CHAPTER 3

3.4 EXPERIMENT 4 - DAILY MILK PRODUCTION OF SELECTION EWES AFTER THE REMOVAL OF THEIR LAMBS AT BIRTH

INTRODUCTION

In Experiment 2, a lamb-suckling technique was used to estimate milk production in early lactation. The procedure had several disadvantages, including variable errors in milk yield estimates associated with the lamb's ability to withdraw milk (Coomb et al., 1960; Peart, 1982). Significant effects of lamb genotype on ewe milk production have been demonstrated in Experiment 3. By removing the lambs at birth and totally milking the ewes by hand or machine using the oxytocin method (McCance, 1959), difficulties due to the variations in lambs' sucking stimuli would be avoided (Ricordeau and Denamur, 1962; Treacher, 1970). The present study therefore examines the influence of ewe genotype on daily milk production of selection line animals in the absence of any confounding lamb effects.

MATERIALS AND METHODS

ANIMALS

The 1984 weight selection ewes were oestrus synchronized in order to concentrate the lambings and thus minimize any "date of lambing" effects. Details of the management of the animals throughout joining and pregnancy were given in Experiment 1b. All ewes raddle marked by the rams at the second post-synchronizing oestrus were separated from the main flock on September 18 and allocated to the lambing paddocks. Each morning, the lambing paddocks were examined and newborn lambs indentified.

Lambing was due to commence on September 25, with 26W+, 32R, and 15W- ewes anticipated to lamb within the following 2 weeks. Only 9W- ewes produced single lambs between September 24 and October 6 and this dictated the experimental group size to be used. A corresponding number of W+ and R ewes lambing within the 12 days were thus selected for Experiment 4. The ewes and their lambs were removed from the lambing paddocks at approximately 3 p.m. each day; the lambs were then taken to be artificially reared, and the ewes made up the "milking mob" which grazed a native grass/white clover pasture throughout the study.

DETERMINATION OF MILK YIELD

The ewes were milked to obtain additional colostrum for the artificially reared lambs on the afternoon of Day 1 of lactation. Commencing on Day 2 of lactation and continuing until Day 40, the ewes were milked twice daily, beginning at 7:30 a.m. and 3:30 p.m. each day, using the oxytocin technique described in Experiment 1a. The milk volumes yielded by each ewe in the morning and afternoon milkings were recorded and combined to give an estimate of the 24-hour milk production.

The ewes were given approximately 0.5kg/animal/day sorghum grain at the completion of the morning milking. During lactation, the ewes were weighed on October 16 and November 19.

STATISTICAL ANALYSES

The finalized milking group consisted of 10W+, 10R, and 9W- ewes. The cumulative milk production curves of the selection line ewes were examined separately for differences in shape using a cubic polynomial of day of lactation as the independent variable. The fitted regression coefficients were then compared between lines as a test of homogeneity.

RESULTS

Mean daily milk production of the R ewes approached the levels of the W+ ewes, while the mean yields of the W- ewes were markedly lower (Figure 4.1). Apart from the daily fluctuations in yield, the three curves generally exhibited gradual increases to reach peak levels at approximately the fourth week of lactation. Milk production tended to decline after approximately Day 30 of lactation. For W-, mean peak yield was 37.6% below R. The comparable value for W+ was only 8.0% above R. Mean daily milk yields with their corresponding standard errors for the 3 selection lines are tabulated in Appendix 5.

The cumulative milk yield curves to Day 40 of lactation are represented in Figure 4.2; total cumulative production was 44.9 litres for W+, 41.2 litres for R, and 25.9 litres for W-. Over the 40 days of milking, W+ ewes thus produced 9.0% more milk and W- ewes 37.1% less milk than those of the R line.

The tests of the corresponding regression coefficients for homogeneity of lines (Table 4.1) showed that, in either the cubic or quadratic coefficients, the 3 selection lines were significantly ($P<0.05$) different in the functional form of the cumulative yield over time. Because cubic coefficients were not homogeneous, testing the elevations of the cumulative curves would not be meaningful.

The ewes gained 6.6-6.8% in liveweight between October 16 and

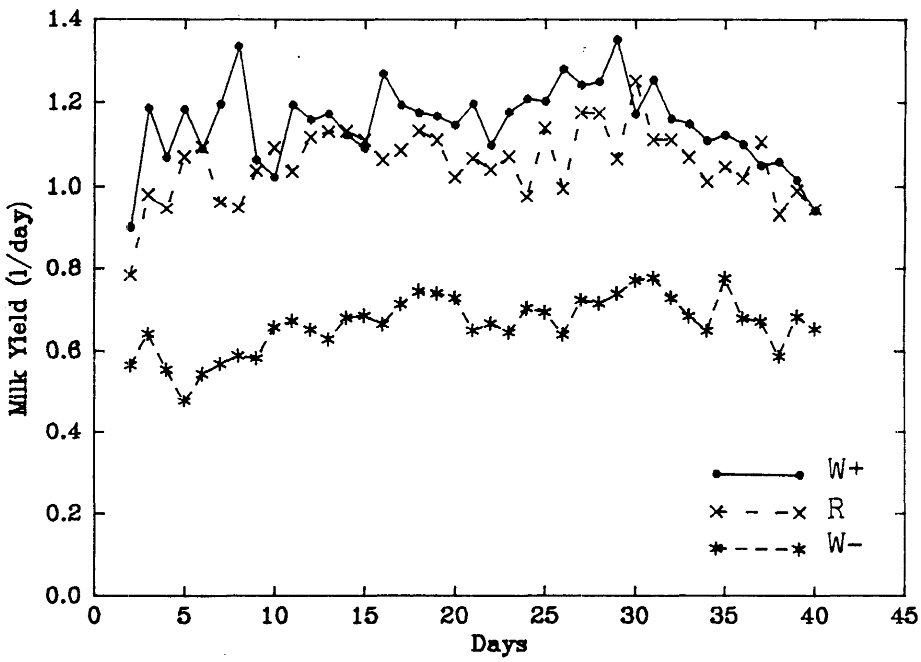


Figure 4.1. Mean lactation curves of the daily milked W+, R, and W- ewes.

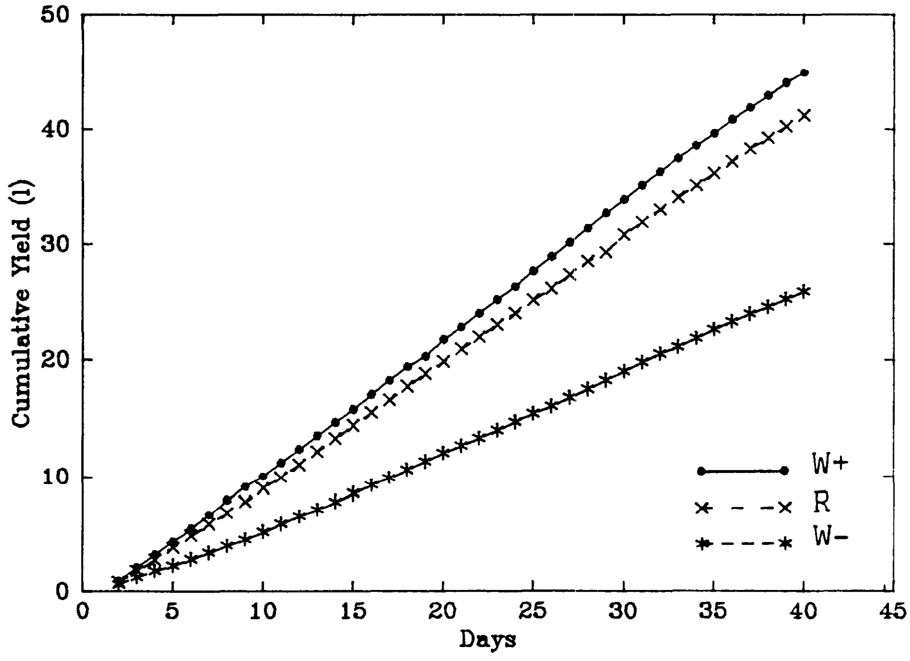


Figure 4.2. Cumulative lactation curves of the daily milked selection line ewes to Day 40 of lactation.

Table 4.1. Fitted regression coefficients[1] (±SE) for the polynomial functions of the cumulative selection line yields (d.f.=35).

	W+		R		W-	
	Regr. Coef	SD	Regr. Coef	SD	Regr. Coef	SD
Linear	1.03533	0.02527	0.97217	0.01971	0.49059	0.01139
Quadratic	0.00764	0.00137	0.00551	0.00107	0.00846	0.00062
Cubic	-0.00012	0.00002	-0.00008	0.00002	-0.00011	0.00001

1. All regression coefficients significant at the 0.1% level.

November 19 (Table 4.2), and at both times, differences between lines in ewe liveweight were significant (P<0.001). Table 4.3 presents the predicted peak yields, based on a function of metabolic liveweight (Taylor, 1973), and the actual mean peak yields recorded in Experiment 4. The recorded mean peak milk yields for all 3 selection lines were below the corresponding predicted values. This trend was particularly noticeable in the W- line, which had a mean peak of 31.6% lower than predicted.

Table 4.2. Mean liveweight during lactation with associated standard errors of the daily milked selection ewes.

	W+		R		W-	
Date	Mean	SE	Mean	SE	Mean	SE
October 16	45.8	1.2	38.8	1.0	32.2	1.1
November 19	48.8	1.4	41.4	1.0	34.5	1.3

Table 4.3. Mean ewe liveweights (±SE) in early lactation and predicted peak and mean peak yield (±SE) of the W+, R, and W- ewes milked daily.

	W+	R	W-
Mean ewe liveweight (kg)	45.8±1.2	38.8±1.0	32.3±1.1
Predicted peak yield (l/day)[1]	1.47	1.30	1.14
Mean peak yield (l/day)	1.35±0.09	1.25±0.10	0.78±0.07

1. Predicted peak yield (l/day): $0.09 \times W^{0.73}$ (Taylor, 1973).

DISCUSSION

Apart from daily variations in milk production, a general trend in the lactation profiles of the selection lines was observed. The W+, R, and W- lines showed a gradual increase in milk yield to peak levels, recorded on Day 29, 30, and 31, respectively. Differences in time of peak lactation were also revealed in earlier trials. The W- and R ewes studied in Experiments 1a and 1b recorded maximum milk yields earlier than the W+ ewes, suggesting that the time of peak production may be influenced by the lamb sucking stimulus. In addition, total milking may prolong the time to peak and assist in the maintenance of peak yield. The W+ animals in the current study exhibited a smaller initial peak in milk production on Day 8. Similar high levels for the W+ were also observed in Experiment 1a (on Day 12), 1b (Day 9), and 2 (Day 9). Therefore, it appears that the W+ ewes have a unique lactation profile.

A similar procedure for the determination of milk yields in mutton breeds was used by Treacher (1970), in which the ewes were milked twice daily at 16-hour and 8-hour intervals. The results of his study support the earlier findings of Ricordeau and Denamur (1962) that milk yield of ewes under machine milking was 60-80% of the yield of suckled ewes. The results of the present study are consistent with these findings. The respective mean peak yields of the W+, R, and W- ewes were 75-89%, 90-91%, and 62-74% of the yields of the suckled ewes of Experiments 1a, 1b, and 2. By way of comparison, the cumulative yield to Day 40 of lactation in the present study was markedly lower only for W- (63-80% of Experiments 1a, 1b, and 2 values).

Oxytocin (10 U.I.) was administered prior to each milking to stimulate milk ejection. A dose exceeding the endogenous level is usually required to elicit a normal milk release; this high level of oxytocin is probably necessary to overcome the blocking influence of the adrenal hormones associated with stress to the artificially milked ewe (Linzell, 1972). From the evidence available at the time, Doney et al. (1979) concluded that there is a long-term, cumulative effect of regular and repeated administration of oxytocin when used in a dairy context, although no significant galactopoietic effect had been found when oxytocin was used episodically. Little information is currently available on the relative difference in response of different breeds or strains of sheep to a standard dose of oxytocin. It is possible, therefore, that milk yield as well as lactation pattern may be influenced by oxytocin.

In 1984, ewe liveweight gains during lactation were seen in both suckled ewes (Experiment 1b) and machine milked ewes (Experiment 3), which indicates that the ewes were well nourished and had the opportunity to express their lactation potential. Although mean peak yields in the current work were below predicted values based on liveweight, only the W- deviated markedly. Hence, significant differences found in the milk production of the W+, R, and W- ewes after the effects of lamb genotype have been removed are not solely a function of ewe liveweight.

Experiments 1 through 4 in this thesis have focused on the influence of prolonged selection for weaning weight on ewe milk yield. Significant differences were revealed in the quantity of milk produced by W+, R, and W- ewes suckling single lambs as measured by either the oxytocin (Experiment 1) or lamb-suckling technique

(Experiment 2). The influences of lamb genotype (Experiment 3) and ewe genotype (Experiment 4) on milk yield were also significant. In addition to the volume of milk produced by the ewe, the chemical composition of milk of selection line ewes will be examined in the next experiment (Experiment 5).

3.5 EXPERIMENT 5 - THE COMPOSITION OF MILK OF SELECTION EWES

INTRODUCTION

As discussed in the review (Chapter 2.1.4) the composition of milk is known to vary with species and breed. However, little is known of possible strain effects within any one breed. In the dairy cattle literature, heritability estimates of the milk components are numerous, and in a review compiled by Maijala and Hanna (1974), average heritability estimates (95% C.I.) given for fat and protein percentages were 0.47 (0.43-0.52) and 0.48 (0.39-0.57), respectively.

In dairy goats and sheep, the heritability of milk production is comparable to that reported in dairy cows (0.30; Flamant and Casu, 1978), but estimates of the heritability of milk constituents are less numerous. Recently, Flamant and Morand-Fehr (1982) reported a mean heritability of "milk composition" to be between 0.60 and 0.80. Although the heritabilities of both milk yield and composition decrease in the second and third lactations (Flamant and Morand-Fehr, 1982), the published estimates remain relatively high (e.g. 0.24; Barker and Robertson, 1966).

Many authors have reported positive genetic correlations between milk yield and the yield of fat and protein. For example, Wilcox et al. (1971) found the correlation between milk yield and fat yield to be 0.70, and that between milk yield and protein yield to be 0.82. However, the percentages of fat and protein are negatively correlated with milk yield (Wilcox et al., 1971; Maijala and Hanna, 1974; Flamant and Casu, 1978). Thus, direct selection for quantity of milk would lower fat and protein percentages, yet increase the overall amount produced. In a study of ewe's milk, Ashton et al. (1964) obtained values of -0.27, -0.39 ($P<0.05$), and -0.47 ($P<0.05$) for the correlations between milk yield and percentages of fat, protein, and total solids, respectively.

Positive genetic correlations have also been reported between milk yield and weaning weight or body size (see Chapter 2.1.2), as the selection for weaning weight will increase liveweight at all other ages from birth to weaning (Barlow, 1978). In sheep, Pattie (1965b) found the gross correlation between ewe weight and milk volume to be approximately 0.33.

Therefore, it is possible that prolonged selection based on weaning weight, as has been practised in the Trangie flocks under current study, may have led to changes in milk composition, as well as in milk production. Animals selected for weaning weight would be expected to produce more milk but with a lower percentage of total solids. Evidence refuting this point was presented by Pattie and Trimmer (1964) in a study using twin rearing Merino ewes from the divergent weaning weight selection lines. Although increased milk yields were reported in the W+ line, no significant differences were detected in the percentages of fat, protein, and solids-not-fat between the selection lines after 5 generations, but trends in the data were visible, with overall higher percentages of fat and protein in the W+ milk than in the milk of the R line.

A survey of the English literature revealed no subsequent studies on the effects of selection for body weight (weaning weight) on milk composition in the domestic species.

If there are any real differences between lines, it would be expected that these would become more obvious as selection proceeds. The following experiment was thus conducted to establish if differences in milk composition between the W+, R, and W- lines exist in contemporary animals which have undergone a further 7 generations of selection since the study of Pattie and Trimmer (1964).

MATERIALS AND METHODS

SAMPLES

Individual subsamples of milk for compositional analyses were collected from the 62 ewes (29W+, 17R, and 16W-) of Experiment 1a. At the second milking at each of the 10 stages studied, the milk from each ewe was mixed, the volume was recorded, and an approximately 80ml subsample was taken. In order to preserve the samples during road transport to a laboratory with the required autoanalytical equipment, 300km distant, potassium dichromate ($K_2Cr_2O_7$, 1mg/ml) was added to the samples taken on September 9, 12, 15, 18 and 24. The samples containing preservative were thus identified as Lambing Period 1, Days of Lactation 4 and 10; Period 2, Days 4, 10, and 16; Period 4, Days 4 and 10; and Period 6, Day 4. These samples were stored at 4°C for up to 12 days until it transpired that the autoanalytical system, which could read a maximum of 10% protein and 15% fat, would not produce reliable results with ewe's milk. Consequently, its use was rejected in favour of older, manual techniques. All the above mentioned samples were then immediately frozen at -12°C for approximately 9 months until they could be analysed manually. All subsequent milk samples were frozen at -12°C within 24 hours and stored for approximately 6 months before being analysed.

Individual subsamples of milk were also collected from the 29 ewes (10W+, 10R, and 9W-) involved in the 1984 daily milking study described in Experiment 4. Samples were collected, in the same manner as described for the 1983 flock, on Days 1, 4, 10 and 16 of lactation, a period which corresponds to many missing data items in the 1983 study. The milk was frozen (-12°C) within 12 hours of collection and stored for up to 85 days until analysed manually for percent fat, protein, total solids, and ash.

CHEMICAL ANALYSES

$K_2Cr_2O_7$ Trials

Before proceeding with manual determination of milk constituents, one way analyses of variance on compositional data from milk samples containing $K_2Cr_2O_7$ were conducted to ascertain the preservative's effect on percent fat, protein, total solids, and ash.

Fat

The Gerber method was selected for the determination of percent fat. Walter (1967) described, in detail, the necessary apparatus and procedures. Two minor modifications were adopted in the current work: 10.94ml milk pipettes were used, and all samples were diluted 1:2 with distilled water in view of the fact that the available Gerber butyrometers measured a maximum of 8% fat. Sheep's milk reportedly contains higher percentages than this (e.g. 5.1-10.0% Ling et al., 1961). Actual percent fat was calculated as twice the butyrometer reading.

Since it was intended to analyse all samples for protein, total solids, and ash, as well as for fat, the Gerber method was chosen over a similar technique, the Babcock method, because the former requires less sample per analysis.

Protein

The Biuret method was used for total protein analysis. The procedure described by Layne (1957) was modified for analysis of milk as follows. Approximately 5ml of thoroughly mixed sample was centrifuged for 5 minutes at 3500rpm and the fat layer removed with a spatula. Exactly 1ml of skim milk was diluted to 10ml with distilled water. To duplicate 1ml samples of the diluted skim milk was added 2ml of 15% trichloroacetic acid to precipitate the proteins. After being allowed to stand for 5 minutes at room temperature, the tubes were centrifuged at 3500rpm for 5 minutes, the supernatant was discarded, and the protein precipitate was resuspended in 1ml 1N sodium hydroxide. Standard protein solutions were prepared as follows:

	Blank	Std.1	Std.2	Std.3	Std.4
Bovine albumin (ml) 10mg/ml	-	0.25	0.50	0.75	1.00
1N NaOH (ml)	1.00	0.75	0.50	0.25	-

After the addition of 6.0ml Biuret reagent (see Layne, 1957), all standards and tests were mixed and allowed to stand at room temperature for 30 minutes. Any fat remaining in the reaction mixture was cleared by shaking with 1.5ml diethyl ether and centrifuging at 3500rpm for 5 minutes in capped tubes. The aqueous phase was read at 540μm on a Gilford Auto Spectrophotometer. The instrument was calibrated with the prepared standard solutions. The average of the duplicates was taken as the protein percent of each sample.

Other than proteins, virtually no substances normally present in biological material contribute significantly to the Biuret reaction (Layne, 1957). The Biuret method was selected over the more commonly used, but time consuming, Kjeldahl procedure for the determination of total nitrogen when the number of samples (N=560) to be analysed was considered.

Total Solids

Total solids were determined by evaporation. Into each clean, preweighed 15ml porcelain crucible (W1), 5.0-5.1g well mixed milk sample was weighed to the nearest 0.001g (W2). The crucibles were then placed in a drying oven at 95°C for a minimum of 12 hours. After removal from the oven, the crucibles were cooled in a desiccator for a minimum of 30 minutes and weighed to the nearest 0.001g (W3). The percent total solids was calculated as:

$$\frac{W3 - W1}{W2 - W1} \times 100 = \%\text{ total solids}$$

Ash

Once the total solids had been determined, the crucibles containing the dried milk were ashed in a muffle furnace at 550°C for a minimum of 5 hours (as per Ashton et al., 1964; Peart, Edwards and Donaldson, 1975), cooled for 5-10 minutes, placed in a desiccator for 30 minutes, and then weighed to the nearest 0.001g (W4). The percent ash was calculated as:

$$\frac{W4 - W1}{W2 - W1} \times 100 = \%\text{ ash}$$

Duplicates that differed by greater than 0.4% for fat, protein, and total solids, and 0.08% for ash were reanalysed. Only 9 out of the 560 samples (<2%) collected were of insufficient volume to allow analyses for all constituents. These account for the discrepancy in the numbers (N) in Appendix 6.

STATISTICAL ANALYSES

Separate analyses of covariance were applied to the 1983 milk composition data at each of the 10 stages of lactation for the effects of selection line and lambing period, with ewe age as the covariate. To achieve equal groups (lambing period) within each of the selection lines and thus allow orthogonal analyses of variance, a small number of data items were omitted from the analyses. On Day 10, Period 4, the 3W+ and 2W- observations of fat, protein, total solids, and ash were omitted to balance the 2 missing R observations (see Table 1.1). Again on Day 76, Period 5, the remaining 1R and 2W- observations on fat, total solids, and ash were omitted to balance the 2 missing W+ observations (see Table 1.1). No analyses for total solids and ash were performed on Day 4 due to insufficient data. Changes in constituents over lactation were tested using regression analyses.

Similar analyses of covariance were applied at each of the 4 stages of lactation in 1984 with date of lambing and ewe age as covariates. The composition of colostrum (Day 1) was compared with milk of Day 4 using a t-test.

Least significant differences were used to compare means at those times when analyses revealed that line effects were significant.

RESULTS

POTASSIUM DICHROMATE

One way analyses of variance were performed on compositional data from milk samples containing 6 treatment levels of $K_2Cr_2O_7$ (0.5-3.0mg/ml, in 0.5mg/ml increments) and 2 control treatments. There were 3 replicates per treatment level. Between levels sums of squares were partitioned into regression and deviation about the regression line, using the concentration of $K_2Cr_2O_7$ as the independent variate. From the results presented in Table 5.1, it is apparent that the percentages of fat and protein were not significantly affected by the presence of the preservative. Therefore, preserved and non-preserved samples were treated in the same manner when chemically analysed for fat and protein. However, the percentages of both total solids and ash were significantly influenced by the concentration of $K_2Cr_2O_7$ present and thus a total of 80 samples that contained dichromate were omitted from the analyses of total solids and ash.

Table 5.1. One way analysis of variance of $K_2Cr_2O_7$ data.

a) Fat.

Source		d.f.		S.S.		M.S.		V.R.	
Between	Regression	7	1	0.0596	0.0105	0.0085	0.0105	2.24ns	2.76ns
	Deviation		6		0.0491		0.0082		2.16ns
Error			16		0.0600		0.0038		
Total			23		0.1196				

Table 5.1. Continued.

b) Protein.

Source		d.f.	S.S.		M.S.		V.R.	
Between	Regression	7	0.0314	0.0071	0.0045	0.0071	0.88ns	1.39ns
	Deviation			0.0243		0.0041		0.80ns
		1						
		6						
Error		16	0.0815		0.0051			
Total		23	0.1129					

c) Total Solids.

Source		d.f.	S.S.		M.S.		V.R.	
Between	Regression	7	0.1215	0.1003	0.0085	0.1003	11.6***	66.9***
	Deviation			0.0212		0.0035		2.33ns
		1						
		6						
Error		16	0.0241		0.0015			
Total		23	0.1456					

d) Ash.

Source		d.f.	S.S.		M.S.		V.R.	
Between	Regression	7	0.1373	0.1263	0.0196	0.1263	28.0***	180.4***
	Deviation			0.0110		0.0018		2.57ns
		1						
		6						
Error		16	0.0115		0.0007			
Total		23	0.1488					

ns - not significant *** $P<0.001$

DRYING TIME FOR SOLIDS

The drying curve for 5g milk in a 15ml crucible at 95°C is shown in Figure 5.1. Twelve hours was taken as the minimum time required to dry to a constant weight.

MILK COMPOSITION 1983

The mean percentages of fat, protein, total solids, and ash, with associated standard errors, for each line at the 10 stages of lactation are presented in Appendix 6. Table 5.2 summarizes these data and presents the mean composition of milk from each of the

Table 5.2. Mean composition of milk during lactation (±SE).

Line	Fat N	Fat (%)	Protein N	Protein (%)	Total Solids N	Total Solids (%)	Ash N	Ash (%)
W+	261	6.09±0.11	262	5.63±0.06	219	19.19±0.16	219	0.91±0.01
R	156	6.11±0.15	157	5.57±0.07	129	19.05±0.19	129	0.91±0.01
W-	141	6.19±0.16	141	5.57±0.08	123	19.42±0.26	123	0.90±0.01

selection lines in 1983.

Because of serial correlation in the sequential observations taken during lactation, separate analyses of covariance were conducted at each of the 10 stages of lactation. These analyses revealed that, except for percent total solids at Day 52 of lactation, differences between the W+, R, and W- lines in any of the constituents were not significant. A least significant difference

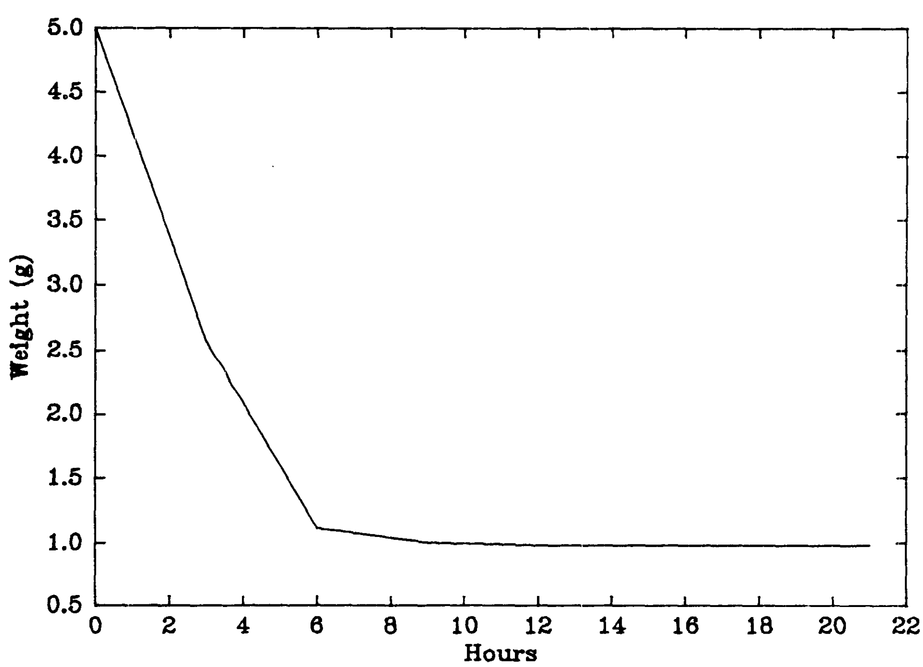


Figure 5.1. Average drying curve for 5g ewe's milk in a 15ml porcelain crucible at 95°C.

test, used at Day 52 to compare the means of total solids, showed that the mean percentage for W- (19.96) was significantly higher (P<0.05) than for W+ (18.67) but not significantly different from the mean of R (19.16).

Period of lambing had a significant effect on the composition of milk at many stages of lactation (Table 5.3). No overall analysis was undertaken as there appeared to be no obvious pattern in the significance levels attributed to between lambing periods over the 76 days of lactation. Significant interactions between selection lines and periods of lambing were present in only 4 of the analyses: for fat, Day 64; for protein, Days 4 and 10; and for ash, Day 76. As shown in Table 5.4, the covariate ewe age had a significant effect on

Table 5.3. Effect of period of lambing on milk constituents at intervals from Day 4 to Day 76 of lactation.

	Day of Lactation									
	4	10	16	22	28	34	40	52	64	76
Fat	*	*	**	ns	*	*	ns	***	***	ns
Protein	***	***	ns	ns	*	ns	ns	***	**	ns
Solids	-	ns	ns	ns	*	*	ns	***	***	ns
Ash	-	ns	ns	ns	*	**	ns	***	***	ns

ns - not significant * P<0.05 ** P<0.01 *** P<0.001

Table 5.4. Effect of ewe age as a covariate on milk constituents at each of the 10 stages of lactation studied.

	Day of Lactation									
	4	10	16	22	28	34	40	52	64	76
Fat	ns	*	ns	ns	ns	*	ns	ns	***	ns
Protein	ns	ns	*	ns	ns	**	*	ns	ns	ns
Solids	-	*	ns	ns	*	*	ns	ns	**	ns
Ash	-	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns - not significant * P<0.05 ** P<0.01 *** P<0.001

the analyses for fat, protein, and total solids at several stages. Once again, however, no obvious pattern in the significance levels was apparent. At no time did ewe age affect the analyses for ash.

For each line at each stage of lactation, the mean yield of total solids was calculated as the product of the mean percentage of total solids and the mean milk yield (see Appendix 1). As shown in Figure 5.2, the production of total solids was highest for the W+ ewes and lowest for the W- ewes at all times.

The effects of stage of lactation on milk composition with respect to fat, protein, total solids, and ash for each of the selection lines is illustrated in Figure 5.3. Fat and protein showed a similar pattern of change during lactation, declining in early days followed by an increase to levels exceeding those of early lactation.

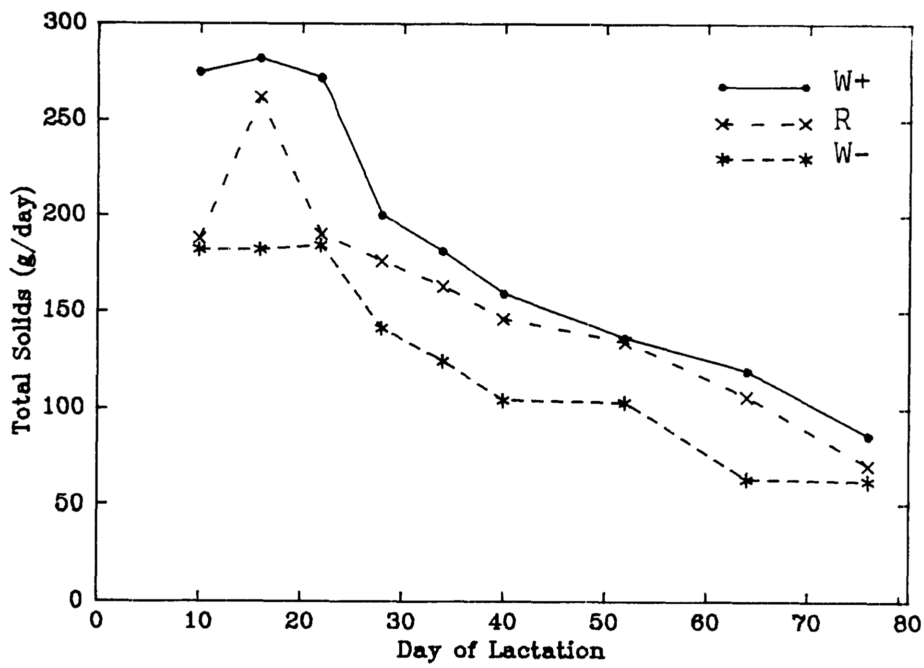
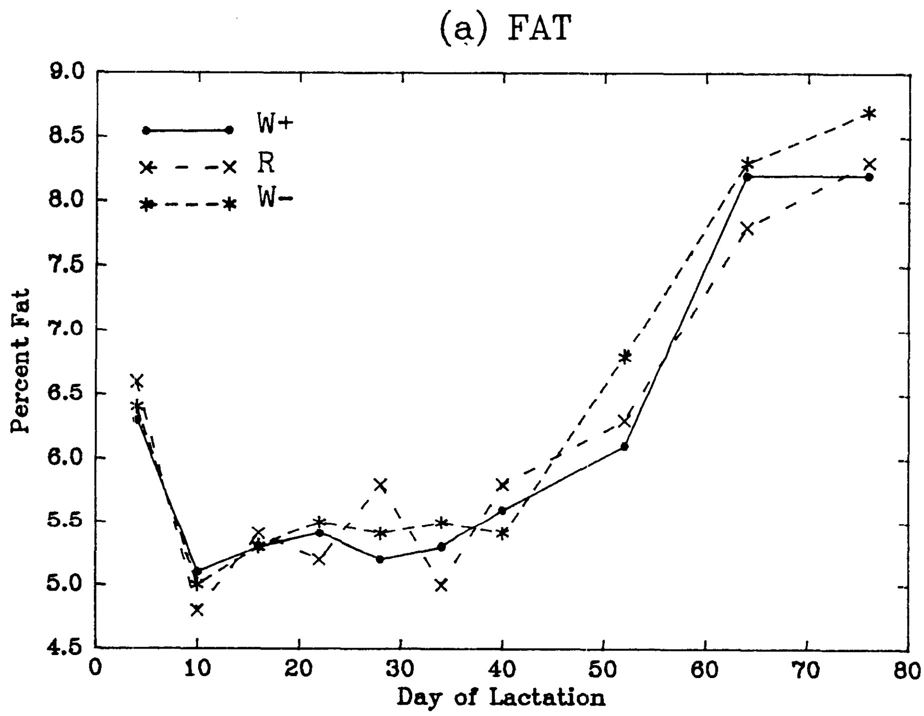


Figure 5.2. Mean yield of total solids for the W+, R, and W- ewes studied in 1983.



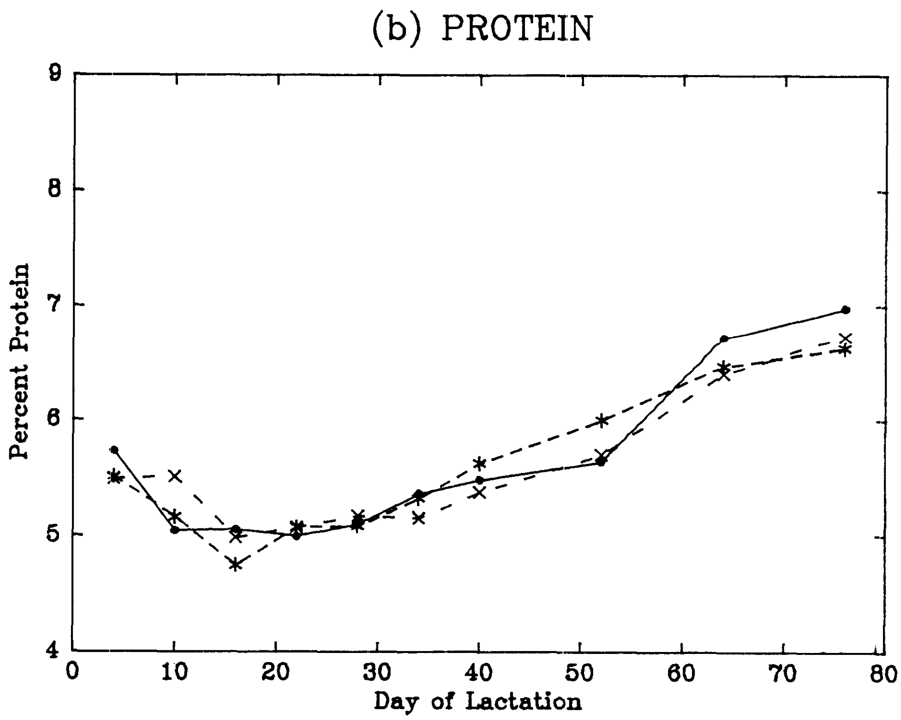
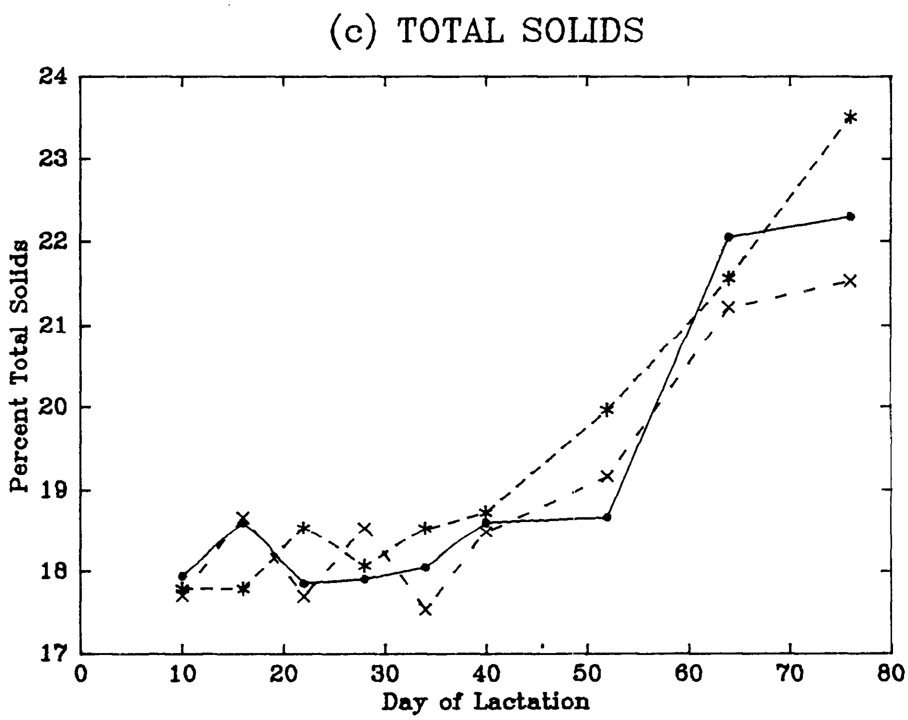


Figure 5.3. Effect of stage of lactation on milk composition 1983: a) fat b) protein c) total solids d) ash. (Data omitted prior to Day 10 for solids and ash due to small numbers. See pages 98 and 103.)



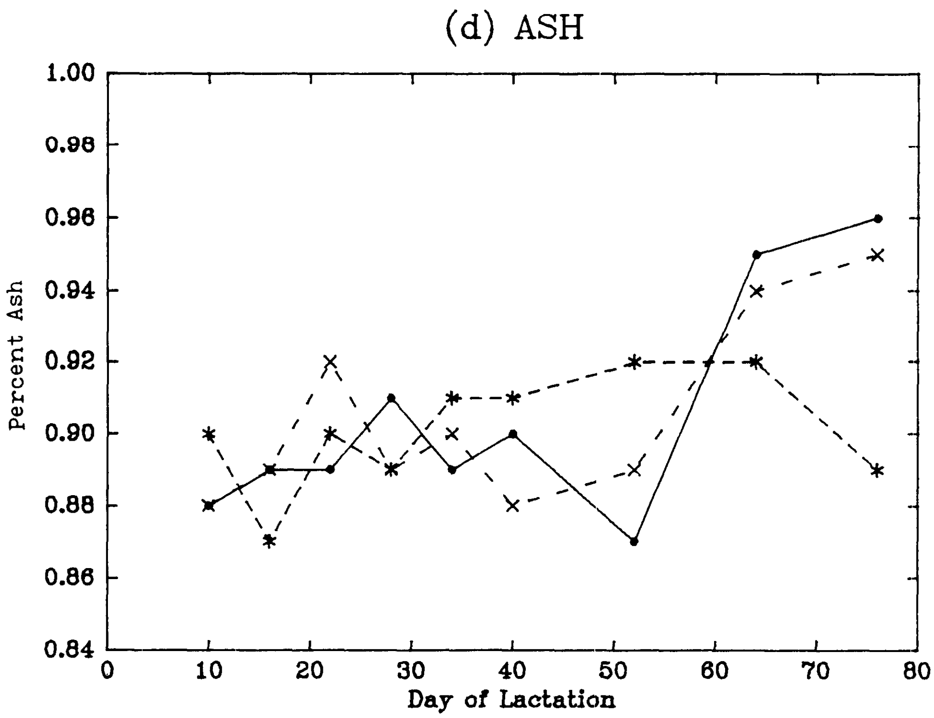


Figure 5.3. Continued.

Regression analyses testing homogeneity of slopes indicated significant increases ($P<0.001$) in fat and protein from Day 10 to Day 76 of lactation, with no significant differences between the slopes of the three selection lines. Results for total solids and ash were more variable in early lactation, primarily due to the small numbers of observations which resulted from samples being rejected because of the presence of $K_2Cr_2O_7$. On Day 4, the remaining 8 data items for both total solids and ash were subsequently eliminated. Regression analyses showed a significant increase ($P<0.01$) in total solids from Day 22 to Day 76, but not in ash. Both these constituents showed homogeneity of slopes in the W+, R, and W- lines.

MILK COMPOSITION 1984

Figure 5.4 illustrates the changes in milk composition over the first 16 days of lactation. The concentration of constituents other than ash declined in early lactation. Protein levels of colostral milk (Day 1) reached almost twice the levels in normal milk (Day 4; $P<0.01$). Percentages of total solids in the W+, R, and W- lines, and fat in the R line only were significantly higher ($P<0.05$) on Day 1 than on Day 4.

The mean percentages of the various milk constituents, with standard errors, for each line at Days 1, 4, 10, and 16 of lactation are included in Appendix 6. Separate covariate analyses for the effect of selection line revealed that at no time were ewe age and lambing date significant. Hence, analyses of variance without covariates were performed and the results are presented in Table 5.5. Least significant differences of the constituent means when the line

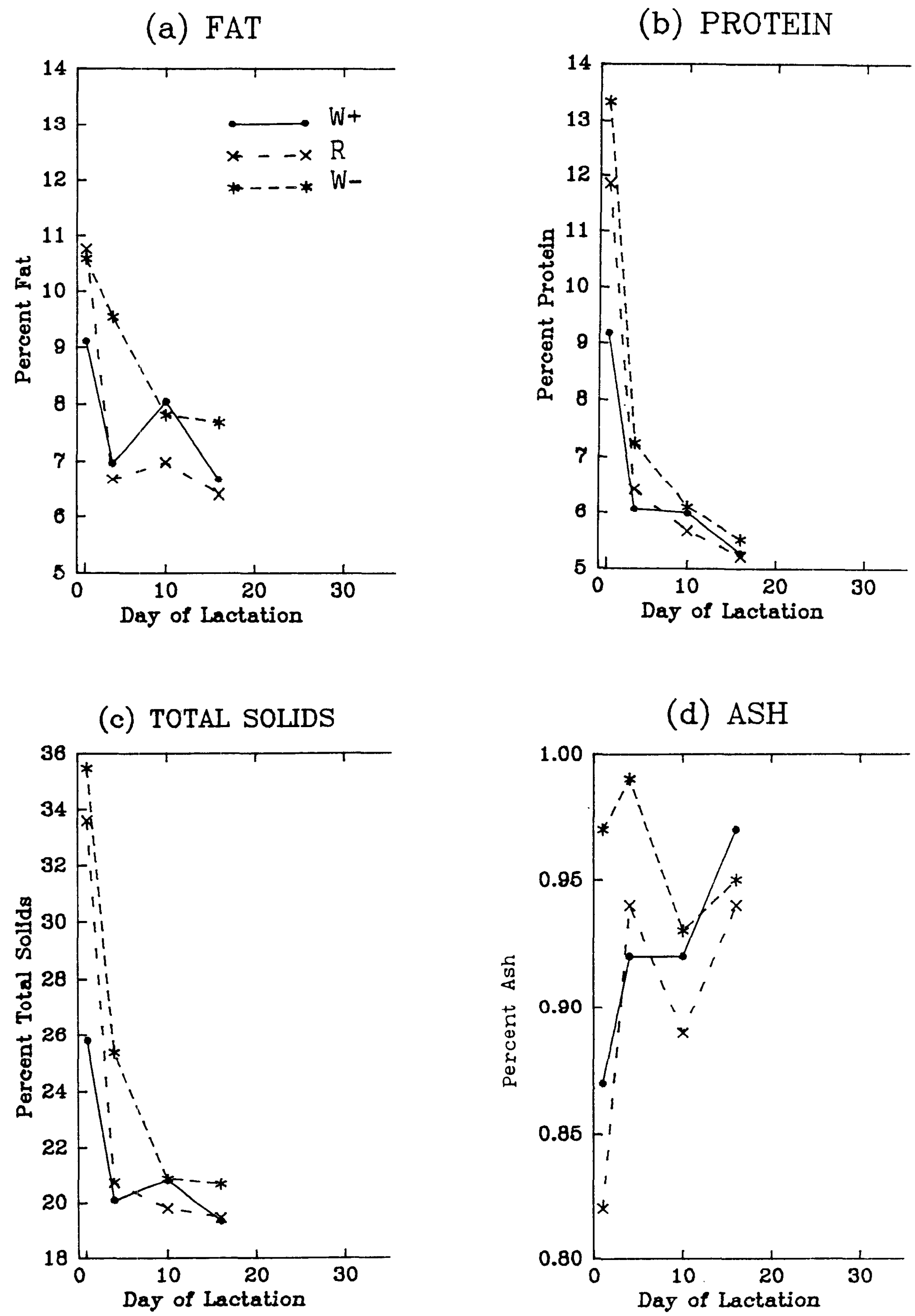


Figure 5.4. Effect of stage of lactation on milk composition in 1984: a) fat b) protein c) total solids d) ash.

effects were significant are shown in Table 5.6.

The mean yields of total solids shown in Table 5.7 were individually calculated from the mean percentages of total solids and the mean milk yields (see Appendix 5). The W+ and R ewes produced considerably more total solids than the W- ewes.

Table 5.5. The effects of selection line on milk constituents at each of the 4 stages of lactation studied in 1984.

	Day of Lactation			
	1	4	10	16
Fat	ns	*	ns	ns
Protein	*	**	ns	ns
Solids	*	*	ns	ns
Ash	*	**	ns	ns

ns - not significant   * P<0.05   ** P<0.01

Table 5.6. Least significant differences of constituent means. Means above a common line do not differ significantly (P<0.05).

Day of Lactation	Milk Constituent	Means (%) W+	R	W-
1	Protein	9.18	11.86	13.33
	Total Solids	25.79	33.60	35.46
	Ash	0.87	0.82	0.97
4	Fat	6.96	6.67	9.54
	Protein	6.06	6.40	7.24
	Total Solids	20.08	20.68	25.39
	Ash	0.92	0.94	0.99

Table 5.7. Mean yield of total solids (g/day) for the W+, R, and W- ewes studied in 1984.

Day of Lactation	W+	R	W-
4	215	194	140
10	212	216	138
16	245	208	136

DISCUSSION

The aim of this study was to determine if differences existed between selection lines in the nutritive value of the ewe's milk by examining its chemical composition. The results showed that while continued selection based on weaning weight has altered the volume of milk yielded (see Experiment 1a and 4), it has not led to significant differences between lines in the percentages of milk fat, protein, total solids, or ash. No significant correlated response to selection in milk composition is thus indicated. Preliminary results from a study examining the milk composition of weight selection Angus cows at the Agriculture Research Station at Trangie support the current findings. Difference in the percentages of fat, protein, and solids-not-fat were not apparent in the Trangie Angus data, although statistical analyses were not available prior to completion of this study (pers. com., Herd, 1985).

These results were unexpected in that there are established correlations between milk volume and constituents in both the literature for dairy cattle and sheep (e.g. Ashton et al., 1964; Wilcox et al., 1971). However, the current results were influenced by the large between-animal variation which may exceed any between-line variation. Further studies with increased numbers may provide significant results by reducing the between-animal variance.

1983 MILK COMPOSITION

The overall average composition of ewe's milk in 1983 was 6.12% fat, 5.60% protein, 19.21% total solids, and 0.91% ash, values which are within the range recorded in the literature (see page 27).

Fat content, reportedly the most variable constituent (Schmidt, 1971; Poulton and Ashton, 1972), ranged from 2.0-12.4% in post colostral milk. Foley et al. (1972) emphasized the great variability in the milk fat content of dairy cattle (up to 30% from unknown causes), and stated that differences between individuals within a breed are often greater than differences between breeds. Appendix 6 shows the standard errors of the mean fat percentages to be higher than those for the other constituents. The variability of fat and protein is, of course, reflected in total solids. Of the milk constituents, ash reportedly varies the least between individuals and between breeds (Corbin and Whittier, 1965), as indicated on page 23. Ling et al. (1961) reported ash in ewe's milk to range from 0.83 to 0.97%. Although values reported in the current work ranged from 0.53 to 1.21% ash, approximately 75% of these fell within the 0.80-1.00% range.

In examining trends over the 76 days of lactation, no one selection line had a consistently higher or lower percentage of milk constituents than any other line. Considering the latter half of this period, however, W- tended to have a higher percentage fat and total solids than both W+ and R, and reached significance ($P<0.05$) on Day 52 of lactation. These trends are consistent with Flamant and Morand-Fehr (1982) in that the concentration of total solids in sheep's milk depends upon the milk potential of the animal, and as production increases, the concentration of total solids decreases, particularly fat. If this were the case, a given volume of W- ewes' milk would have a higher nutritive value than that of either R or W+ ewes, and the net influence of the reduced milk production of the W- ewes would thus be decreased by this mechanism. However, the effect of this mechanism was small, as shown by the yield of total solids (Figure 5.2). On Day 52, for example, W+ produced 40.4% more milk than W-, and there was a 32.0% difference in the amount of total solids produced. For R, 34.6% more milk and 30.1% more solids than W- were produced. The yield of total solids (Figure 5.2) for each line followed a very similar pattern to the production of milk (Figure 1.1), with the W+ ewes superior over all stages of lactation.

The patterns of change of constituents during lactation (Figure 5.3) are in agreement with other authors. Corbett (1968) and Peart, Edwards and Donaldson (1975) found that fat and protein contents declined in the early weeks of lactation, then rose to their highest values recorded at the end of lactation. Significant increases in fat, protein, and total solids as lactation advanced reported in the present study are consistent with the findings of Ashton et al. (1964), Poulton and Ashton (1970), Wilson et al. (1971), and Torres-Hernandez and Hohenboken (1979).

Compared with the milk composition of the weight selection lines determined by Pattie and Trimmer (1964), two main differences in the 1983 results were evident: the overall percentages of fat were lower, and the total solids in the current experiment tended to be higher than the combined values of the percent fat and solids-not-fat in the study of Pattie and Trimmer in the latter half of lactation (Figure 5.5). Discrepancies between these two studies are confounded by the effects of environment, nutrition, and possibly sampling technique. In the work of Pattie and Trimmer (1964), R milk was consistently, but not significantly, below W+ and W- milk in percentage fat and in the combined percentage of solids-not-fat and

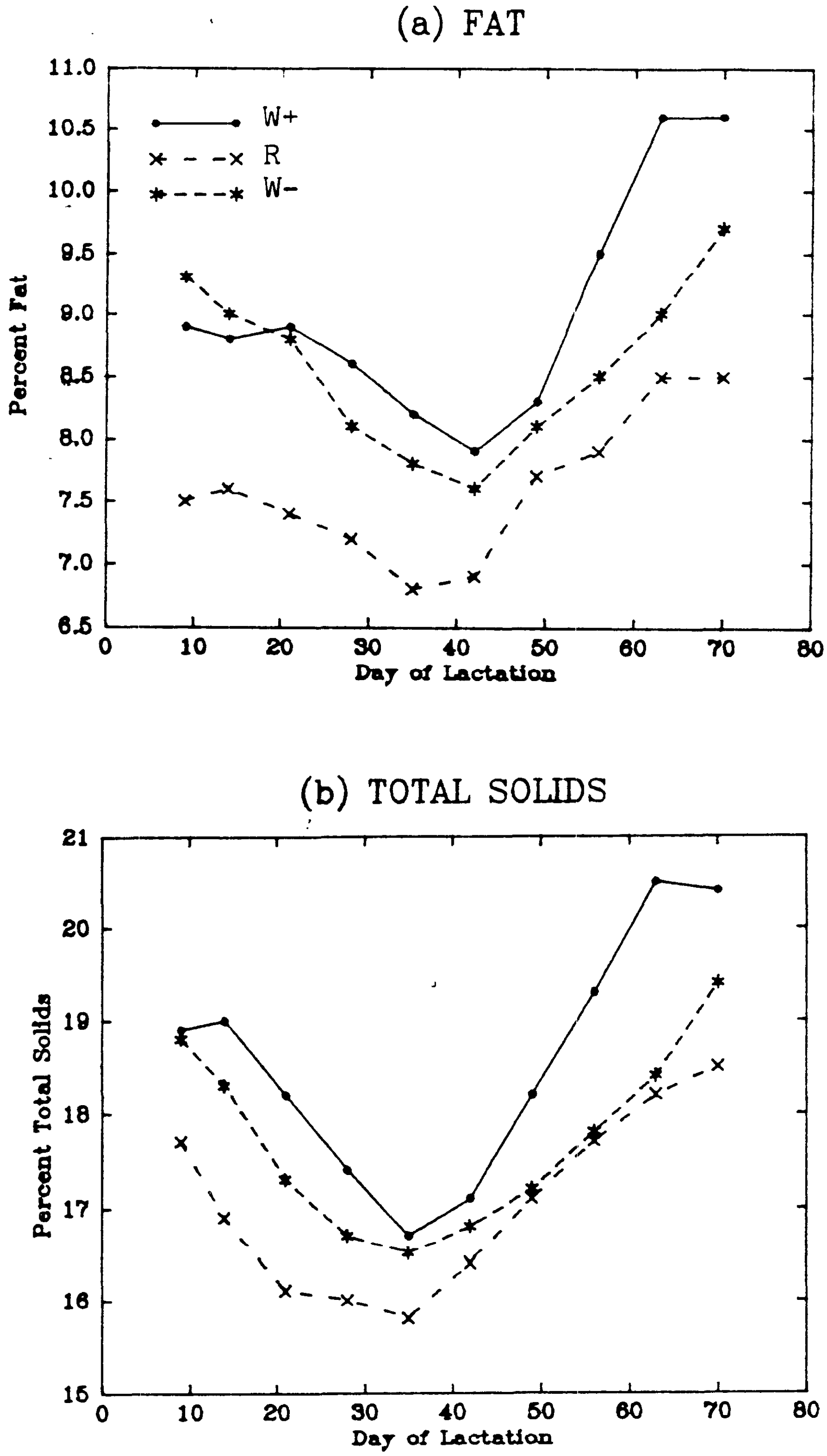


Figure 5.5. Mean percentages of milk constituents obtained by Pattie and Trimmer (1964): a) fat b) total solids (fat and solids-not-fat combined).

fat. The results in the current study showed no distinction between R and the two weight selected lines (Figure 5.2).

1984 MILK COMPOSITION

In 1984, analyses were conducted on samples taken from Day 1 to Day 16 of lactation in order to gain more information on early lactation, a period which had been affected by missing observations and the problems of analysing samples containing $K_2Cr_2O_7$ in 1983. Significant differences found between selection lines in the composition of colostrum (Day 1, Table 5.6) may be misleading because of the times at which colostrum samples were collected. Some ewes lambed almost 24 hours before the first milk sample was taken, while others lambed only a few hours prior to collection. As mentioned in Chapter 2.1.3, the composition of colostrum changes very quickly. In ewe's milk, Noble et al. (1970) demonstrated a decrease in fat from 17.9% immediately post partum to 10.4% by the second day. In cow's milk, fat content may drop from 6.9 to 3.4% within 24 hours (Corbin and Whittier, 1965). Nevertheless, the significant results obtained (Table 5.5 and 5.6) suggest a more detailed study of early lactation is warranted, with a standardized time of colostrum sampling recommended.

At Day 4 of lactation, the W- line had significantly ($P<0.05$) higher percentages of all constituents than the other two lines (Tables 5.5 and 5.6), yet the total yield of each constituent was still considerably less for the smaller ewes due to the smaller volume of milk produced. For example, the yield of total solids for W- ewes on Day 4 was 34.9% below that of W+ ewes (Table 5.7). Between-line differences in the concentration of constituents became non-significant by Day 10, so that any benefit the smaller W- lambs may get from the increased nutritive value of their dam's milk in early lactation is likely to be short-term.

Although between-year effects could not be analysed because different animals were used in 1983 and 1984, it was observed that percentages of all constituents in early lactation were higher in the second year, in which the ewes were maintained on a higher plane of nutrition (see Experiment 4). The results therefore suggest that year (nutritional) effects on milk composition are likely to be greater than those associated with selection responses.

OTHER FACTORS AFFECTING MILK COMPOSITION

The major factors affecting the composition of milk have been reviewed in Chapter 2.1.4.

Although many experiments regarding milk composition have involved the use of oxytocin, very few authors have considered the effects of the hormone on the rates of secretion of the milk constituents. Wheelock et al. (1965) found that increases in the secretion of sodium, chloride, and whey proteins following oxytocin injections were due to the direct effect of oxytocin on the permeability of the mammary epithelium. Assuming oxytocin has a similar effect on the ovine mammary epithelium, prolonged administration of oxytocin, as in Experiments 1a and 4, may cause the milk to adopt an uncharacteristic chemical composition. Further investigations in this area with sheep are necessary to clarify this point.

The possibility that the composition of milk in the study of Pattie and Trimmer (1964) and in this study was influenced by the difference in the number of lambs suckled seems unlikely in view of the findings of Peart, Edwards and Donaldson (1975), in which no significant differences between single and multiple suckled ewes in any of the 4 milk constituents were found. Similar findings have been reported more recently by Torres-Hernandez and Hohenboken (1979) and Wohlt et al. (1981).

Ashton et al. (1964) concluded that the different techniques employed in milking contribute to the great variation in the fat content of ewe's milk found by various workers. The fat content of milk varies during milking or suckling, for example in dairy cattle, from 1-2% in the first drawn milk to 8-15% in the last strippings (Rathore, 1976), and in sheep, from 6.5 to 7.4% ($P<.001$; Peart et al., 1972). Barnicoat (1949a) found that fat percentages in ewe's milk rises during milking, not however in any regular manner. Attempts were thus made in the present study to ensure the milk was mixed before subsamples were taken. Hence, it is unlikely that variations in composition within each milking affected the results to a significant extent.

There is no evidence to the author's knowledge that the length of time that samples are frozen affects in any way the compositional results. It may be argued, however, that the analytical methods used in a study such as this could influence the results obtained, though any consistent bias would presumably not have influenced the present between-strain comparisons.

The results of Experiment 5 indicate no significant differences between the W+, R, and W- lines in the overall nutritive value of the milk and presumably differences revealed in the survival and growth of lambs of the selection lines (see Chapter 4) are primarily related to factors other than the composition of the ewes' milk. The W- ewes tended to have higher percentages of constituents in early lactation, and the possibility that these differences could be of significance to the survival of W- lambs warrants further investigation.

3.6 EXPERIMENT 6 - CORRELATION BETWEEN LAMB GROWTH AND EWE MILK PRODUCTION

INTRODUCTION

Many investigations have established that the preweaning growth of lambs is largely dependent on the milk production of their dams (e.g. Neidig and Iddings, 1919; Robinson et al., 1969; Kilkenny, 1978). Correlations coefficients of 0.67-0.80 between lamb growth and ewe milk yield, measured by either the oxytocin or lamb-suckling technique have been reported by Moore (1962) and Slen et al. (1963). Whiting et al. (1952) and Coombe et al. (1960) found the correlation to be highest in early lactation when the milk supply of the ewe dictates lamb growth. After approximately 6-8 weeks, when the rumen is fully functional, the lamb increases its herbage intake and hence the contribution of milk supply to lamb growth is reduced (Owen, 1957; Hodge, 1966). For Merino sheep, Scales (1968) reported correlation coefficients of 0.78 ($P<0.05$) for 0-6 weeks of lactation, -0.04 ($P>0.05$) for 6-12 weeks, and overall 0.37 ($P>0.05$) for 0-12 weeks of lactation.

Pattie (1965b) demonstrated signficant gross correlations between lamb growth and milk volume, and total yield of protein for the W+, R, and W- selection lines ($r=0.57$ for both; $P<0.01$), yet the individual line correlations were not given. Experiment 6 investigates the correlations between milk production of each previously studied ewe group and the preweaning growth of their lambs. Since no significant differences in milk composition were shown between selection lines (see Experiment 5), only the milk volume was considered in the correlations, as the total yield of protein would be proportional to total milk yield.

MATERIALS AND METHODS

ANIMALS

All ewes involved in the previous lactation studies reared single lambs. In 1983, 29W+, 17R, and 16W- (see Experiment 1a) and 11R+ and 13R- ewes and their lambs (see Experiment 3a) were studied at Armidale. The lambs were weaned on December 12. In the following year, 7W+, 7R, and 7W- (see Experiment 1b) and 14ET+ and 15ET- ewes and lambs (see Experiment 3b) at Armidale were used. The ET lambs were weaned October 22, while the selection flock lambs were weaned on December 6. The 6W+, 8R, and 1W- ewes and lambs at Trangie (see Experiment 2) were also studied, and weaning took place on November 28.

Lamb weights were recorded at birth and at weaning. In addition, the 1983 selection flock lambs were weighed on Day 40 of lactation (approximately 6 weeks of age).

STATISTICAL ANALYSES

Three lambs died prior to weaning: 1W+ and 1W- in 1983, and 1ET+ in 1984. Data associated with these animals were discarded. Separate analyses of variance were conducted on birthweights, weaning weights, and growth rates to weaning for the effects of selection line. Correlation coefficients were calculated between lamb growth rates and ewe milk yields which were determined in the aforementioned experiments.

RESULTS

Mean growth rates of the 1983 selection line lambs and correlations between lamb growth and milk production are given in Table 6.1. The mean rate of growth of the W- lambs was only two-thirds that of the R and W+ lambs. Similar correlation coefficients were recorded for the W+ and R lines, but only the W+ coefficients reached significance. Growth rate to weaning had a higher correlation with cumulative yield than did growth rate to Day 40 for all 3 lines.

Mean growth rates of the 1984 selection lines were substantially higher than the previous year, as shown in Table 6.2. The only significant positive correlation found was between growth rate to weaning and peak milk yield for W+. Interestingly,

Table 6.1. Mean birthweights, weaning weights, and growth rates (±SE) of the selection lambs in 1983, and correlations between lamb growth rates and ewe milk production (see Experiment 1a).

	W+	R	W-	Line
Birthweight (kg)	4.6±0.1	4.0±0.1	3.2±0.1	***
Weaning weight (kg)	16.7±0.8	15.2±0.7	10.7±0.6	***
Growth rate to weaning (g/day)	124±9	123±7	82±6	***
Correlation coefficient between				
Growth rate to Day 40: Peak milk yield	0.45*	0.40ns	0.33ns	
Growth rate to weaning: Peak milk yield	0.36ns	0.31ns	0.34ns	
Growth rate to Day 40: Cumulative yield to Day 40	0.43*	0.43ns	-0.06ns	
Growth rate to weaning: Cumulative yield	0.57**	0.44ns	0.18ns	

ns - not significant * P<0.05 ** P<0.01 *** P<0.001

Table 6.2. Mean birthweights, weaning weights, and growth rates (±SE) of the selection lambs in 1984, and correlations between lamb growth rates and ewe milk production (see Experiment 1b).

	W+	R	W-	Line
Birthweight (kg)	4.2±0.2	3.4±0.1	3.4±0.2	***
Weaning Weight (kg)	22.8±0.9	18.8±1.0	17.2±0.3	***
Growth rate to weaning (g/day)	218±9	183±9	163±5	***
Correlation coefficient between				
Growth rate to weaning: Peak milk yield	0.85*	0.57ns	-0.70ns	
Growth rate to weaning: Cumulative yield	0.59ns	0.70ns	-0.83*	

ns - not significant   * P<0.05   *** P<0.001

high negative correlation coefficients for W- were recorded.

No significant correlations were shown between growth rate and milk production in the W+ and R lines at Trangie (Table 6.3). Mean growth rates of the W+ and R lambs reared at Trangie were comparable to those reared at Armidale in 1984 (Table 6.2).

Significant correlation coefficients were demonstrated for the R- line, as shown in Table 6.4. For the ET flock, however, significant correlations between lamb growth and milk production were found for the ET+ line.

The ET lambs had the highest preweaning growth rates of all lambs (Table 6.5).

No relationship was apparent in the correlations between growth rate to weaning and peak milk yield, and growth rate to weaning and cumulative milk yield.

Table 6.3. Mean birthweights, weaning weights, and growth rates (±SE) of the selection lambs at Trangie, and correlations between lamb growth rates and ewe milk production (see Experiment 2).

	W+	R	W-[1]	Line[2]
Birthweight (kg)	4.9±0.3	3.9±0.2	3.0	*
Weaning weight (kg)	30.7±1.4	23.9±1.3	14.2	**
Growth rate to weaning (g/day)	218±10	168±10	94	**
Correlation coefficient between Growth rate to weaning: Peak milk yield	0.30ns	-0.07ns		
Growth rate to weaning: Cumulative yield	0.28ns	0.35ns		

ns - not significant * $P<0.05$ ** $P<0.01$

1. Insufficient data to calculate standard error or correlation coefficients.
2. W- data not included in analyses of variance.

Table 6.4. Mean birthweights, weaning weights, and growth rates (±SE) of the R+ and R- lambs , and correlations between lamb growth rates and ewe milk production (see Experiment 3a).

	R+	R-	Line
Birthweight (kg)	4.1±0.1	3.9±0.1	ns
Weaning weight (kg)	15.7±0.9	13.9±0.8	ns
Growth rate to weaning (g/day)	134±9	116±9	ns
Correlation coefficient between Growth rate to weaning: Peak milk yield	0.57ns	0.67*	
Growth rate to weaning: Cumulative yield	0.43ns	0.79**	

ns - not significant * $P<0.05$ ** $P<0.01$

Table 6.5. Mean birthweights, weaning weights, and growth rates ($\pm$SE) of the ET lambs, and correlations between lamb growth rates and ewe milk production (see Experiment 3b).

	ET+	ET-	Line
Birthweight (kg)	4.2$\pm$0.2	3.7$\pm$0.1	*
Weaning weight (kg)	22.6$\pm$0.5	18.2$\pm$0.6	***
Growth rate to weaning (g/day)	301$\pm$6	233$\pm$8	***
Correlation coefficient between			
Growth rate to weaning: Peak milk yield	0.69**	0.28ns	
Growth rate to weaning: Cumulative yield	0.64*	0.25ns	

ns - not significant * P<0.05 ** P<0.01 *** P<0.001

DISCUSSION

The results of this study do not agree with those previously reported in which strong relationships between growth rate and milk yield were found in early lactation. In 1983, the correlations between growth rate to weaning and cumulative milk yield were higher than those between growth rate and milk yield to Day 40 for all 3 selection lines. These values, however, were only significant for one line. Lack of significant correlations in early lactation may be due partly to low experimental numbers which add to the error of the estimates. In addition, the 1983 correlations may not be truly representative, perhaps resulting from random seasonal effects on milk intake and lamb growth in that year. Continued research with increased numbers of experimental animals is thus indicated to substantiate the current findings.

Significant positive correlations between lamb growth and ewe milk production were recorded for the W+ and ET+ lines, suggesting that the efficiency of conversion of milk to live weight gain is higher for the more rapidly growing lambs. The results of the R+ and R- lines failed to support this hypothesis. However, only half the genetic make-up of these lambs is from the weight selection lines and it may be the random maternal genetic component that has a major influence on the growth efficiency of the lambs.

Further investigations of the underlying mechanisms which have led to the differences in weaning weights in these particular lines is required. It is reasonable to assume that the hormone mechanisms which regulate growth may have been altered during selection for growth. These weight selection lines are an ideal source of animals to further examine the fundamental endocrine mechanisms that control both lactation and lamb growth.