a gradual increase in the body measurements of the genotypes and the comparison was as what has been described by the age groups earlier.

Table 4.31 Least square means and std. errors of the height at wither for all the genotypes at the age of 90, 180, 270 and 360 days

Genotypes	Height at wither (cm)			
	90-days	180-days	270-days	360-days
Cameroon	47.05 ± 1.04^{c} (8)	53.01 ± 1.65^{b} (8)	53.01 ± 1.64^{d} (8)	55.39 ± 1.84^{d} (8)
Thai Long Tail	49.77 ± 0.32^{a} (85)	55.40 ± 0.49^{a} (57)	58.44 ± 0.46^{a} (75)	60.65 ± 0.75^{b} (40)
F_1	48.65 ± 0.27^{b} (163)	53.07 ± 0.42^{b} (114)	56.26 ± 0.41^{b} (130)	58.29 ± 0.50^{c} (124)
F_2	47.54 ± 0.36^{c} (76)	53.14 ± 0.44^{b} (76)	55.60 ± 0.50^{c} (69)	59.77 ± 0.59^{b} (70)
F_3	47.14 ± 0.62^{c} (21)	52.33 ± 0.99^{b} (13)	58.02 ± 1.20^{a} (12)	61.46 ± 1.42^{b} (13)
BC_1	49.25 ± 0.52^{a} (33)	52.96 ± 0.65^{b} (32)	57.32 ± 0.75^{b} (29)	60.31 ± 0.87^{b} (32)
BC_2	49.11 ± 0.58^{a} (25)	54.94 ± 0.71^{a} (26)	59.65 ± 0.95^{a} (19)	64.92 ± 0.99^{a} (23)

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

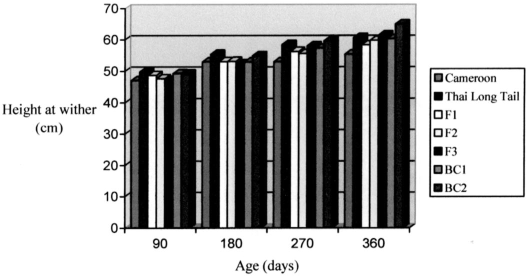

Figure 4.16 Height at withers for all the genotypes at the age of 90, 180, 270 and 360 days

Table 4.32 Least square means and std. errors of the body length for all the genotypes at the age of 90, 180, 270 and 360 days

	Body length (cm)			
Genotypes	**90-days**	**180-days**	**270-days**	**360-days**
Cameroon	45.49 ± 1.37^{c} (8)	49.88 ± 2.42^{c} (8)	51.28 ± 2.03^{d} (8)	56.20 ± 2.07^{d} (8)
Thai Long Tail	49.92 ± 0.42^{a} (85)	54.96 ± 0.61^{a} (57)	59.95 ± 0.57^{b} (75)	61.01 ± 0.84^{b} (40)
F_1	47.87 ± 0.36^{b} (163)	52.50 ± 0.52^{b} (114)	56.42 ± 0.50^{c} (130)	59.46 ± 0.56^{c} (124)
F_2	46.60 ± 0.48^{c} (76)	52.91 ± 0.54^{b} (76)	56.71 ± 0.62^{c} (69)	59.28 ± 0.66^{c} (70)
F_3	50.93 ± 0.82^{a} (21)	53.02 ± 1.22^{a} (13)	59.34 ± 1.48^{b} (12)	64.71 ± 1.59^{a} (13)
BC_1	47.41 ± 0.69^{b} (33)	53.80 ± 0.81^{a} (32)	56.79 ± 0.93^{c} (29)	59.37 ± 0.98^{c} (32)
BC_2	47.06 ± 0.77^{b} (25)	55.14 ± 0.87^{a} (26)	61.89 ± 1.17^{a} (19)	65.98 ± 1.12^{a} (23)

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

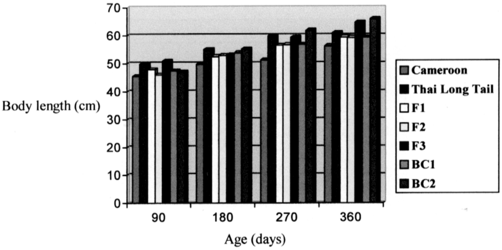

Figure 4.17 Body length for all the genotypes at the age of 90, 180, 270 and 360 days

Table 4.33 Least square means and std. errors of the heart girth for all the genotypes at the age of 90, 180, 270 and 360 days

Genotypes	Heart Girth (cm)			
	90-days	**180-days**	**270-days**	**360-days**
Cameroon	53.26 ± 1.26^d (8)	60.73 ± 2.55^c (8)	64.58 ± 1.86^c (8)	69.61 ± 1.89^d (8)
Thai Long Tail	56.46 ± 0.39^b (85)	63.54 ± 0.64^b (57)	69.90 ± 0.52^b (75)	77.04 ± 0.77^a (40)
F_1	56.90 ± 0.33^b (163)	65.28 ± 0.55^a (114)	69.74 ± 0.46^b (130)	75.04 ± 0.51^b (124)
F_2	56.39 ± 0.44^b (76)	64.06 ± 0.57^b (76)	69.14 ± 0.57^b (69)	72.95 ± 0.60^c (70)
F_3	56.33 ± 0.75^b (21)	63.65 ± 1.29^b (13)	68.34 ± 1.35^b (12)	73.28 ± 1.45^b (13)
BC_1	59.40 ± 0.63^a (33)	65.73 ± 0.85^a (32)	71.70 ± 0.85^a (29)	76.02 ± 0.89^a (32)
BC_2	55.75 ± 0.70^c (25)	65.02 ± 0.92^a (26)	73.45 ± 1.07^a (19)	76.57 ± 1.02^a (23)

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

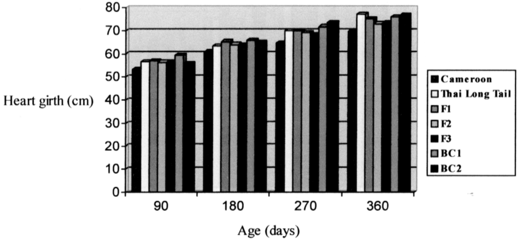

Figure 4.18 Heart girths for all the genotypes at the age of 90, 180, 270 and 360 days

Table 4.34 Least square means and std. errors of the back girth for all the genotypes at the age of 90, 180, 270 and 360 days

	Back Girth (cm)			
Genotypes	**90-days**	**180-days**	**270-days**	**360-days**
Cameroon	55.80 ± 2.15^{c} (8)	67.64 ± 3.60^{b} (8)	71.06 ± 2.60^{c} (8)	74.35 ± 2.63^{c} (8)
Thai Long Tail	56.03 ± 0.66^{c} (85)	67.47 ± 0.90^{b} (57)	73.22 ± 0.73^{c} (75)	80.27 ± 1.07^{a} (40)
F_1	59.01 ± 0.56^{b} (163)	70.66 ± 0.77^{a} (114)	74.35 ± 0.64^{b} (130)	79.66 ± 0.71^{b} (124)
F_2	57.76 ± 0.75^{b} (76)	67.27 ± 0.83^{b} (76)	72.05 ± 0.80^{c} (69)	76.61 ± 0.84^{c} (70)
F_3	61.21 ± 1.29^{a} (21)	67.10 ± 1.82^{b} (13)	72.90 ± 1.89^{c} (12)	77.18 ± 2.02^{b} (13)
BC_1	61.58 ± 1.07^{a} (33)	71.99 ± 1.20^{a} (32)	75.88 ± 1.20^{b} (29)	79.52 ± 1.24^{b} (32)
BC_2	56.47 ± 1.20^{c} (25)	71.67 ± 1.30^{a} (26)	80.53 ± 1.51^{a} (19)	82.07 ± 1.42^{a} (23)

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

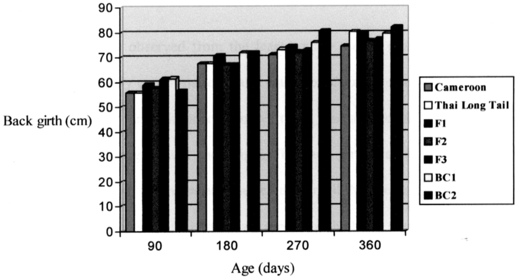

Figure 4.19 Back girths for all the genotypes at the age of 90, 180, 270 and 360 days

4.2.3 Effect of sex on BCT

The effect of sex on the body conformation traits was found to be significantly different at 90-days ($P \leq 0.01$), 180-days ($P \leq 0.01$) and 270-days ($P \leq 0.01$) but not significant at the age of 360-days.

The least square means of the height at wither, body length, heart girth and the back girth for all the genotypes at the age of 90, 180, 270 and 360 days by the effect of sex was summarized in Table 4.35. It was revealed that the males were on the average of 1.13 cm, 2.10 cm, 1.44 cm and 0.48 cm taller than the females by the height at wither at the age groups of 90, 180, 270 and 360 days old respectively. On the other hand, the females were found to be longer in body length and had bigger circumference at the heart girth than the males at all the age groups studied. The males had only 0.39 cm bigger (58.46 ± 0.65 cm) back girth than the females (58.07 ± 0.71 cm) at 90 days of age but at the later age of 180, 270 and 360 days the females was revealed to have bigger back girth than the males, with the differences of 1.57 cm, 1.53 cm and 1.13 cm respectively.

It could also be observed from the least square means (Table 4.35) that the measurements of the body conformation traits was proportional to the increase in age, which means that as the animals become older there was a gradual increase in their height, body length, heart girth and back girth. The back girth was found to be bigger than the heart girth for both the males and the females in all the age groups.

Table 4.35 also shows the least square means of the body conformation traits at the different age groups by the effect of sex. Since the interaction effect between genotypes and sex was not significant only one table is presented (Table 4.36) for this result to show the interaction effect and at other ages similar observations were

Table 4.35 Least square means and std. errors of the body conformation traits at the different age groups by the effect of sex

Sex of the genotypes by age	Height at Wither (cm)	Body Length (cm)	Heart Girth (cm)	Back Girth (cm)
At 90-days old				
Male	48.93 ± 0.32^{a} (229)	47.83 ± 0.42^{a} (229)	56.15 ± 0.38^{a} (229)	58.46 ± 0.65^{a} (229)
Female	47.80 ± 0.34^{b} (182)	47.96 ± 0.45^{a} (182)	56.56 ± 0.41^{a} (182)	58.07 ± 0.71^{a} (182)
At 180-days old				
Male	54.60 ± 0.41^{a} (169)	53.05 ± 0.51^{a} (169)	63.70 ± 0.54^{a} (169)	68.33 ± 0.76^{a} (169)
Female	52.50 ± 0.62^{b} (157)	53.30 ± 0.76^{a} (157)	64.31 ± 0.81^{a} (157)	69.90 ± 1.14^{a} (157)
At 270-days old				
Male	57.51 ± 0.48^{a} (175)	57.40 ± 0.59^{a} (175)	69.16 ± 0.54^{a} (175)	73.52 ± 0.76^{a} (175)
Female	56.07 ± 0.55^{b} (167)	57.56 ± 0.68^{a} (167)	69.95 ± 0.62^{a} (167)	75.05 ± 0.87^{a} (167)
At 360-days old				
Male	60.85 ± 0.61^{a} (151)	60.59 ± 0.68^{a} (151)	73.67 ± 0.62^{b} (151)	77.96 ± 0.87^{a} (151)
Female	59.37 ± 0.58^{b} (159)	61.13 ± 0.65^{a} (151)	75.05 ± 0.59^{a} (151)	79.09 ± 0.82^{a} (151)

Difference in superscripts a and b within the column indicates significant differences ($P \leq 0.05$)

Table 4.36 Least square means and std. errors of the body conformation traits for the interaction effect of genotype and sex at the age of 90 days

Genotypes	N	Height at Wither (cm)	Body Length (cm)	Heart Girth (cm)	Back Girth (cm)
Cameroon					
Male	4	48.90 ± 1.44^{b}	44.97 ± 1.90^{d}	52.96 ± 1.75^{c}	56.63 ± 2.98^{c}
Female	4	45.21 ± 1.44^{d}	46.01 ± 1.90^{d}	53.55 ± 1.75^{c}	54.98 ± 2.98^{d}
Thai Long Tail					
Male	51	50.62 ± 0.40^{a}	50.37 ± 0.53^{a}	56.93 ± 0.49^{b}	56.79 ± 0.83^{c}
Female	34	48.92 ± 0.50^{b}	49.47 ± 0.65^{b}	56.00 ± 0.60^{b}	55.27 ± 1.02^{c}
F_1					
Male	88	49.50 ± 0.33^{b}	48.01 ± 0.44^{b}	57.09 ± 0.40^{b}	59.99 ± 0.69^{b}
Female	75	47.80 ± 0.38^{c}	47.73 ± 0.50^{c}	56.72 ± 0.46^{b}	58.02 ± 0.78^{c}
F_2					
Male	45	47.57 ± 0.46^{c}	46.15 ± 0.61^{d}	56.00 ± 0.56^{b}	58.91 ± 0.95^{b}
Female	31	47.51 ± 0.54^{c}	47.04 ± 0.71^{c}	56.78 ± 0.65^{b}	56.60 ± 0.11^{c}
F_3					
Male	10	47.23 ± 0.89^{c}	51.37 ± 1.18^{a}	55.98 ± 1.08^{b}	60.65 ± 1.85^{a}
Female	11	47.06 ± 0.86^{c}	50.49 ± 1.14^{a}	56.69 ± 1.05^{b}	61.76 ± 1.78^{a}
BC_1					
Male	19	49.70 ± 0.66^{a}	47.15 ± 0.87^{c}	58.78 ± 0.80^{a}	60.29 ± 1.36^{a}
Female	14	48.80 ± 0.78^{b}	47.66 ± 1.03^{c}	60.02 ± 0.95^{a}	62.87 ± 1.61^{a}
BC_2					
Male	12	48.96 ± 0.85^{b}	46.78 ± 1.13^{c}	55.33 ± 1.03^{b}	55.92 ± 1.76^{c}
Female	13	49.26 ± 0.79^{b}	47.34 ± 1.04^{c}	56.16 ± 0.95^{b}	57.01 ± 1.63^{c}

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

F_1 = Cameroon x Thai Long Tail
F_2 = F_1 x F_1
F_3 = F_2 x F_2
BC_1 = F_1 (male) x Thai Long Tail (female)
BC_2 = Thai Long Tail (male) x F_1 (female)

recorded. The males in all the genotypes were shown to be taller than the females throughout their growth period. The Thai Long Tail males were the tallest at 90 days of age but Cameroon males became the tallest males at 180 days.

At 270 and 360 days the BC_2 males became the tallest animals amongst the males as well as the females, except the BC_2 females at 360 days old. Their heights were 50.62 ± 0.40 cm, 56.48 ± 1.78 cm, 60.09 ± 1.18 cm and 64.30 ± 1.49 cm for the tallest Thai Long Tail, Cameroon and BC_2 male's genotypes at the age of 90, 180, 270 and 360 days respectively.

The BC_2, Thai Long Tail, BC_2 females were the tallest female genotypes at the age of 90, 180, 270 and 360 days with the heights of 49.26 ± 0.79 cm, 55.24 ± 0.66 cm, 59.20 ± 1.48 cm and 65.53 ± 1.31 cm respectively. The least square means also showed that the BC_2 females were the tallest genotypic group at the age of 360 days and were 1.23 cm taller than the tallest males, the BC_2 which had the height of 64.30 ± 1.49 cm Unlike the Cameroon males, throughout the growth period, the Cameroon females remained as the shortest females in comparison to the other genotypic groups. The Cameroon females however were longer in body length and had bigger heart girth than their males counterpart at the age of 90 days, bigger heart girth and back girth at 180 days and had longer body length than the Cameroon males again at the age of 360 days.

In all cases the back girth measurements for all the genotypes were higher than the heart girth and in most of the cases, the heart girth and the back girth measurements of the females genotypes from the various genotypic groups were greater that that of the males genotypes.

4.2.4 Effect of the type of birth on BCT

It was earlier mentioned by the least square analysis of variance (Table 4.27 and Table 4.28) that the effect of the type of birth on the body conformation traits for all the age groups was not significant. Due to that and because of the small number of animals in an unequal data analysis, the least square means for the interaction effect between the genotypes and the type of birth could not be estimated. The following results are presented to show the least square means for the main effect of the type of birth only (Table 4.37).

It was mentioned earlier that in all the age groups studied the measurements for the body conformation traits of the genotypes by their type of birth were almost similar between the singles and the twins. As for the age at 180 days and 270 days the single lambs were only 0.72 cm and 0.34 cm taller than the twins lambs. Their respective height at wither were 53.91 ± 0.37 cm and 53.19 ± 0.58 cm at 180 days old and 56.96 ± 0.37 cm and 56.62 ± 0.55 cm at 270 days for the single and twin lambs respectively.

Comparison between body conformation traits at 90 days and 360 days showed that the twins were taller, longer and had bigger heart girth and back girth than the single born lambs at 360 days old even though they were shorter at weaning. However the differences showed no significant differences between the genotypes studied.

4.3 Reproductive traits

Results of studies on the various reproductive traits of the Cameroon, Thai Long Tail, F_1 and F_2 genotypes are presented in the following Table 4.38 to Table 61. Since primary attention was focused mainly on the performance of the purebreds

Table 4.37 Least square means and std. errors of the body conformation traits of the different age groups by the effect of the type of birth

Type of birth of the Genotypes by age	Height at Wither (cm)	Body Length (cm)	Heart Girth (cm)	Back Girth (cm)
At 90-days old				
Single	48.35 ± 0.22^{a} (325)	48.11 ± 0.30^{a} (325)	56.74 ± 0.28^{a} (325)	58.25 ± 0.47^{a} (325)
Twins	48.37 ± 0.40^{a} (91)	47.69 ± 0.52^{a} (91)	55.97 ± 0.48^{a} (91)	58.28 ± 0.82^{a} (91)
At 180-days old				
Single	53.91 ± 0.37^{a} (283)	53.36 ± 0.45^{a} (283)	63.93 ± 0.48^{a} (283)	68.91 ± 0.68^{a} (283)
Twins	53.19 ± 0.58^{a} (61)	52.99 ± 0.71^{a} (61)	64.07 ± 0.75^{a} (61)	69.32 ± 1.06^{a} (61)
At 270-days old				
Single	56.96 ± 0.37^{a} (258)	57.34 ± 0.46^{a} (258)	69.60 ± 0.42^{a} (258)	74.13 ± 0.59^{a} (258)
Twins	56.62 ± 0.55^{a} (84)	57.62 ± 0.68^{a} (84)	69.50 ± 0.62^{a} (84)	74.44 ± 0.87^{a} (84)
At 360-days old				
Single	60.03 ± 0.44^{a} (236)	60.26 ± 0.49^{a} (236)	73.84 ± 0.45^{a} (236)	77.96 ± 0.62^{a} (236)
Twins	60.20 ± 0.66^{a} (74)	61.46 ± 0.74^{a} (74)	74.88 ± 0.67^{a} (74)	79.09 ± 0.93^{a} (74)

Difference in superscripts a, b and c within the column indicates significant differences ($P \leq 0.05$)

Cameroon hair sheep, Thai Long Tail wool sheep and their crossbreds, the analyses were done on the reproductive performance of these two genotypes and their first (F_1) and second generation (F_2) crosses only. Backcross females from the BC_1 and the BC_2 genotypes were not included in this reproduction study because only a few of these have complete reproductive records.

4.3.1 Least square analysis of variance for reproductive traits

Least square analysis of variance and the least square means for the various reproductive traits of the Cameroon, Thai Long Tail, F_1 and the F_2 females are tabulated in Table 4.38 and Table 4.39. The results are discussed vis-a-vis the analysis of variance and the least square means simultaneously according to the parameters studied.

4.3.2 Age at first oestrus

There was a very high significant difference ($P \leq 0.001$) on the effect of genotypes on the age at first oestrus (Table 4.38). However no significant difference was found for other sources of variation.

Table 4.39 shows that the Cameroon females matured earliest at the youngest age of 241.06 ± 40.79 days while the Thai Long Tail females matured most slowly at the age of 400.77 ± 14.97 days. The maturity of the crossbred females (F_1 and F_2) on the other hand as expressed by their first oestrus were found to be 320.09 ± 12.98 days and 322.46 ± 16.19 days respectively. The differences were significant between Cameroon and Thai Long Tail and between the crossbreds (F_1 and F_2) and their parents.

Table 4.38 Least square analysis of variance for the age at first oestrus and the age at first successful mating

Sources of Variations	Age at first oestrus		Age at first successful mating	
	df	Mean Squares	df	Mean Squares
Genotypes	3	79779.94 ***	3	47367.25 ***
Type of birth	1	14487.89	1	4926.91
Parity of birth	3	4321.14	3	993.46
Genotype x Type of birth	3	4578.56	3	155.40
Genotype x Parity of birth	9	7605.38	9	4001.45
Error	120	5621.45	92	6185.55

*** $P \leq 0.001$

Comparison between the females born as single lambs and twin lambs showed that the single born females matured earlier than the twin born lambs (Table 4.40); whereas the single born females had the first oestrus at the age of 316.16 ± 13.01 days, the twin born females at the age of 326.02 ± 21.28 days old. The difference between their ages at first oestrus was however found to be not significant (Table 4.40).

Table 4.41 shows the least square means for the interaction effect between the genotypes and the type of birth. There were no twins in the Cameroon genotype therefore only the single-born Cameroon can be compared with the single-born females from the other genotypes. Comparison amongst the twins involved only the Thai Long Tail, the F_1 and the F_2 genotypes.

The analysis of variance had shown that there was no significant difference between the singles and the twins from the various genotypic groups, however it should be noted that the singles reached their age at first oestrus earlier than the twins.

Genotype and the type of birth comparison showed that the females born as singles from the Thai Long Tail and the F_1 matured earlier than their twin counterparts. The least square means for the differences between the singles and the twins were 376.82 ± 15.89 days versus 445.54 ± 23.24 days in Thai Long Tail, 314.52 ± 10.61 days versus 316.18 ± 28.87 days in the F_1. However the twins from the F_2 genotypes were found to mature faster than their single-born counterparts with the average age of 261.41 ± 30.97 days versus 329.70 ± 13.60 days respectively. The age at the first oestrus for the F_2 twins was the earliest amongst the twin genotypes and the second earliest after the single born Cameroon hair sheep (241.06 ± 40.79 days). In descending order the earliest age at the first oestrus for the single females were from the Cameroon, F_1 , F_2 and Thai Long Tail while for the twins were the F_2 , F_1 and the Thai Long Tail respectively.

Table 4.39 Least square means of the age at first oestrus and the age at first successful mating for the various genotypes

Genotypes	Age at first oestrus (days)	Age at first successful mating (days)
Cameroon (C)	241.06 ± 40.79[c]	248.76 ± 41.22[d]
	(4)	(4)
Thai Long Tail (TLT)	400.77 ± 14.97[a]	421.08 ± 16.59[a]
	(41)	(34)
F_1 (C x TLT)	320.09 ± 12.98[b]	356.59 ± 13.43[b]
	(59)	(56)
F_2 (F_1 x F_1)	322.46 ± 16.19[b]	343.10 ± 20.58[c]
	(36)	(18)

Difference in superscripts a, b, c and d within the column indicates significant differences (P≤0.05)

Table 4.40 Least square means of the age at first oestrus and the age at first successful mating for all the genotypes by the effects of the type of birth and the parity of birth

	Age at first oestrus (days)	Age at first successful mating (days)
Type of birth		
Singles	316.16 ± 13.01[a] (108)	344.11 ± 13.95[a] (85)
Twins	326.02 ± 21.28[a] (32)	340.66 ± 22.69[a] (27)
Parity of birth		
Parity 1	323.58 ± 16.39[a] (62)	348.76 ± 41.22[b] (46)
Parity 2	308.03 ± 14.70[a] (46)	421.08 ± 16.59[a] (41)
Parity 3	337.00 ± 20.48[a] (20)	356.59 ± 13.43[b] (15)
Parity 4	315.76 ± 30.26[a] (8)	343.10 ± 20.58[b] (8)

Difference in superscripts a and b within the column indicates significant differences (P≤0.05)

Table 4.41 Least square means of the age at first oestrus and the age at first successful mating by the interaction effect of genotypes and the type of birth

Genotypes and type of birth	Age at first oestrus (days)	Age at first successful mating (days)
Cameroon (C)		
Singles	241.06 ± 40.79^{d} (4)	248.76 ± 41.22^{c} (4)
Twins	-	-
Thai Long Tail (TLT)		
Singles	376.82 ± 15.89^{b} (22)	414.37 ± 17.96^{a} (18)
Twins	445.54 ± 23.24^{a} (19)	436.27 ± 26.74^{a} (16)
F_1 (C x TLT)		
Singles	314.52 ± 10.61^{c} (52)	359.74 ± 11.27^{b} (49)
Twins	316.18 ± 28.27^{c} (7)	349.35 ± 29.77^{b} (7)
F_2 (F_1 x F_1)		
Singles	329.70 ± 13.60^{c} (30)	349.23 ± 20.36^{b} (14)
Twins	261.41 ± 30.97^{d} (6)	305.55 ± 38.18^{c} (4)

Difference in superscripts a, b, c and d within the column indicates significant differences (P≤0.05)

The effect of the parity of birth of the genotypes on their age at first oestrus was also not significant. The least square means of their age at first oestrus for females born as the first, second, third and fourth parity was presented in Table 4.40. The second parity females were found to reach their age at first oestrus as the earliest (308.03 ± 14.70 days), when compared to the females of parity four (315.76 ± 30.26 days), parity one (323.58 ± 16.39 days) and parity three (337.00 ± 20.48 days) respectively.

Genotype comparison between the parity of birth in Table 4.42 showed that the females from the parity 2 of the Cameroon genotype reached their age at first oestrus at the youngest age of 221.94 ± 43.55 days while females of parity 3 from the Thai Long Tail reached their age at first oestrus at the latest age of 488.83 ± 33.69 days old.

Parity 1 females from the Cameroon genotype matured fastest when compared to parity 1 females from the F_1, F_2 and Thai Long Tail. They matured at the corresponding age of 239.80 ± 75.29 days, 330.81 ± 17.41 days, 332.58 ± 16.43 days and 374.37 ± 17.34 days respectively. Mean while, parity 2 females from the Cameroon genotype (221.94 ± 221.94 days) also matured the earliest among the parity 2 females followed by that of those from the F_1 (298.60 ± 16.78 days), F_2 (305.38 ± 22.69 days) and Thai Long Tail (407.78 ± 28.50 days). Parity 3 females from the F_2 genotype matured at the age of 278.32 ± 37.76 days when compared to the parity 3 females from the F_1 (320.52 ± 23.82 days) and Thai Long Tail genotype (488.83 ± 33.69 days). Comparison between parity 4 females revealed that parity 4 females from the F_1 had their age at first oestrus faster than the parity 4 females from the Thai Long Tail parents. No record was available for parity 3 and parity 4 in the Cameroon genotype, therefore no comparison could be made with the other genotypes.

In general, it was revealed that the purebred females from the first and second parity group of the purebred Cameroon hair sheep matured earlier than the purebred

Table 4.42 Least square means of the age at first oestrus and the age at first successful mating by the interaction effect of genotypes and the parity of birth

Genotypes x Parity of birth	Age at first oestrus (days)	Age at first successful mating (days)
Cameroon (C)		
Parity 1	239.80 ± 75.29^{de} (2)	239.54 ± 75.88^{d} (2)
Parity 2	221.94 ± 43.55^{e} (2)	240.79 ± 43.93^{d} (2)
Parity 3	-	-
Parity 4	-	-
Thai Long Tail (TLT)		
Parity 1	374.37 ± 17.34^{b} (21)	414.74 ± 18.48^{b} (21)
Parity 2	407.78 ± 28.50^{b} (10)	406.89 ± 34.10^{bc} (10)
Parity 3	488.83 ± 33.69^{a} (6)	506.96 ± 43.83^{a} (6)
Parity 4	386.67 ± 53.54^{b} (2)	403.17 ± 54.07^{bc} (2)
F_1 (C x TLT)		
Parity 1	330.81 ± 17.41^{cd} (19)	372.13 ± 18.70^{c} (19)
Parity 2	298.60 ± 16.78^{d} (22)	336.32 ± 17.14^{cd} (22)
Parity 3	320.52 ± 23.82^{cd} (10)	364.72 ± 24.02^{c} (10)
Parity 4	314.84 ± 26.61^{cd} (6)	380.50 ± 28.69^{bc} (6)
F_2 (F_1 x F_1)		
Parity 1	332.58 ± 16.43^{c} (21)	348.36 ± 25.37^{cd} (21)
Parity 2	305.38 ± 22.69^{cd} (11)	340.72 ± 26.84^{cd} (11)
Parity 3	278.32 ± 37.76^{de} (4)	254.79 ± 75.87^{d} (4)
Parity 4	-	-

Difference in superscripts a, b, c, d and e within the column indicates significant differences ($P \leq 0.05$)

Thai Long Tail wool sheep. The crossbred females of parity 1 to parity 4 however matured later than the purebred Cameroon (parity 1 and parity 2) but earlier than their wool sheep mother, Thai Long Tail.

4.3.3 Age at first successful mating

Least square analysis of variance for the age at first successful mating is presented in Table 4.38. The analysis revealed significant difference ($P \leq 0.001$) for the effect of genotypes only.

The results for the least square means for the age at first successful mating for the Cameroon, Thai Long Tail, F_1 and F_2, effects of the type of birth and the parity of birth, the interaction between genotype and the type of birth and the interaction between genotype and the parity of birth are tabulated in Tables 4.39, 4.40, 4.41 and 4.42.

The age at first successful mating for the Cameroon, Thai Long Tail, F_1 and F_2 was compared and the least square means were tabulated in Table 4.39. The Cameroon genotype was found to be successfully mated for the first parturition at the youngest age of 248.76 ± 41.22 days followed by the F_2 (343.10 ± 20.58 days), F_1 (356.59 ± 13.43 days) and the Thai Long Tail (421.08 ± 16.59 days). Although the F_1 genotype was found to have reached the age at first oestrus earlier than the F_2, the F_2 females were successfully mated on an average of thirteen days earlier. The Thai Long Tail females were mated successfully to produce their first offspring at a latter age than the other three genotypes under comparison.

Females born as twins became pregnant earlier than females that were born as singles. The difference was only between 340.66 ± 22.69 days for the twins and 344.11 ± 13.95 days for the singles and was not significantly different. The singles were found to mature earlier than the twins (Table 4.40) but the twins were successfully mated to produce offspring at a slightly younger age than the singles.

The interaction effect between the genotype and the type of birth in Table 4.41 showed that the Cameroon singles were successfully mated earlier than the other single-born females as well as between all the groups compared. Among the single-born females, at the age of 248.76 ± 41.22 days the Cameroon were mated successfully. Then the single-born genotypes that followed were the F_2 (349.23 ± 20.36 days), F_1 (359.74 ± 11.27 days) and Thai Long Tail (414.37 ± 17.96 days).

On the other hand the twin-born F_2 genotype were the first to be successfully mated (305.55 ± 38.18 days), followed by the F_1 (349.35 ± 29.77 days) and the Thai Long Tail (436.27 ± 26.74 days). Only the Thai Long Tail showed that the single born females were successfully mated earlier than the single born, that was at the age of 414.37 ± 17.96 days versus 436.27 ± 26.74 days for the twins and the single born females respectively.

Within the genotypes of the F_1 and the F_2, the twins were shown to be successfully mated earlier than the single born females, that were at the age of 349.35 ± 29.77 days versus 359.74 ± 11.27 days in the F_1, and at the age of 305.55 ± 38.18 days versus 349.23 ± 20.36 days in the F_2. These differences were however not significant.

The least square means of the main effect of the parity of birth and the interaction effect between genotype and the parity of birth were presented in Table 4.40 and Table 4.42. The differences within and between the groups were earlier found to be generally not significant. Nevertheless it was revealed by these results that parity four females were mated successfully at the youngest age (343.10 ± 20.58 days) in comparison to females of parity one (348.76 ± 41.22 days), parity three (356.59 ± 13.43 days) and parity two (421.08 ± 16.59 days) respectively. It could be observed that with subsequent parities the females were able to reproduce faster. In contrast to the age at first oestrus, the parity two females were the earliest to mature (308.03 ± 14.70 days) but the last group to be successfully mated (421. 08 ± 16.59 days).

Comparison between the interaction effect showed that there was no specific trend in parity effect from each genotype mated successfully for the production of the first offspring. Parity one females from the Cameroon genotype were found to produce offspring at the youngest age of all (239.54 ± 75.88 days) followed by the parity two females from the same genotype (240.79 ± 43.73 days).

4.3.4 Age at first and second parturition

The least square analysis of variance presented in Table 4.43 showed that there was a significant ($P \leq 0.01$) effect of genotype on the age at first parturition but the effect of genotype became not significant on the age at second parturition. Other main effects and the interaction effects during the first and the second parturition showed no significant differences. This result was in conformity with the significant effect of genotype on the age at first oestrus and the age at first successful mating which had been described earlier.

The average age for all the females from the various genotypes at the first and the second parturition was 521.47 ± 0.76 days and 854.24 ± 0.57 days respectively. The least square means of the age at first and second parturition in Table 4.44 showed the Cameroon genotype had its first lambing at the age of 395.28 ± 46.09 days, following the pattern set for age at first oestrus and the age at first successful mating. The purebred Thai Long Tail lambed at the oldest age while the F_1 and the F_2 had their first lambs at the intermediate age between their parental genotype, which were older than the Cameroon but younger than the Thai Long Tail. The F_1 and the F_2 had their first

Table 4.43 Least square analysis of variance for the age at first and second parturition

Sources of Variations	Age at first parturition		Age at second parturition	
	df	Mean Squares	df	Mean Squares
Genotypes	3	43100.61 ***	3	80900.02
Type of birth	1	2888.84	1	5385.84
Parity of birth	3	798.90	3	20143.10
Genotype x Type of birth	3	1437.44	3	9615.69
Genotype x Parity of birth	9	2016.64	9	59228.82
Error	94	7695.83	51	23009.29

*** $P \leq 0.001$

parturition at the age of 503.50 ± 15.00 days and 507.11 ± 22.99 days respectively while the purebred Thai Long Tail genotype first parturited at the age of 571.02 ± 17.71 days. This is due to the fact that the Cameroon matured and successfully mated at the youngest age between the genotypes.

At the second parturition (Table 4.44) however the Cameroon genotype was found to have its second lambing at the eldest age (948.91 ± 91.16 days) in comparison to the F_1 (822.68 ± 47.66 days), F_2 (839.22 ±67.92 days) and Thai Long Tail (890.11 ± 50.25 days). One of the possible reasons would be that the Cameroon had the longest first post-partum oestrus than the other genotypes and their breeding period was not consistent.

The F_1 genotype had its first and second parturition at an earlier age than the F_2 but the differences as per least square means were only at the average of 3.61 days and 16.54 days at the first and second parturition respectively. The differences were found to be not significant.

The least square mean for all the genotypes that was born as single were found to have their first and second parturition 2.62 days and 38.26 days later than the twins (Table 4.45). Age at first and second parturition for the singles and the twins were on the average of 495.54 ± 15.42 and 894.36 ± 59.34 days for the singles, and 492.92 ± 25.17 and 856.10 ± 78.91 days for the twins respectively. The twins therefore had the first and the second lambing earlier than the singles.

Least square means for the effect of the parity of birth for all the genotypes on the age at first and second parturition was summarized in Table 4.45. The results revealed that females from parity 2 had their first parturition earlier than the other parity groups (482.75 ± 17.07 days) while females of parity 4 had the second parturition earlier (820.21 ± 136.76 days) than the parity 1 (865.96 ± 60.48 days), parity 2 (834.77 ± 59.96 days) and parity 3 (979.98 ± 72.29 days).

Table 4.44 Least square means of the age at first and second parturition for the various genotypes

Genotypes	Age at first parturition (days)	Age at second parturition (days)
Cameroon (C)	395.28 ± 46.09^{c}	948.91 ± 91.16^{a}
	(4)	(4)
Thai Long Tail (TLT)	571.02 ± 17.71^{a}	890.11 ± 50.25^{a}
	(36)	(24)
F_1 (C x TLT)	503.50 ± 15.00^{b}	822.68 ± 47.66^{a}
	(56)	(36)
F_2 (F_1 x F_1)	507.11 ± 22.99^{b}	839.22 ± 67.92^{a}
	(18)	(10)

Difference in superscripts a, b and c within the column indicates significant differences ($P \leq 0.05$)

Table 4.45 Least square means of the age at first and second parturition for the various genotypes by the type of birth and the parity of birth

	Age at first parturition (days)	Age at second parturition (days)
Type of birth		
Singles	495.54 ± 15.42^{a}	894.36 ± 59.34^{a}
	(85)	(54)
Twins	492.92 ± 25.17^{a}	856.10 ± 78.91^{a}
	(27)	(16)
Parity of birth		
Parity 1	498.97 ± 20.20^{a}	865.96 ± 60.48^{a}
	(46)	(32)
Parity 2	482.75 ± 17.07^{a}	834.77 ±`59.96^{b}
	(41)	(27)
Parity 3	504.91 ± 25.34^{a}	979.98 ± 72.29^{a}
	(15)	(13)
Parity 4	490.29 ± 34.26^{a}	820.21 ± 136.76^{b}
	(8)	(4)

Difference in superscripts a, b, c and d within the column indicates significant differences ($P \leq 0.05$)

Parity 3 females from all the genotypes were found to be the oldest at the first (504.91 ± 25.34 days) and second (979.98 ± 72.29 days) parturition. This could be related to earlier finding (Table 4.40) that the third parity females for the various genotypes had their first oestrus at the oldest age than females of parity 1, parity 2 and parity 4. Parity 1 females could be observed to have had their age at first and second parturition latter than the parity 2 and parity 4 females. Thus, females born at parity 2 and parity 4 females were the youngest at the first and the second parturition, with the average age of 482.75 ± 17.07 days and 820.21 ± 136.76 days respectively. On the other hand parity 3 females were the oldest at the first (504.91 ± 25.34 days) and second (979.98 ± 72.29 days) parturition and parity 1 females were the second oldest by age at the first (498.97 ± 20.20 days) and second (865.96 ± 60.48 days) parturition respectively. All the differences were not significant except those in the second parturition.

The least square means for the interaction effect of the genotype and the type of birth are tabulated in Table 4.46. Comparison between the single born females from the four genotypic groups showed that the Cameroon was the first genotype to reproduce followed by the F_1, F_2 and Thai Long Tail. The age at first parturition for these single born genotypes was 395.28 ± 46.09, 507.35 ± 12.33, 520.92 ± 22.36 and 561.88 ± 19.23 days in ascending order respectively. Interaction effect was not significant, however significant differences were found for the differences between the age at first parturition between the Cameroon and Thai Long Tail ($P \leq 0.01$), F_1 ($P \leq 0.01$) and F_2 ($P \leq 0.01$) singles; and between Thai long Tail and F_1 single-born females ($P \leq 0.05$). At the second parturition however, results showed that the Thai long Tail single females lambed faster than the F_1, F_2 and the Cameroon. The Cameroon had the longest interval for oestrus between the first and the second parturition (568.06 days)

Table 4.46 Least square means of the age at first and second parturition by the interaction effect of the genotypes and the type of birth

Genotypes	Age at first parturition (days)	Age at second parturition (days)
Cameroon (C)		
Singles	395.28 ± 46.09^{c} (4)	948.91 ± 91.16^{a} (4)
Twins	-	-
Thai Long Tail (TLT)		
Singles	561.88 ± 19.23^{a} (19)	847.77 ± 47.94^{a} (13)
Twins	593.72 ± 27.74^{a} (17)	954.62 ± 68.87^{a} (11)
F_1 (C x TLT)		
Singles	507.35 ± 12.33^{b} (49)	860.17 ± 31.85^{a} (32)
Twins	495.43 ± 32.69^{b} (7)	686.24 ± 94.40^{b} (4)
F_2 (F_1 x F_1)		
Singles	520.92 ± 22.36^{b} (14)	870.68 ± 61.33^{a} (8)
Twins	452.15 ± 41.93^{c} (4)	704.86 ± 123.51^{b} (2)

Difference in superscripts a, b and c within the column indicates significant differences ($P \leq 0.05$)

when compared to the other single-born Thai Long Tail (285.89 days), F_2 (349.76 days) and F_1 (352.82 days) females respectively.

Since there were no twins in the Cameroon genotype, comparison for the age at first and second parturition was done between the twins from the Thai Long Tail, F_1 and F_2 genotypes only. The age at first parturition was the earliest for the F_2 (452.15 ± 41.93 days), followed by the F_1 (495.43 ± 32.69 days) and Thai Long Tail (593.72 ± 27.74 days) twins while the age at second parturition for the F_1 (686.24 ± 94.40 days) twins was the earliest in comparison to that of the F_2 (704.86 ± 123.51 days) and Thai Long Tail (954.62 ± 68.87 days) twins.

In general, it could be observed from the result that for the Thai Long Tail genotype, the single born females had their first and second parturition earlier than the twins while in the F_1 and the F_2 genotypes, the age for the first and second parturition for the twins were younger than the singles.

The age at first and second parturition of the genotypes by their parity of birth was also analyzed. The least square means was tabulated in Table 4.47, showing the interaction effect between genotype and the parity of birth of the various genotypes.

Parity 2 females from the Cameroon were the youngest (389.22 ± 49.36 days) at the first parturition and the F_1 had the earliest (773.28 ± 41.28 days) at the second parturition than parity 2 females from the other genotypes. For Cameroon, there is almost no difference between parity 1 (390.31 ± 85.26 days) and parity 2 (389.22 ± 49.36 days) females. Both parity 1 and parity 2 females from the Cameroon genotype had their age at first parturition faster than parity 1 to parity 4 from the other genotypic groups. However the Cameroon was found to take a longer period to have the second parturition in comparison to the other parity groups within and between the genotypes.

Table 4.47 Least square means of the age at first and second parturition by the interaction effect of genotypes and the parity of birth

Genotypes	Age at first parturition (days)	Age at second parturition (days)
Cameroon (C)		
Parity 1	390.31 ± 85.26^{c} (2)	961.59 ± 148.97^{b} (2)
Parity 2	389.22 ± 49.36^{c} (2)	-na-
Parity 3	-na-	-na-
Parity 4	-na-	-na-
Thai Long Tail (TLT)		
Parity 1	564.47 ± 20.77^{a} (21)	829.42 ± 42.97^{b} (13)
Parity 2	579.17 ± 34.97^{a} (10)	876.79 ± 67.05^{b} (7)
Parity 3	614.17 ± 42.68^{a} (6)	1380.59 ± 105.30^{a} (3)
Parity 4	548.10 ± 60.75^{a} (2)	743.25 ± 159.33^{bc} (2)
F_1 (C x TLT)		
Parity 1	512.72 ± 21.02^{b} (19)	877.03 ± 44.68^{b} (12)
Parity 2	488.89 ± 19.18^{bc} (22)	773.28 ± 41.28^{b} (15)
Parity 3	513.33 ± 26.98^{b} (10)	889.69 ± 52.76^{b} (8)
Parity 4	529.56 ± 32.23^{b} (6)	893.92 ± 149.00^{b} (2)
F_2 (F_1 x F_1)		
Parity 1	531.45 ± 28.51^{ab} (21)	921.40 ± 74.67^{b} (5)
Parity 2	489.97 ± 30.15^{bc} (11)	825.45 ± 66.87^{b} (5)
Parity 3	401.17 ± 85.24^{bc} (4)	555.25 ± 148.82^{c} (2)
Parity 4	-na-	-na-

na = not available

Difference in superscripts a, b and c within the column indicates significant differences (P≤0.05)

4.3.5 The first and the second gestation periods

Least square analysis of variance was done to study the gestation periods of the Cameroon, Thai Long Tail, F_1 and F_2 genotypes. The following results presented the gestation periods for the first and the second pregnancy, by the effects of genotypes, the type of birth, the parity of birth, the interaction between genotype and the type of birth and the interaction between genotype and the parity of birth (Table 4.48).

Genotype had no significant effect on the length of the first and second gestation periods. No significant differences were found for the other main effects as well as the interaction effects.

The least square means of the first and second gestation period for the genotypes studied were tabulated in Table 4.49. The average length of the first gestation was 148.71 ± 0.76 days and that of the second was 149.21 ± 0.70 days. The gestation period for the four genotypes, shown by the least square means ranged between 148.54 – 151.42 days for the first, and 148.30 – 150.66 days for the second gestation period respectively. Differences between the gestation period were very small and their gestation periods were almost the same.

In the first and the second gestation period, the Cameroon showed the longest gestation periods (151.42 ± 0.87 days and 150.66 ± 1.14 days) but only slightly longer when compared to the Thai Long Tail (149.19 ± 0.38 days and 150.58 ± 0.60 days), F_1 (148.83 ± 0.28 days and 149.47 ± 0.52 days) and F_2 (148.54 ± 0.43 days and 148.30 ± 0.71 days) genotypes.

In both comparison the F_2 genotype was shown to have the shortest gestation period, with the average of 148.54 ± 0.43 days and 148.30 ± 0.71 days for the first and the second pregnancy respectively.

Table 4.48 Least square analysis of variance for the first and the second gestation periods

Sources of variations	First gestation period		Second gestation period	
	df	Mean Squares	df	Mean Squares
Genotypes	3	10.70	3	9.30
Type of birth	1	0.04	1	0.58
Parity of birth	3	0.44	3	4.53
Genotype x Type of birth	3	2.97	3	0.38
Genotype x Parity of birth	9	2.51	9	2.25
Error	92	2.74	57	3.59

Table 4.49 Least square means of the first and second gestation period of the various genotypes

Genotypes	First gestation period (days)	Second gestation period (days)
Cameroon (C)	151.42 ± 1.88^{a} (4)	150.66 ± 1.14^{a} (3)
Thai Long Tail (TLT)	149.19 ± 0.38^{a} (34)	150.58 ± 0.60^{a} (26)
F_1 (C x TLT)	148.83 ± 0.28^{a} (56)	149.47 ± 0.52^{a} (37)
F_2 (F_1 x F_1)	148.54 ± 0.43^{a} (18)	148.30 ± 0.71^{a} (11)

Difference in superscript a within the column indicates significant differences ($P \leq 0.05$)

Table 4.50 Least square means of the first and second gestation period of the various genotypes by the type of birth and the parity of birth

	First gestation period (days)	Second gestation period (days)
Type of birth		
Singles	149.03 ± 0.29^a	149.68 ± 0.53^a
	(85)	(60)
Twins	149.95 ± 0.48^a	149.83 ± 0.75^a
	(27)	(17)
Parity of birth		
Parity 1	149.52 ± 0.38^a	149.13 ± 0.50^a
	(46)	(35)
Parity 2	149.69 ± 0.33^a	149.42 ± 0.42^a
	(41)	(29)
Parity 3	148.94 ± 0.49^a	149.28 ± 0.61^a
	(15)	(11)
Parity 4	149.83 ± 0.65^a	151.19 ± 1.75^a
	(8)	(2)

Difference in superscript a within the column indicates significant differences ($P \leq 0.05$)

The effect of the type of birth showed that the single – born females and the twin born females had almost similar gestation periods. Their first and second gestation periods for the single and the twins were 149.03 ± 0.29 days and 149.68 ± 0.53 days for the singles and 149.95 ± 0.48 days and 149.83 ± 0.75 days for the twins respectively. The first and second gestation period of the singles was 0.92 and 0.15 days shorter than their twin's counterparts (Table 4.50). The result showed that the first gestation period was shorter 0.65 days than that of the second gestation for the singles but 0.12 longer days for the twins. The least square means for the effect of the type of birth on the first and second gestation period was not significant and the average gestation period for both the single and the twins was 149.62 days.

The effect of the parity of birth was not significant and the least square means in Table 4.50 revealed that the first and second gestation periods for all the parity groups was on the average of 149.63 days. The first gestation periods for the parity 1 and parity 2 were only 0.39 days and 0.17 days longer than the second gestation. On the other hand the first gestation periods for the parity 3 and parity 4 females were 0.34 days and 1.36 days shorter than the second gestation period. The third parity females had the shortest gestation period (148.94 ± 0.49 days) in the first pregnancy while the first parity females had the shortest gestation period (149.13 ± 0.50 days) in the second pregnancy.

4.3.6 The first and the second post-partum oestrus

Analysis was done for the first and the second post-partum oestrus only. Data collection and evaluation for this study was conducted up to the second parturition due to very small samples and no record available in some of the genotypic groups studied in the following gestation periods.

Table 4.51 Least square analysis of variance of the length of the first and the second post-partum oestrus for the various genotypes

Sources of variations	First post-partum oestrus		Second post-partum oestrus	
	df	Mean Square Values	df	Mean Square Values
Genotypes	3	4639.84	3	1251.86
Type of birth	1	108.11	1	192.80
Parity of birth	3	367.21	3	516.46
Genotype x Type of birth	3	2733.34	3	209.24
Genotype x Parity of birth	9	1439.05	9	873.81
Error	83	2516.10	49	1015.32

Table 4.52 Least square means of the length of the first and the second post-partum oestrus for the various genotypes

Genotypes	Length of the first post-partum oestrus (days)	Length of the second post-partum oestrus (days)
Cameroon (C)	189.19 ± 26.65^{a}	147.57 ± 24.61^{a}
	(4)	(4)
Thai Long Tail (TLT)	117.04 ± 10.62^{b}	118.13 ± 12.69^{a}
	(25)	(20)
F_1 (C x TLT)	133.99 ± 9.23^{b}	129.39 ± 11.56^{a}
	(52)	(35)
F_2 (F_1 x F_1)	122.51 ± 14.19^{b}	144.03 ± 15.39^{a}
	(17)	(11)

Difference in superscripts a and b within the column indicates significant differences ($P \leq 0.05$)

The results presented in Table 4.51 revealed that there was no significant difference for the effects of genotypes, the type of birth, the parity of birth, the interaction of genotypes and the type of birth, and the interaction of genotypes and the parity of birth on the length of the first post-partum and the second post-partum oestrus.

The average length of the first and the second post-partum oestrus for all the genotypes were 128.60 ± 0.85 and 119.54 ± 0.75 days after parturition respectively. The length of the second post-partum oestrus was found to be shorter than the first, and in this case the length of the second post-partum oestrus was on the average of nine (9) days shorter than the first.

The length of the first and the second post-partum oestrus for the genotypes was tabulated in Table 4.52. The least square means for the effects of genotypes, the type of birth, the parity of birth, the interaction between genotype and the type of birth, and the interaction between genotype and the parity of birth were tabulated in the tables that follow.

The least square means of the length of the first and the second post-partum oestrus of the Cameroon, Thai Long Tail, F_1 and F_2 genotypes showed that the Thai Long Tail had the shortest first and second post-partum oestrus when compared to the other genotypes. In descending order it could be observed that after the first parturition the Thai Long Tail took 117.04 ± 10.62 days to come back to oestrus while the F_2, F_1 and Cameroon came on oestrus again after 122.51 ± 14.19 days, 133.99 ± 9.23 days and 189.19 ± 26.66 days respectively. Although the Cameroon had its first oestrus the earliest amongst the genotypes, the Cameroon was also found to have the longest first and second post-partum oestrus. However the second post-partum oestrus (147.57 ± 24.61 days) for the Cameroon was 41.62 days shorter than the first (189.19 ± 26.66 days).

The first and the second post-partum for the F_1 and the F_2 genotypes were intermediates of their parental genotypes, the Cameroon and the Thai Long Tail. They had their first and second post-partum oestrus as 133.99 ± 9.23 versus 129.39 ± 11.56 days and 122.51 ± 14.19 versus 144.03 ± 15.39 days after the first and the second parturition for the F_1 and the F_2 genotypes respectively. The least square means also showed that the F_1 genotype had the second post-partum oestrus oestrus shorter than the first while the F_2 had the second post-partum oestrus longer than the first. Coincidentally, the F_1 followed the trend showed by the Cameroon while the F_2 followed that of the Thai Long Tail.

Since there was no significant different between type of birth and parity on first and second post-partum oestrus, least square means of these effects are not presented here.

4.4 Estimates of genetic and phenotypic parameters

4.4.1 Heritability estimates

Heritability estimates obtained by regressing the F_3 offsprings' body weight at various ages (birth, 90-days, 180-days and 270-days) on ewes' body weight at the same age are presented in Table 4.53. These estimates are based on 2x additive genetic variance/phenotypic variance.

The heritability estimates are 0.68 ± 0.48 at birth, 0.34 ± 0.64 at 90-day weight (weaning), 0.90 ± 0.82 at 180-day weight and 0.26 ± 0.62 at 270-day body weights. The highest estimate is obtained for 180-day body weight while the least at 270-day weight. The estimate for birth weight is fairly high but later decreases at 90-day weight, increases to the highest at 180-day weight and becoming the lowest at 270-day weight.

Generally the values decrease from birth to 90 and 270-day weight but fluctuate with a sudden increase at 180-day weight.

4.4.2 Estimates of genetic and phenotypic correlations

Estimates for genetic correlations using the F_1 offsprings and their Thai Long Tail (TLT) ewes and F_2 offsprings and their F_1 ewes between body weight traits, at birth, 90, 180 and 270-day body weights are tabulated in Table 4.54. The estimates for the phenotypic correlations between traits for the F_1 and the F_2 are also tabulated in Table 4.55.

Genetic correlations (Table 4.54) obtained from variance-covariance analysis of F_2 and F_1 data (Falconer, 1980) were much lower than phenotypic correlations for all the traits. The estimates for F_2 offspring on F_1 ewes are higher than the estimates for F_1 on TLT. The genetic correlations for the F_1 on TLT ranged from –0.07 to 0.25 while for the F_2 on F_1 the values ranged from 0.06 to 0.38. The estimates are all positive except for the F_1 on TLT for birth weight, birth weight and 90-day weight, 90-day and birth weight and 90-day and 90-day weights respectively.

Phenotypic correlations between different body weight traits were found to be not consistent across generations (Table 4.55). The F_2 estimates were in general higher than the F_1 estimates. All traits were positively correlated at a moderate to higher level. Values ranged between 0.23 to 0.92 in F_1 and between 0.51 to 0.96 in F_2. The standard errors of phenotypic correlations ranged from 0.08 to 0.96, showing considerable differences in the limits of the estimation of heritability.

Table 4.53 Heritability estimates and std. errors of different body weight traits

Character	Heritability estimates
Birth weight	0.68 ± 0.48
90-day weight	0.34 ± 0.64
180-day weight	0.90 ± 0.82
270-day weight	0.26 ± 0.62

Table 4.54 Genetic correlations between traits using the method of Falconer (1980)

			Genetic correlations				
	O	**E**	**Birth weight (E)**	**90-day weight (E)**	**180-day weight (E)**	**270-day weight (E)**	**360-day weight (E)**
Birth weight (O)	F_1 $\mathbf{F_2}$	TLT **F1**	-0.07 **0.35**	-0.13 **0.18**	0.06 **0.27**	0.04 **0.31**	0.13 **0.38**
90-day weight (O)	F_1 $\mathbf{F_2}$	TLT **F1**	-0.14 **0.31**	-0.05 **0.06**	0.08 **0.15**	0.07 **0.18**	0.09 **0.27**
180-day weight (O)	F_1 $\mathbf{F_2}$	TLT **F1**	0.11 **0.35**	0.06 **0.19**	0.10 **0.27**	0.06 **0.25**	0.17 **0.28**
270-day weight (O)	F_1 $\mathbf{F_2}$	TLT **F1**	0.21 **0.26**	0.12 **0.15**	0.15 **0.21**	0.10 **0.21**	0.16 **0.25**
360-day weight (O)	F_1 $\mathbf{F_2}$	TLT **F1**	0.25 **0.26**	0.09 **0.17**	0.09 **0.26**	0.04 **0.25**	0.08 **0.29**

O = Offspring
E = Ewes

TLT = Thai Long Tail
F_1 = Cameroon x Thai Long Tail
F_2 = F_1 x F_1

Table 4.55 Phenotypic correlations between various body weights in the F_1 and F_2 offsprings

Body weights		Phenotypic correlations: Birth weight	90-day weight	180-day weight	270-day weight	360-day weight
Birth weight	F_1	1	0.53 ± 0.20	0.27 ± 0.10	0.23 ± 0.08	0.28 ± 0.10
	F_2	**1**	**0.66 ± 0.23**	**0.70 ± 0.25**	**0.73 ± 0.26**	**0.76 ± 0.28**
90-day weight	F_1	0.53 ± 0.20	1	0.44 ± 0.16	0.35 ± 0.12	0.30 ± 0.10
	F_2	**0.66 ± 0.23**	**1**	**0.55 ± 0.17**	**0.53 ± 0.17**	**0.51 ± 0.16**
180-day weight	F_1	0.27 ± 0.10	0.44 ± 0.16	1	0.91 ± 0.52	0.87 ± 0.45
	F_2	**0.70 ± 0.25**	**0.55 ± 0.17**	**1**	**0.94 ± 0.49**	**0.90 ± 0.42**
270-day weight	F_1	0.23 ± 0.08	0.35 ± 0.12	0.91 ± 0.52	1	0.92 ± 0.55
	F_2	**0.73 ± 0.26**	**0.53 ± 0.17**	**0.94 ± 0.49**	**1**	**0.96 ± 0.53**
360-day weight	F_1	0.28 ± 0.10	0.30 ± 0.10	0.87 ± 0.45	0.92 ± 0.55	1
	F_2	**0.76 ± 0.28**	**0.51 ± 0.16**	**0.90 ± 0.42**	**0.96 ± 0.53**	**1**

F_1 = Cameroon x Thai Long Tail

F_2 = F_1 x F_1