Effects of maturity of silage and protein content of concentrates on milk production of ewes rearing twin or triplet lambs

A. Roy[1,3], J. P. Laforest[1], F. Castonguay[2,4,5], and G. J. Brisson[1]

[1]*Département des sciences animales, Université Laval, Sainte-Foy, Québec, Canada G1K 7P4;* [2]*Dairy and Swine Research and Development Centre, Agriculture and Agri-Food Canada, Lennoxville, Québec, Canada JIM 1Z3.* *Received 9 April 1999, accepted 28 July 1999*

Roy, A., Laforest, J. P., Castonguay, F. and Brisson, G. J. 1999. **Effects of maturity of silage and protein content of concentrates on milk production of ewes rearing twin or triplet lambs.** Can. J. Anim. Sci. **79**: 499–508. Fifty-one Outaouais Arcott ewes were used to study the effects of silage maturity, protein level and number of lambs suckled on milk production and lamb growth in a $2 \times 2 \times 2$ factorial design experiment. Ewes were given ad libitum access to either an early-bloom (EB) or full-bloom (FB) bromegrass silage supplemented with 725 g d^{-1} of a 15 or 21% CP concentrate. Number of lambs suckled were two or three per ewe. During the 6 wk of lactation, ewes receiving the EB silages consumed more DM (2.07 vs. 1.74 kg d^{-1}, $P < 0.01$), and gained more (1.3 and –2.7 kg, $P < 0.05$) than ewes fed FB. Ewes that raised three lambs had greater silage intake (2.00 vs 1.86 kg d^{-1}) and lost more weight during lactation (–2.8 vs. +0.3 kg) than those suckling twins. Milk yields of ewes offered the EB and FB silages were 2.42 and 2.28 kg d^{-1}, respectively ($P < 0.05$), for the first 4 wk of lactation. Ewes that raised three lambs produced less milk (2.25 vs. 2.43 kg d^{-1}) than those nursing twins ($P < 0.05$). Milk fat content (8.2%) was not influenced by treatments, whereas milk protein content was higher ($P < 0.05$) from ewes receiving the EB silage compared with the FB silage (5.05 vs. 4.76%). At 4 and 6 wk of age, twin lambs were 2.6 kg (9.5 vs. 6.9 kg) and 3.5 kg (12.0 vs. 8.5 kg) heavier ($P < 0.01$) than triplet lambs for EB and FB silages, respectively. However, at the end of the 6-wk period, ewes nursing triplets weaned 1.3 kg more lambs than did ewes nursing twins ($P < 0.05$). Lambs from ewes that received the EB silage were 1.1 kg heavier at 6 wk ($P < 0.05$) than those from ewes fed with the FB silage. Also, lambs from ewes receiving the 21% CP concentrate were 1.1 kg heavier at 6 wk ($P < 0.05$) than the lambs from ewes fed the 15% CP. Litters were heavier at 6 wk with 21% CP concentrate compared with 15% (25.1 vs. 24.1 kg, $P < 0.05$), and triplet litters were heavier ($P < 0.01$) than twin with the EB silage. Within litter weight variation (weight difference between the biggest and the smallest lambs in a litter) proved to be greater ($P < 0.05$) with triplets (4.2 kg) than twins (2.2 kg). In conclusion, providing a higher quality silage (lower ADF and higher CP contents) improved ewe feed intake, milk production, lamb growth and litter weight, while feeding a higher protein concentrate only improved lamb growth with the lower quality silage.

Key words: Ewe, lamb, growth, milk production, silage, protein, triplet

Roy, A., Laforest, J. P., Castonguay, F. et Brisson, G. J. 1999. **Effets de la maturité de l'ensilage et du niveau de protéines du supplément sur la production laitière de brebis allaitant deux ou trois agneaux.** Can. J. Anim. Sci. **79**: 499–508.Cinquante et une brebis Arcott Outaouais ont été utilisées dans une étude factorielle $2 \times 2 \times 2$ sur les effets de la maturité de l'ensilage, du niveau de protéines du supplément et du nombre d'agneaux allaités sur la production laitière et la croissance des agneaux. Les brebis étaient alimentées avec de l'ensilage de brome récolté au stade début épiaison (DE) ou épiaison totale (ET), distribué à volonté, qui était supplémenté avec 725 g j^{-1} d'un concentré contenant 15 ou 21% de protéines brutes (PB). Les brebis allaitaient deux ou trois agneaux. Durant les 6 sem de lactation, les brebis alimentées avec l'ensilage DE ingéraient plus de matière sèche (MS) que celles recevant l'ensilage ET (2.07 vs 1.74 kg, $P < 0.01$) et obtenaient un gain de poids supérieur (1.3 vs –2.7 kg, $P < 0.05$). Les brebis qui ont élevé trois agneaux ingéraient plus d'ensilage (2.00 vs 1.86 kg j^{-1}) et ont perdu plus de poids (–2.8 vs 0.3 kg) que les brebis allaitant deux agneaux. Pour les 4 premières sem de lactation, la production laitière des brebis recevant l'ensilage DE était supérieure à celle des brebis alimentées avec l'ET (2.42 vs 2.28 kg j^{-1}, $P < 0.05$). Les brebis allaitant trois agneaux ont produit moins de lait que celles qui en élevaient deux (2.25 vs 2.43 kg j^{-1}, $P < 0.05$). Le contenu en gras du lait n'a pas été influencé par les traitements (8.2%), alors que le niveau de protéines du lait était plus élevé pour les brebis alimentées avec l'ensilage DE comparativement à celles recevant le ET (5.05 vs 4.76%, $P < 0.05$). À 4 et 6 sem d'âge, les agneaux élevés en couple étaient 2.6 kg (9.5 vs 6.9 kg) et 3.5 kg (12.0 vs 8.5 kg) plus lourds ($P < 0.01$) que les agneaux élevés à trois. Cependant, à la fin des 6 sem de lactation, les brebis qui ont élevé des triplets ont sevré 1.3 kg d'agneaux de plus ($P < 0.05$) que les brebis élevant deux agneaux.

[3]*Present address: Grober Inc., 162 Savage Drive, Cambridge, Ontario, Canada N1T 1S4.*
[4]*Present address: Département des Sciences Animales, Faculté des Sciences de l'Agriculture et de l'Alimentation, Université Laval, Sainte-Foy, Québec, Canada G1K 7P4.*
[5]*To whom requests for reprints should be sent. E-mail: francois.castonguay@san.ulaval.ca*

Abbreviations: **ADF,** acid detergent fiber; **CP**, crude protein; **DM**, dry matter; **DMI**, dry matter intake; **EB**, early-bloom silage; **FB**, full-bloom silage; **ME**, metabolizable energy; **NDF**, neutral detergent fiber

De plus, les agneaux allaités par les brebis recevant l'ensilage DE étaient 1.1 kg plus lourds à 6 sem que les agneaux des brebis alimentées avec l'ensilage ET ($P < 0.05$). Les agneaux des brebis recevant le concentré à 21% PB étaient également plus lourds de 1.1 kg à 6 sem comparativement à ceux dont les mères recevaient le concentré à 15% PB ($P < 0.05$). Le poids de la portée à 6 sem était supérieur pour les brebis recevant le concentré à 21% PB comparativement au supplément à 15% (25.1 vs 24.1 kg, $P < 0.05$) et les portées de triplets étaient plus lourdes que les jumeaux pour les brebis recevant l'ensilage DE. La différence de poids entre l'agneau le plus lourd et le plus léger à l'intérieur d'une même portée était plus importante dans les portées de triplets que dans les portées de jumeaux (4.2 kg vs 2.2 kg, $P < 0.05$). En conclusion, alimenter des brebis avec un ensilage de bonne qualité (faible niveau ADF et contenu en PB élevé) augmente la prise alimentaire, la production laitière, la croissance des agneaux et le poids de la portée, alors que servir un concentré riche en protéines n'est profitable que pour les brebis qui reçoivent un ensilage de moindre qualité.

Mots clés: Brebis, agneaux, croissance, production laitière, ensilage, protéines, triplet

In commercial flocks, an increasing proportion of ewes give birth to three lambs due to the introduction of prolific breeds, such as the Romanov, Finnish Landrace or the new Outaouais Arcott. Typically, the third lamb is raised on artificial milk which increases feed costs and labor. If milk production were increased, then the ewe could feed all three lambs and the cost of production would be less.

Ewes increase their milk production by about 40% when rearing two lambs compared with one (Gardner and Hogue 1964; Treacher 1983). However, a similar increase in milk production when litter size increases from two to three is harder to obtain. Loerch et al. (1985) found an increase of 28% in milk production for ewes rearing triplets compared with ewes rearing twins. Treacher (1985) reviewed the literature on the subject and reported increases of 5 to 20%, though not always significant. Recent research showed that triplet rearing ewes do not always have higher milk yields (Gallo and Davies 1991; Petit 1997). Owen (1976) concluded that almost maximum stimulation of the mammary gland is already obtained with twin lambs.

Generally, with enough metabolizable energy in the diet to sustain a milk production of 3 kg ewe^{-1} d^{-1}, microbial proteins alone are not sufficient to fulfill protein requirements (Gonzalez et al. 1982). Indeed, milk production in ewes varies with the percentage of CP in the diet (Robinson et al. 1974, 1979; Gonzalez et al. 1982). Ewes receiving 340 g d^{-1} or 415 g d^{-1} of protein produced 21 and 28% more milk, respectively, than ewes receiving 273 g d^{-1} (Robinson et al. 1974). Determination of the amount of CP needed in the diet of lactating ewes depends not only on the extent to which the supplementary protein escapes the rumen undegraded, but also on the magnitude of energetic deficiency for maintenance and milk production (Robinson et al. 1974). The objective of the present study was to determine the effect of silage quality, and percentage of CP in the concentrate, on milk production and growth of lambs reared as twins or triplets.

MATERIALS AND METHODS

Animals and Management

The experimental conditions respected the guidelines set by the Canadian Council on Animal Care and were approved by the La Pocatière Experimental Farm Animal Care Committee. The animals used in this experiment were Outaouais Arcott, a synthetic prolific breed composed of 49% Finnish Landrace, 26% Shropshire, 21% Suffolk, and 4% other breeds (Shrestha and Heaney 1992). A total of 97 mature ewes were treated with progestagen sponges (Veramix®, Upjohn, Orangeville, Ontario, Canada). Fourteen days later, at sponge withdrawal, ewes were injected with 500 IU of PMSG (Equinex®, Ayerst Laboratories, Montréal, Québec, Canada), and hand mated 36 to 48 h later to Arcott Outaouais rams. Ewes were mated in two different groups exposed in October ($n = 45$) and December ($n = 52$). The number of fetuses was determined on day 60 of pregnancy with a real time ultrasonic scanner (Aloka, model SSD-210DX). From mating until 2 wk before parturition, ewes were kept in groups of 10 to 12 and had ad libitum access to good-quality grass silage (heap silo).

To synchronize lactation periods for all ewes in each group, only ewes that conceived at the synchronized estrus (first mating) were kept. In the early fall exposed group (October), 35 ewes lambed between 21 and 27 February, while in the late fall breeding group (December), 39 ewes lambed between 2 and 6 May. To respect the treatment groups for the experiment (number of fetuses, possibilities for adoptions, and diet before lambing), 51 of all those ewes that lambed could be used in the experiment. These ewes were evenly distributed between both lambing groups. From 2 wk before lambing until the end of the 6-wk lactation period, ewes were individually housed on concrete floor pens. Water was constantly available and lambs had no access to creep feed.

Experimental Design

From 6 to 2 wk before lambing, the diet of the pregnant ewes was supplemented progressively, with 200 to 600 g d^{-1} of a commercial concentrate (2.8 Mcal kg^{-1} ME and 18% CP). Two weeks before lambing, within each lambing group, ewes were assigned to a $2 \times 2 \times 2$ factorial experiment. The factorial treatments were maturity of bromegrass silage harvested, early bloom vs. full bloom, protein supplementation, 725 g of concentrate containing either 15% CP vs. 21% CP, and litter size, two vs. three lambs suckled. Percentages of CP for the concentrates were chosen as follows, using the total daily CP requirements (435 g) for an 80 kg ewe nursing twins (National Research Council [NRC] 1985). First, voluntary intake of silage was estimated from NRC (1985) recommendations for a 65% forage diet. Since the silages averaged 17% CP (EB, 19% CP; FB, 15.2% CP), protein intake from the silages represented 75% of the total requirements. To fulfill protein requirements, 725 g d^{-1} of a 15% CP or 21% CP concentrate was offered. The 15% CP concentrate met 25% of total protein requirements and the 21% CP concentrate met 35% of total protein requirements, for ewes nursing twins. It was assumed that silage intake would not be markedly affected by the protein content of the concentrate.

Ewes were first distributed between the two nursing groups, according to the number of fetuses recorded by ultrasound (two or less and more than two). Ewes were then further randomly distributed among the other treatments (maturity of silages and CP content of the concentrates) so that approximately equal numbers of ewes were assigned to each of the eight groups.

Two weeks before lambing, the ewes received 600 g d^{-1} of a 15 or 21% CP concentrate and 700 g d^{-1} the last week before lambing to reach the treatment value of 725 g d^{-1} at lambing. After lambing, ewes were reassigned according to the actual number of lambs suckled in accordance with their feeding treatment before parturition. Body weight at lambing was also used to balance treatment groups.

On day 36 of lactation, the amount of concentrate offered was cut approximately in half (375 g d^{-1}) and no concentrate was offered after day 40 to prepare the ewes for drying off milk production. Silage intake was also restricted from day 40 of lactation until weaning (42 d).

Measurements

Feed Intake

Feed intake was recorded daily from 2 wk before lambing until weaning. Silage was offered ad libitum twice daily (0800 and 1600 h) in equal amounts estimated to allow for approximately 10% refusal. Samples of silages and refusals were taken daily (100 g) and pooled at the end of the week. A sample of each concentrate was taken weekly. All samples were kept frozen for later chemical analysis. The composition of silages and concentrates fed and formulation of concentrates is presented in Table 1.

Milk Yield and Composition

Milk yield was measured every 10 d starting on day 7. Yields were taken on 2 consecutive days for each milking period (days 7 and 8, days 17 and 18, days 27 and 28, days 37 and 38 of lactation) using a milking machine (Alfa-Laval,) following an oxytocin injection (Brown and Hogue 1985). The milking machine was adjusted to 90 pulses per minute and 5.9 kg of vacuum. At 1000 h, the lambs were removed from their mother but kept in visual contact. The ewes were then injected i.v. with 10 IU of oxytocin (Oxytocin®, Rogar/Stb Inc, Pointe-Claire, Québec, Canada) to stimulate milk let down. Milking began within 3 min of injection and this milk was discarded. At 1300 h, ewes were again milked using the same procedure. The lambs were then returned to their dam after a 1-h period. The milk produced during the 3-h period was weighed and used to estimate production over 24 h (Doney et al. 1979). Results for the daily milk production for each of the milking periods were calculated from the average of the 2 consecutive days. Milk samples were taken for each of the milking periods (75 g each for the 2-d milkings) and kept frozen until analysis. The California mastitis test was done every week on every ewe to detect mastitis problems. All ewes that were kept in the research project were in good health.

Table 1. Composition of silages and concentrates (dry matter basis) and formulation of concentrates fed to the ewes 2 week before parturition and during the first week of lactation

	Silage		% protein (CP)[z]	
Item	Early bloom	Full bloom	15%	21%
DM (%)	23.0	26.3	86.9	87.1
CP (% DM)	19.3	15.2	16.9	23.8
ADF (% DM)	28.7	33.5	7.8	6.5
NDF (% DM)	47.0	55.1		
ME (Mcal kg^{-1})[y]	2.45	2.22	2.94	3.00
pH	4.3	4.0		
N-NH3 (% of total N)	11.2	9.9		
Lactic acid (g kg^{-1} DM)	108.3	171.3		
Acetic acid (g kg^{-1} DM)	39.7	16.2		
Propionic acid (g kg^{-1} DM)	17.3	5.0		
Butyric acid (g kg^{-1} DM)	14.2	2.3		
Corn (sieved)			40.0	40.0
Rolled oats			30.1	13.0
Oat meal			7.1	7.1
Soybean meal			15.1	27.8
Corn gluten feed (21% CP)			0.0	2.2
Corn gluten meal (60% CP)			0.0	1.4
Canola meal			0.0	1.7
Molasses			4.0	4.0
Mineral-vitamin premix			2.8	2.8

[z] Percentage of CP on an as fed basis.
[y] Estimated from ADF concentration.

Live Weight

Ewes were weighed at breeding, 2 wk before parturition, at parturition (24 h max. after lambing), and every week during lactation (6 wk). Lambs were weighed at birth and weekly thereafter.

Chemical Analysis

Feed Composition

Dry matter content of fresh silage was determined by toluene distillation (Dewar and McDonald 1961). Dry matter content of concentrate was determined by freeze-drying (Model 10MR-TR-LP, Virtis Co., Gardiner, NY). Freeze-dried samples of silages and concentrates were homogenized using a domestic food processor and analyzed for N, ADF, NDF and ash. Nitrogen content was measured using the micro-Kjeldahl method (Kjel-Foss Automatic 16210 A/S N; Foss Electric, Hillerød, Denmark), ash content after a complete combustion in a Muffle furnace at 550°C for 24 h, concentrations of ADF and NDF were measured using standard techniques (Van Soest and Robertson 1985). The pH (Model 380, Fisher Scientific, Montreal, QC, Canada), ammonia N (using an ammonia-sensitive selective electrode [McCullough 1967]; Orion ammonia electrode, model 95-12) and the concentration of volatile fatty acids (Canale et al. 1984: HPLC system, High Performance Liquid Chromatography: System Gold, Beckman Instruments Inc., San Ramon, CA) of silages were determined on fresh material ground with dry ice in a domestic food processor.

Milk

Dry matter content was determined after 48 h of freeze drying. The freeze-dried samples were analyzed for milk fat

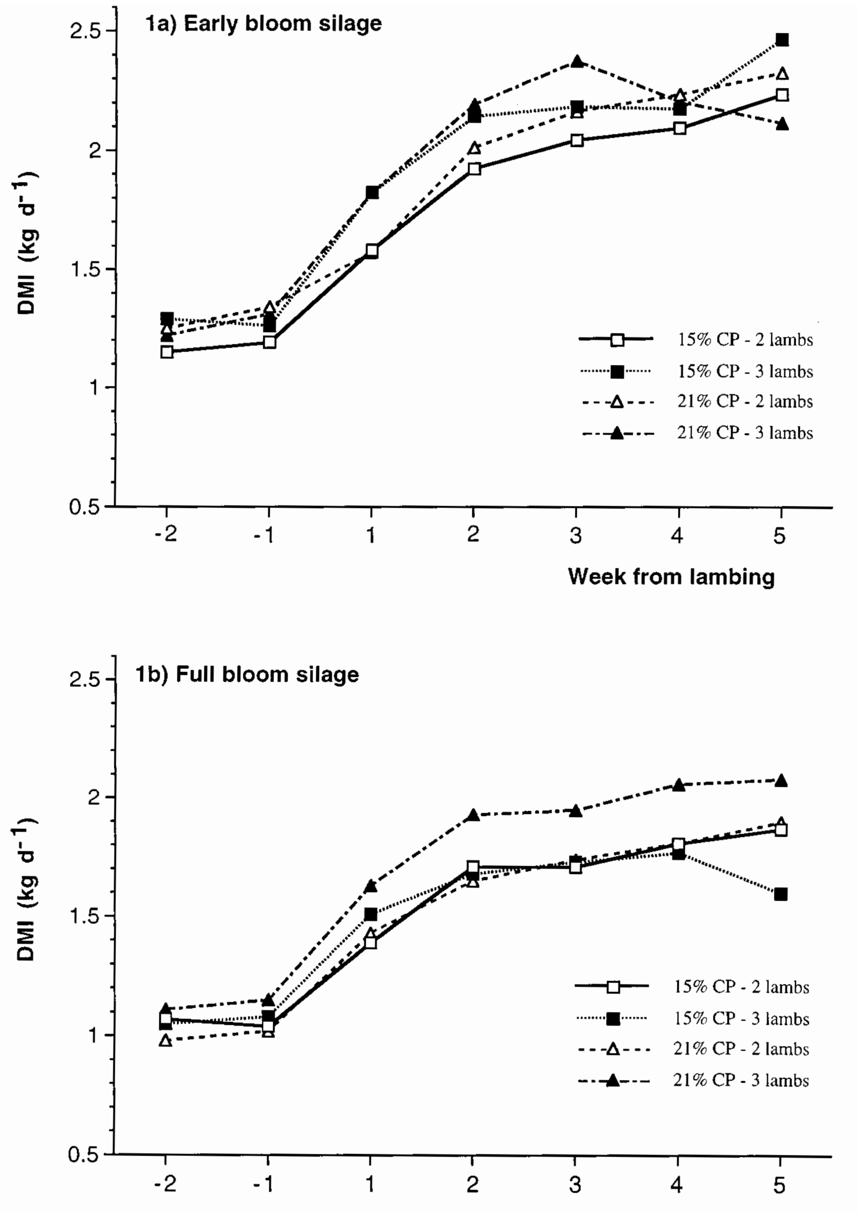

Fig. 1. Dry matter intake of silage by ewes fed early-bloom (a) or full-bloom (b) grass silages supplemented with a 15 or 21% CP concentrate while nursing two or three lambs. Data are for the last 2 wk of gestation (–2 and –1) and for the first 5 wk of lactation (+1 to +5).

using the Mojonnier method (Mojonnier and Troy 1922), protein using the Kjeldahl method (N × 6.38 method no. 920.105 [Association of Official Analytical Chemists 1990]), and ash after a complete combustion in a Muffle furnace.

Statistical Analysis

An analysis of variance was performed using the GLM procedure of the SAS Institute, Inc. (1988). All parameters were tested according to the factorial design. Variations of individual lamb weight within litter were analyzed using the GLM procedure of the SAS Institute, Inc. (1988). Individual lamb weights and litter weights at 4 and 6 wk were analyzed using birth weight as a covariate. For all analyses, lambing period (determined by the breeding groups — early or late fall) and interactions between lambing period and treatments were included in the model. As no interaction was detected, data from the two lambing periods were pooled.

RESULTS

Early and late fall lambing groups had 78 and 75% fertility, and 2.97 and 2.08 lambs born per ewe, respectively. To increase the number of ewes available for the experiment, three adoptions were necessary for the ewes nursing three lambs and one adoption for a ewe nursing two lambs.

Of the 51 ewes that began the experiment, a total of 12 ewes, all nursing three lambs, were discarded during the lactation period following mastitis problems or development of mammary impetigo (superficial pyoderma), which lead to mastitis. Before week 4 of lactation, four ewes were

Table 2. Effects of silage maturity, crude protein content of the diet, and number of lambs suckled on feed intake, body weight change, and milk production parameters for the first 5 wk of lactation

	Early bloom silage				Full bloom silage					
	15% CP		21% CP		15% CP		21% CP			Significance
	2[z]	3	2	3	2	3	2	3	SEM	($P < 0.05$)
DMI (kg d^{-1})	1.97 (7)[y]	2.13 (4)	2.06 (7)	2.14 (3)	1.70 (7)	1.69 (4)	1.71 (6)	1.91 (3)	0.06	S, L
Ewe wt change (kg)	1.6 (7)	–1.5 (4)	3.9 (7)	–3.0 (3)	–3.0 (7)	–6.5 (4)	–1.5 (6)	0.3 (3)	1.70	S, L
Milk yield (kg d^{-1})[x]	2.40 (7)	2.39 (5)	2.51 (7)	2.37 (6)	2.37 (7)	1.98 (4)	2.45 (6)	2.14 (5)	0.12	S, L
Milk fat yield (g d^{-1})[x]	185 (7)	189 (5)	180 (7)	173 (6)	201 (7)	138 (4)	203 (6)	145 (5)	13.75	L, S × L
Milk protein yield (g d^{-1})[x]	119 (7)	111 (5)	125 (7)	106 (6)	104 (7)	83 (4)	113 (6)	88 (5)	6.13	S, L

	Silage (S)		Protein (CP)		Number of lambs (L)	
Main effects	Early bloom	Full bloom	15%	21%	2	3
DMI (kg d^{-1})	2.07	1.74	1.88	1.96	1.86	2.00
Ewe wt change (kg)	1.3	–2.7	–1.9	0.7	0.3	–2.8
Milk yield (kg d^{-1})	2.42	2.28	2.32	2.40	2.43	2.25
Milk fat yield (g d^{-1})	182	180	184	178	193	165
Milk protein yield (g d^{-1})	116	110	106	110	115	99

[z]Number of lambs.
[y]Mean (number of ewes).
[x]Calculated by averaging the daily milk production on days 7–8, 17–18, and 27–28.

weaned, six more between weeks 4 and 5, and two more between weeks 5 and 6, which left 39 ewes at the end of the 6-wk of lactation .

Ewe Nutrient Intake

Only data from the first 5 wk of lactation were kept for the statistical analysis of ewe silage intake and weight change because the silage was not served ad libitum during the 6th wk of lactation to prepare the ewes for drying off.

A rapid increase in silage intake was observed after lambing during the first 2 wk of lactation, followed by a plateau until the end of lactation (Figs. 1a and b). The difference in silage intake between the end of gestation and the plateau ranged from 0.65 to 0.80 kg DM d^{-1}.

Over the 5-wk period, ewes ingested an average of 2.07 kg d^{-1} DM of EB silage compared with 1.74 kg d^{-1} of FB silage (Table 2). Silage intake increased ($P < 0.05$) by 0.08 kg d^{-1} when 21% compared with 15% CP concentrate was offered. Ewes nursing three lambs ingested 0.14 kg DM d^{-1} more ($P < 0.05$) silage than ewes nursing twins.

Ewe Weight Change

Ewe weights at parturition (approximately 75 kg) did not differ between treatment groups. Ewes receiving EB silage increased ($P < 0.05$) their weight during lactation whereas those with FB silage lost weight (+1.3 vs. –2.7 kg; Table 2). Ewes receiving 21% CP concentrate also increased their weight while those receiving 15% CP concentrate lost weight, but this difference was not significant. Ewes nursing triplets lost ($P < 0.05$) an average of 2.8 kg while ewes nursing twins gained 0.3 kg.

Milk Production and Composition

Ewe milk production is an average of the first three 10-d periods because it was not possible to milk a sufficient number of ewes on days 37 and 38 of lactation (Table 2). Silage maturity and number of lambs suckled influenced average milk yield (Table 2). Ewes receiving EB silage produced 6% more milk ($P < 0.05$) than those receiving FB silage and ewes nursing three lambs produced 7.5% less milk ($P < 0.05$) than those nursing two lambs.

The ewes fed EB silage had a lactation curve with a well-defined peak of production at approximately 17 d, followed by a decrease in milk production over time (Fig. 2a). In comparison, ewes receiving FB silage had a lactation curve without any peak and a less obvious decrease at the end of the lactation period (Fig. 2b). Overall, ewes nursing twins had better persistency of production than those nursing triplets.

Milk protein content was not affected by CP concentration or number of lambs suckled (4.97 ± 0.06%), but ewes receiving FB silage had a 7% higher ($P < 0.05$) milk protein content compared with EB silage. Treatments did not affect the fat content of the milk (8.2 ± 0.2%).

Milk protein production (Table 2) for the first 4 wk of lactation was higher ($P < 0.05$) with EB compared with the FB silage and was lower when three lambs were suckled compared with two. Milk protein yield curves during lactation show the same pattern over time as milk yield (data not shown). Total production of milk fat for the first 4 wk shows an interaction ($P < 0.05$) between maturity of silage and number of lambs suckled (Table 2). Ewes offered EB silage produced similar amounts of milk fat, whether nursing two or three lambs, whereas with FB silage, ewes nursing triplets produced 30% less milk fat than those nursing twins. Milk fat production curves follow the same pattern as milk yield curves (data not shown).

Lamb Growth

By week 2 of lactation, individual weights of lambs were greater for twins than for triplets (data not shown). At 4 wk of age, twin lambs weighed on average 2.6 kg more than triplets (9.5 vs. 6.9 kg; Table 3). Lamb weight at 4 wk was not affected by the type of silage or the CP content of the

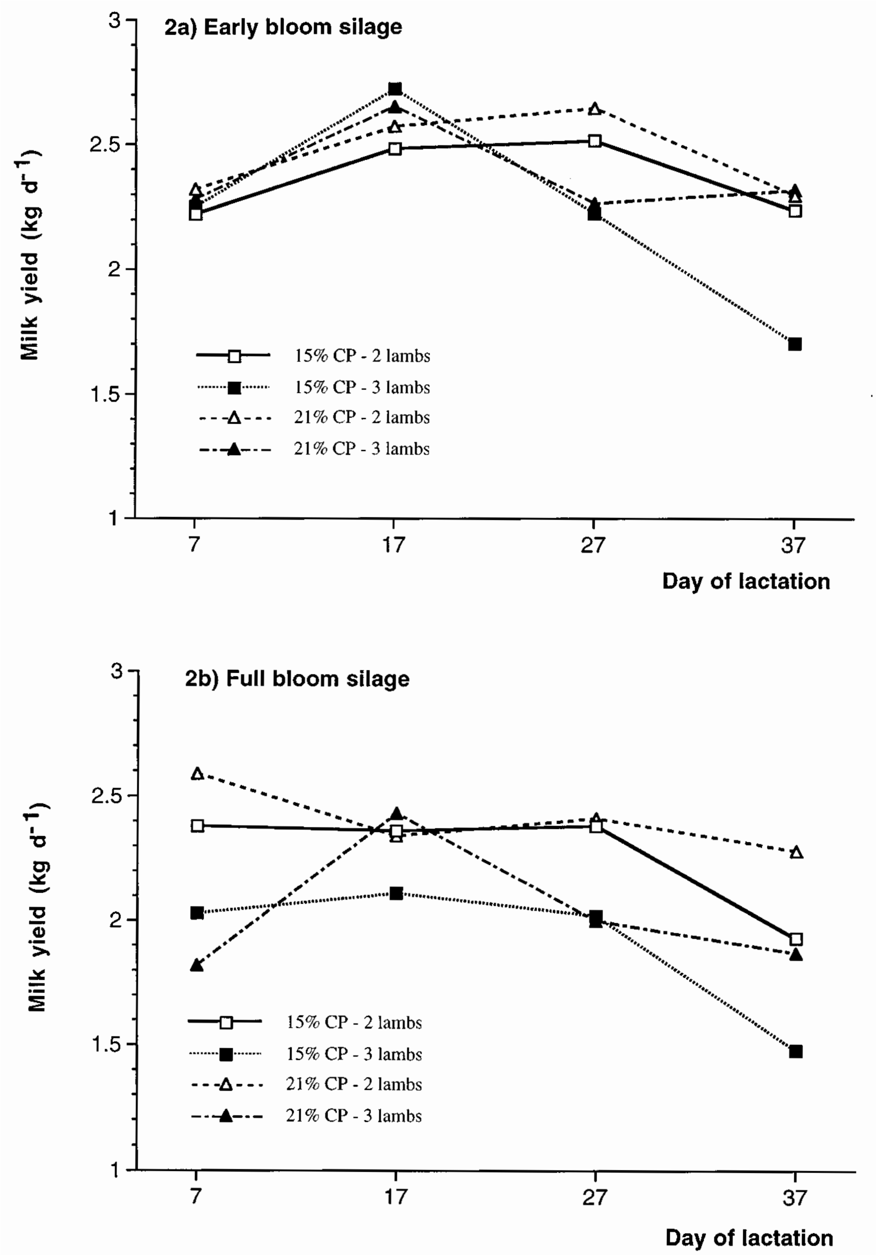

Fig. 2. Milk yield of ewes fed early-bloom (a) or full-bloom (b) grass silages supplemented with a 15 or 21% CP concentrate while nursing two or three lambs. Means are calculated by averaging the daily milk production on days 7–8, 17–18, 27–28 and 37–38.

concentrates. Maximum variation of individual weight within litter was found to be significant ($P < 0.05$) only for the number of lambs suckled (data not presented). Mean weight difference between the biggest and smallest lambs was 1.6 kg and 2.6 kg for twin and triplet lambs, respectively.

Ewes nursing triplets had heavier litter weights at 4 wk with EB silage compared with FB silage (silage × litter size interaction; $P < 0.05$). Ewes nursing triplets had heavier litter weights at 4 wk when receiving 15% CP concentrate, but litter weights did not differ when fed 21% CP concentrate (protein × litter size interaction; $P < 0.05$) (Table 3).

At the end of the 6th wk (weaning), twin lambs weighed 3.5 kg more ($P < 0.05$) than triplets (Table 3). Ewes receiving EB silage weaned lambs that were 1.1 kg heavier ($P < 0.05$) than ewes receiving FB silage. Ewes receiving the 21% CP concentrate also weaned lambs that were 1.1 kg heavier ($P < 0.05$) than ewes receiving the 15% CP concentrate (Table 3).

Only when EB silage was offered did ewes that were nursing triplets have higher litter weights at 6 wk than those nursing twins (silage × litter size interaction; $P < 0.05$); ewes receiving FB silage tended to have smaller triplet litter weights compared with twin litter weights (Table 3). Litters of ewes receiving the 21% CP concentrate were heavier than those receiving the 15% CP concentrate ($P < 0.05$). Variation in individual lamb weights within litter was found to be significantly ($P < 0.05$) affected only by the number of lambs suckled. The mean differences in weight between the biggest

Table 3. Effect of silage maturity, crude protein content of the diet, and number of lambs suckled on lamb growth

	Early bloom silage				Full bloom silage					
	15% CP		21% CP		15% CP		21% CP			Significance
	2[z]	3	2	3	2	3	2	3	SEM	(P < 0.05)
Lamb wt – 4 wk (kg)	9.1 (14)[y]	7.6 (15)	9.6 (14)	7.0 (18)	9.1 (14)	6.4 (12)	10.0 (12)	6.4 (15)	0.4	L
Litter wt – 4 wk (kg)	18.3 (7)[x]	22.7 (5)	19.3 (7)	21.0 (6)	18.2 (7)	18.6 (4)	20.0 (6)	19.0 (5)	0.7	S, L, S × L, CP × L
Lamb wt – 6 wk (kg)	11.6 (14)[y]	9.6 (12)	12.2 (14)	9.8 (3)	11.7 (14)	7.0 (12)	12.5 (12)	8.4 (9)	0.7	S, CP, L
Litter wt – 6 wk (kg)	23.2 (7)[x]	28.8 (4)	24.4 (7)	29.5 (1)	23.4 (7)	21.0 (4)	24.9 (6)	25.1 (3)	0.8	S, CP, L, S × L

	Silage (S)		Protein (CP)		Number of lambs (L)	
Main effects	Early bloom	Full bloom	15%	21%	2	3
Lamb wt – 4 wk (kg)	8.2	7.9	8.1	8.1	9.5	6.9
Litter wt – 4 wk (kg)	20.5	18.9	19.7	19.9	18.9	20.6
Lamb wt – 6 wk (kg)	11.1	10.0	10.1	11.2	12.0	8.5
Litter wt – 6 wk (kg)	25.6	23.5	24.1	25.1	24.0	25.3

[z]Number of lambs.
[y]Mean (number of lambs).
[x]Mean (number of litters).

and smallest lambs in a litter were 2.2 kg and 4.2 kg for twin and triplet lambs, respectively.

Twins lambs obtained higher growth rates compared with triplets (Figs. 3a, b). For the FB silage (Fig. 3b), the 21% CP concentrate allowed a faster growth rate for twin lambs for the whole lactation whereas the faster growth was only observed after week 4 of lactation for the triplet lambs.

Litter total daily gain from ewes receiving EB silage were similar whether two or three lambs were nursed. With FB silage, total daily gain of twin suckled litters was slightly higher than for triplet suckled litter (data not shown).

DISCUSSION

The lower nutritional quality of the FB silage, according to ADF, NDF, and CP contents, might explain why ewes ingested on average 0.33 kg DM d^{-1} less FB than EB silage. The FB silage had 33.5, 55.1, and 15.2% of ADF, NDF, and CP, respectively, compared with 28.7, 47.0, and 19.3% for the EB silage. This may be explained by the observations of Laforest et al. (1986) who found that silage intake was negatively correlated with fiber content (r = –0.87) and positively correlated with CP content (r = 0.92) for wether lambs.

Products from a secondary fermentation can also affect voluntary silage intake. Wilkins et al. (1971) found negative correlations (r) of –0.77 and –0.75 between acetic acid and ammonia concentrations in the silage, and DM. Secondary fermentation occurred in both silages as shown by high acetic, propionic and butyric acid concentrations. However, these characteristics were more desirable for the FB compared with the EB silage. Therefore, fermentation characteristics might not have had a marked effect on silage intake in the present experiment.

Total DMI was lower than what is predicted by NRC (1985) for both EB and FB silages (2.70 and 2.37 kg, respectively vs. 2.9 kg for NRC). Forage intake for ewes receiving both silages represented more than 65% of the diet (77 and 73% for EB and FB silages, respectively) recommended by NRC (1985). This indicates that, when fed with a good-quality silage, ewes are able to satisfy their nutritional needs, with forages representing more than 65% of the total ration.

The ability of ewes to mobilize body reserves for milk production is well documented (Treacher 1983; Agricultural Research Council 1984; NRC 1985) and ewes are expected to lose weight (60 g d^{-1}; NRC 1985) during lactation (Cowan et al. 1980; NRC 1985; Robinson 1987; Institut National de la Recherche Agronomique 1988). Almost all ewes in the present study should have been in negative energy balance according to the initial calculations (6.8 Mcal ME d^{-1}; NRC 1985). However, ewes receiving EB silage ingested on average more than 6.8 Mcal ME d^{-1} (6.96 to 7.42 Mcal ME d^{-1}) whereas those on FB silage ingested less (5.88 to 6.42 Mcal ME d^{-1}). This could explain weight changes for many of the ewes. This also agrees with Loerch et al. (1985) who obtained ewe weight gains at the end of a 42 d lactation with an energy intake of 7.8 Mcal ME d^{-1} and Robinson et al. (1974) who observed weight losses of 265 g d^{-1} with 5.98 Mcal ME d^{-1}.

Responses of milk yield to increased dietary protein have been observed in a number of experiments (Robinson et al. 1974, 1979; Gonzalez et al. 1984; Jaime and Purroy 1995). In the present experiment, increasing dietary protein did not increase milk yield, probably because of the high CP content of the rations. Indeed, on average, the ewes ingested from 380 to 584 g CP d^{-1}, which represents between 15.7 and 20.4% CP content for the total daily intake. Nevertheless, milk yield was influenced by silage quality, as ewes that received EB silage had a higher milk yield, and ingested more protein.

Treacher (1985), and more recently Bencini and Pulina (1997), reviewed the literature on milk production and reported increases in milk produced when ewes reared triplets compared with twin lambs, but ewes rearing triplets do not always give consistently higher milk yields (Gallo and Davies 1991; Petit 1997). In the present experiment, milk yield from ewes that raised three lambs was 7% lower than milk yield from ewes that raised two lambs. The dif-

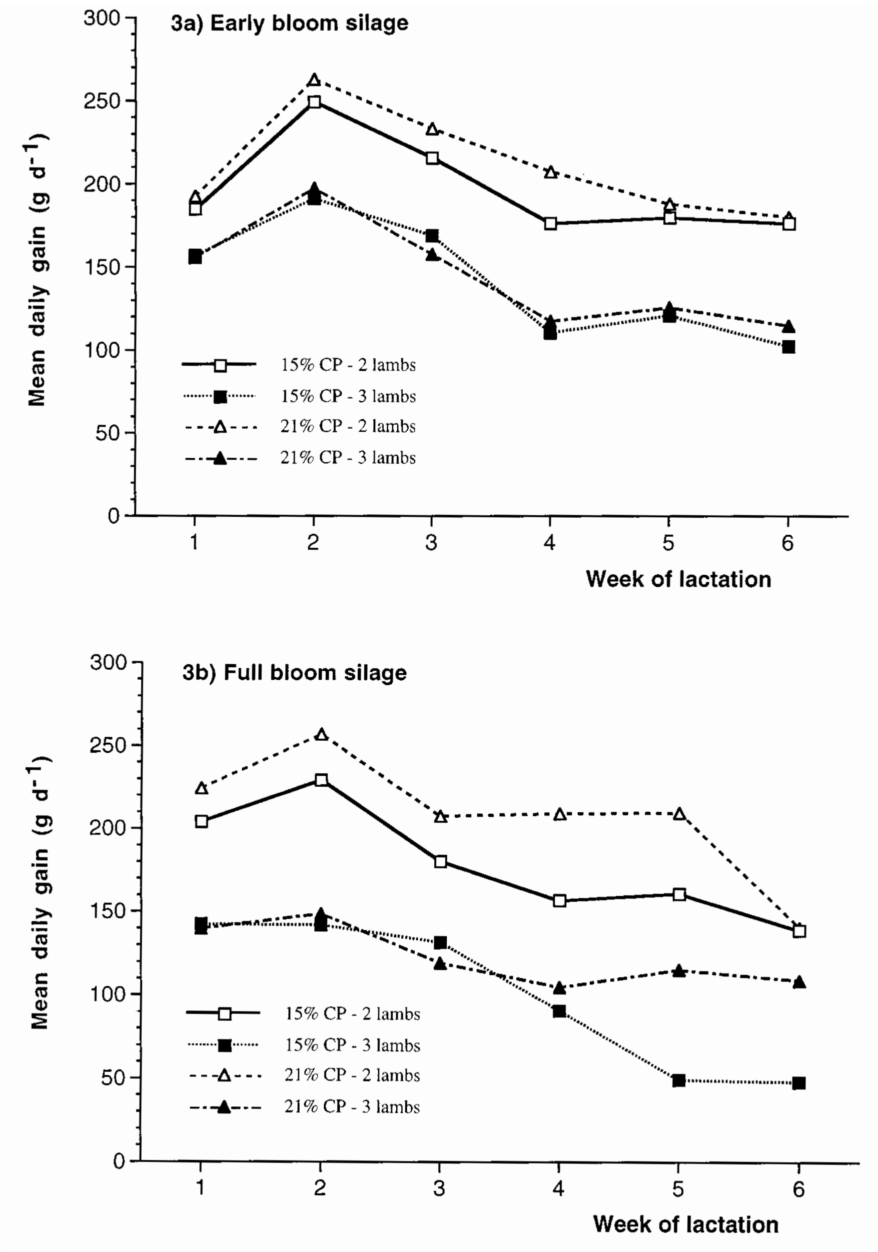

Fig. 3. Mean daily gain of lambs during the first 6 wk of lactation. The dams of the lambs were fed either early-bloom (a) or full-bloom (b) grass silages supplemented with a 15 or 21% CP concentrate while nursing two or three lambs.

ferences between suckling groups were especially large for the ewes receiving FB silage. Because lambs had no access to creep feed and ewes were not able to escape from hungry lambs (individual pens), the physical stress imposed by these procedures might have negatively affected the milk yield of ewes rearing three lambs. In another experiment conducted at Agriculture and Agri-Food Canada's Sheep Research Farm at La Pocatière (A. Roy, F. Castonguay, and G. J. Brisson, unpublished data), ewes suckling two or three lambs were fed 15 or 21% CP concentrates and the same heap silo grass silage. Only growth rate of the lamb was measured. In contrast to the present experiment, creep feed was available for lambs and ewes were housed three per pen, which may have resulted in less stress for the ewes. In that experiment, triplet lambs from ewes that received the 21% CP concentrate were only 1 kg smaller than twin lambs and 2.9 kg of concentrates were consumed by triplet lambs between week 2 of lactation and weaning. These results highlight the importance of creep feeding triplet lambs.

Maturity of silage and number of lambs suckled influenced total fat and protein production in milk, although for fat an effect of litter size was obtained only when FB silage was fed. In previous experiments, milk protein has been proven to respond to increases in dietary protein when fish meal supplement was used (Robinson et al. 1979; Gonzalez et al. 1982; Penning et al. 1988) and also when soybean meal was increased (Gonzalez et al. 1982). Since milk fat concentration was not affected by treatments, the difference in fat yield between EB and FB silages was mainly explained by a higher milk yield and could be caused by the higher daily protein intake with EB compared with FB silage. The higher protein yield for EB silage could be explained similarly, even though the milk protein concentration was higher for FB than EB silage.

Before 4 wk of age, milk is normally the major nutrient source for lambs and the correlation (*r*) between milk intake and liveweight gain is approximately 0.9 (Boyazoglu 1963; Wallace 1948). In the present experiment, increasing CP content by managing silage maturity or feeding concentrates did not influence lamb weight at 4 wk even though milk yield was increased for EB compared with FB silage. However, the litter was heavier with EB compared with FB silage for 15%, but not for 21% CP concentrate. The growth performance of triplet lambs was better than that of twin lambs only with EB silage. Cowan et al. (1981) observed higher milk yields with fish meal supplements only during weeks 4 to 6 of lactation, but lamb performance was not reported. In the present study, lamb weight at 6 wk was 1.1 kg higher for ewes receiving EB silage or the 21% CP concentrate compared with FB silage or the 15% CP concentrate, respectively. Litter weight at 6 wk also responded to EB silage, but only for triplets. Results for litter weights at 6 wk should be interpreted cautiously since there was just one remaining litter with three lambs being suckled in the EB + 21% CP treatment. Nevertheless, comparisons between treatments were relatively similar to what was observed at 4 wk, with more experimental units.

Total daily gain of triplet litters (364 g d^{-1}) was 29 g d^{-1} lower than the gain of twin litters (393 g d^{-1}). Milk yield was also lower. Considering a conversion efficiency of milk to liveweight gain of 0.20 kg liveweight gain kg^{-1} of fresh milk (Treacher 1983; Jaime and Purroy 1995), the difference in total daily gain between triplet and twin suckled lambs (29 g d^{-1}) represents 145 g d^{-1} of fresh milk. This value is close to the actual difference of 180 g d^{-1} obtained in the present experiment.

Ewes raising triplets produced 9% more kilograms of lambs at 4 wk than those raising twins, but this is not as high as the 26% increase that has been reported elsewhere (Loerch et al. 1985). Daily growth rates of triplet and twin litters were almost identical (357 and 381 g d^{-1}, respectively).

The number of lambs suckled influenced the maximum variation of weight within a litter, which may be due to variation in individual birth weights. A small difference of less than 1 kg at birth between the biggest and smallest in a triplet litter became 2.6 kg at 4 wk and 4.2 kg at 6 wk. Furthermore, no creep feed was available, so smaller lambs in triplet litters could not compensate for a lower milk intake.

Therefore, feeding a good-quality silage, in terms of CP and ADF contents, improved the ewes performances during lactation and lamb growth. However, feeding a high-protein concentrate only improved lamb growth when low-quality silage was fed. Ewes weaned more kilograms of lambs when three vs. two lambs suckled, but feeding three lambs reduced the number of ewes that successfully went through the whole lactation period.

CONCLUSIONS

Feeding early-bloom bromegrass silage resulted in better ewe and lamb performance during the 42-d lactation than full-bloom silage. Increasing CP in the concentrate with soybean meal improved weights of lambs and litters at 6 wk. There does not seem to be an advantage of supplementing with soybean meal to improve the performance of the ewe and lamb growth when the ewes receive silage with a low fiber content. Ewes of the prolific Outaouais Arcott breed do not produce more milk with three lambs than with two, and triplets are lighter at weaning than twins. Nevertheless, litter weight of triplets is heavier than twins. Due to a higher culling rate of triplet nursing ewes during lactation, raising triplets seems to impose a supplementary demand on the ewe that is difficult to compensate for by dietary means. Giving access to a creep feed for triplet lambs could reduce the detrimental effect of nursing three lambs.

ACKNOWLEDGMENTS

The authors thank Pierre Brouillette, René Desjardins and Sophie Poulin for technical help, Gilles Gagnon and the sheep barn staff at Agriculture and Agri-Food Canada’s Sheep Research Farm at La Pocatière for animal care, and Lynn Hammell for editorial assistance. Financial support was provided by the *Entente auxiliaire Canada–Québec sur le développement économique des régions du Québec*.

Association of Official Analytical Chemists. 1990. Official methods of analysis. 15th ed. AOAC, Washington, DC.

Agricultural Research Council. 1984. The nutrient requirements of ruminant livestock. Commonwealth Agricultural Bureaux, Slough, UK.

Bencini, R. and Pulina, G. 1997. The quality of sheep milk: A review. Austr. J. Exp. Agric. **37**: 485–504.

Boyazoglu, J. G. 1963. Aspects quantitatifs de la production laitière des brebis. Ann. Zootech. **12**: 237–296.

Brown, D. L. and Hogue, D. E. 1985. Effects of roughage level and physical form of diet on Finn sheep lactation. SID Res. Digest. **2**: 11–19.

Canale, A., Valente, M. E. and Ciotti, A. 1984. Determination of volatile carboxylic acids (C_1 – C_{5i}) and lactic acid in aqueous acid extracts of silage by high performance liquid chromatography. J. Sci. Food Agric. **35**: 1178–1182.

Cowan, R. T., Robinson, J. J., McHattie, I. and Fraser, C. 1980. The prediction of body composition in live ewes in early lactation from live weight and estimates of gut contents and total body water. J. Agric. Sci. (Camb.) **95**: 515–522.

Cowan, R. T., Robinson, J. J. , McHattie, I. and Pennie, K. 1981. Effects of protein concentration in the diet on milk yield, change in body composition and the efficiency of utilization of body tissue for milk production in ewes. Anim. Prod. **33**: 111–120.

Dewar, W. A. and McDonald, P. 1961. Determination of DM in silage by distillation with toluene. J. Sci. Food. Agric. **12**: 790–795.

Doney, J. M., Peart, J. N. and Smith, W. F. 1979. A consideration of the techniques for estimation of milk yield by suckled sheep and a comparison of estimates obtained by two methods in relation to the effect of breed, level of production and stage of lactation. J. Agric. Sci. (Camb.) **92**: 123–132.

Gallo, C. B. and Davies, D. A. R. 1991. Effect of early weaning one lamb in a triplet lamb rearing system. Anim Prod. **52**: 141–148.

Gardner, R. W. and Hogue, D. E. 1964. Effects of energy intake and number of lambs suckled on milk yield, milk composition and energetic efficiency of lactating ewes. J. Anim. Sci. **23**: 935–942.

Gonzalez, J. S., Robinson, J. J. and McHattie, I. 1984. The effects of level of feeding on the response of lactating ewes to dietary protein supplements of fish meal. Anim. Prod. **40**: 39–45.

Gonzalez, J. S., Robinson, J. J., McHattie, I. and Fraser, C. 1982. The effect in ewes of source and level of dietary protein on milk yield, and the relationship between the intestinal supply of non-ammonia nitrogen and the production of milk protein. Anim. Prod. **34**: 31–40.

Institut National de la Recherche Agronomique. 1988. Alimentation des Bovins, Ovins et Caprins. Jarrige, R. Ed. Paris, France.

Jaime, C. and Purroy, A. 1995. Level and quality of protein in rations for lactating ewes. Ann. Zootech. **44**: 135–142.

Laforest, J. P., Seoane, J. R., Dupuis, G., Phillip, L. and Flipot, P. M. 1986. Estimation of the nutritive value of silages. Can. J. Anim. Sci. **66**: 117–127.

Loerch, S. C., McClure, K. E. and Parker, C. F. 1985. Effects of number of lambs suckled and supplemental protein source on lactating ewe performance. J. Anim. Sci. **60**: 6–13.

McCullough, H. 1967. The determination of ammonia in whole blood by a direct colorimetric method. Clin. Chim. Acta **17**: 297–304.

Mojonnier, T. and Troy, H. C. 1922. The technical control of dairy products. Mojonnier Bros. Co., Chicago, IL.

National Research Council. 1985. Nutrient requirements of sheep. 6th ed. National Academy Press, Washington. DC.

Owen, J. B. 1976. Sheep production. Pages 195–238 *in* Nutrition. Baillière Tindall, London, UK.

Penning, P. D., Orr, R. J. and Treacher, T. T. 1988. Response of lactating ewes, offered fresh herbage indoors and when grazing, to supplements containing different protein concentrations. Anim. Prod. **46**: 403–415.

Petit, H. V. 1997. Production of ewes rearing twin or triplet lambs fed grass silage with a commercial concentrate or a mixture of beet pulp and soybean meal. Can. J. Anim. Sci. **77**: 87–93.

Robinson, J. J. 1987. Energy and protein requirements of the ewe. Pages 365–382 *in* W. Haresign and D. J. A. Cole, eds. Recent advances in animal nutrition. Butterworths, London, UK.

Robinson, J. J., Fraser, C., Gill, J. C. and McHattie, I. 1974. The effect of dietary crude protein concentration and time of weaning on milk production and body-weight change in the ewe. Anim. Prod. **19**: 331–339.

Robinson, J. J., McHattie, I., Calderon Cortes, J. F. and Thompson, J. L. 1979. Further studies on the response of lactation ewes to dietary protein. Anim. Prod. **29**: 257–269.

SAS Institute, Inc. 1988. SAS user's guide: Statistics. SAS Institute, Cary, NC.

Shrestha, J. N. B. and Heaney, D. P. 1992. Productivity of Arcott sheep and their crosses when lambs are raised with their dams. Small Ruminant Res. **8**: 333–344.

Treacher, T. T. 1983. Nutrient requirements for the lactation in the ewe. Pages 133–154 *in* Sheep production. W. Haresign, ed. Butterworths, London, UK.

Treacher, T. T. 1985. The possibilities for improving the performance of ewes suckling three or more lambs in grazing systems. Pages 371–381 *in* R. B. Land and D. W. Robinson, eds. Genetics of reproduction in sheep. Butterworths, London, UK.

Van Soest, P. J. and Robertson, J. B. 1985. Analysis of forages and fibrous foods. Cornell University, Ithaca, NY.

Wallace, L. R. 1948. Growth of lambs before and after birth in relation to the level of nutrition. J. Agric. Sci. **38**: 93–153.

Wilkins, R. J., Hutchinson, K. J., Wilson, R. F. and Harris, C. E. 1971. The voluntary intake of silage by sheep. I. Interrelationships between silage composition and intake. J. Agric. Sci. (Camb.) **77**: 531-537.