



Influence of supplementation on the productivity of ewes grazing improved pasture and suckling twins
by Ana Lidia Frey

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Animal Science

Montana State University

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Abstract:

Twenty-six mature Finn-Targhee ewes suckling twin lambs were used to determine the effects of supplementation on milk production and lamb growth. Ewes and their lambs grazed an improved summer pasture, and one-half of the ewes ($n = 13$) were supplemented every third day.

Supplementation provided the equivalent of 25% of the daily NRC (1985) protein requirements for lactating ewes suckling twins. Ewe and lamb weights, milk volume and composition were determined at the beginning of the trial and at 21-day intervals for four periods during the summer. Forage allowance and quality were determined. Milk volume was not influenced by protein supplementation ($P > .10$). . Supplementation had no effect ($P > .10$) on milk quality (protein, fat, lactose and solid not fat content) in the four periods when calculated as a percentage, but in the fourth period a difference ($P < .10$) was observed in protein, fat and solids not fat (SNF) when calculated as total production per day ($\text{g} \cdot \text{d}^{-1}$). Supplemented ewes produced more g of protein, fat and SNF than non-supplemented ewes during period four ($P < .10$). Weight gain for the 84-day grazing period was slightly higher for lambs suckling supplemented ewes (12.62 vs. 10.60 kg) ($P > .10$). In conclusion, there was no benefit to supplementation of lactating ewes grazing a high quality forage during the summer with the exception of increased protein, fat and SNF production during period four.

INFLUENCE OF SUPPLEMENTATION ON THE PRODUCTIVITY OF EWES

GRAZING IMPROVED PASTURE AND SUCKLING TWINS

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This thesis has been read by each member of the author's graduate committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style and consistency, and is ready for submission to the College of Graduate Studies.

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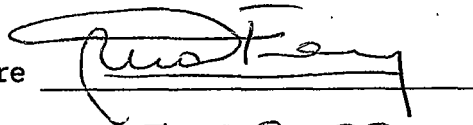
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ABSTRACT

Twenty-six mature Finn-Targhee ewes suckling twin lambs were used to determine the effects of supplementation on milk production and lamb growth. Ewes and their lambs grazed an improved summer pasture, and one-half of the ewes ($n = 13$) were supplemented every third day. Supplementation provided the equivalent of 25% of the daily NRC (1985) protein requirements for lactating ewes suckling twins. Ewe and lamb weights, milk volume and composition were determined at the beginning of the trial and at 21-day intervals for four periods during the summer. Forage allowance and quality were determined. Milk volume was not influenced by protein supplementation ($P > .10$). Supplementation had no effect ($P > .10$) on milk quality (protein, fat, lactose and solid not fat content) in the four periods when calculated as a percentage, but in the fourth period a difference ($P < .10$) was observed in protein, fat and solids not fat (SNF) when calculated as total production per day ($\text{g}\cdot\text{d}^{-1}$). Supplemented ewes produced more g of protein, fat and SNF than non-supplemented ewes during period four ($P < .10$). Weight gain for the 84-day grazing period was slightly higher for lambs suckling supplemented ewes (12.62 vs. 10.60 kg) ($P > .10$). In conclusion, there was no benefit to supplementation of lactating ewes grazing a high quality forage during the summer with the exception of increased protein, fat and SNF production during period four.

CHAPTER 1

INTRODUCTION

Sheep constitute one of the most important species of livestock in the world. They produce a number of products: meat, wool, milk, hide, etc. World sheep population is approximately 1.2 billion head (FAO, 1986). Argentina has twenty-five million head and the United States ten million. Montana has approximately 430,000 head, ranking sixth in sheep numbers in the United States.

Milk is essential in the first three to four weeks of the lamb's life. During this period correlation between milk intake and live weight gain is approximately 0.9 (Treacher, 1983). Although the necessity for milk declines as lactation progresses and lambs grow older, it is still a source of highly digestible energy and high quality protein utilized very efficiently by suckling lambs.

Highest nutritional requirements of the ewe occur during lactation, a time when summer pasture may not meet these requirements due to high moisture content of the forage early in the summer and reduced forage quality later in the summer.

Supplementation of nutrients may offset deficiencies of forage during mid-to-late lactation that limit milk production. Increasing the flow of amino acids to the small intestine is a potential method for stimulating milk production in ewes rearing more than one lamb (Loerch et al., 1985). However, little information is available on

the efficacy of protein supplementation escaping rumen fermentation for increasing milk production in grazing sheep. Ewe milk production and milk efficiency were substantially improved in early lactation by supplementation with blood meal and dried meat and bone meal (Loerch et al., 1985).

The objective of this study was to determine the influence of feeding a by-pass protein supplement to ewes during mid-to-late lactation on milk volume, milk composition and lamb weight gains.

CHAPTER 2

LITERATURE REVIEW

This review summarizes literature concerning 1) methods of estimating milk yield, 2) lactation performance, 3) nutrition of the lactating ewe and 4) nutrition of the suckling lamb. Methods of estimating milk yield and a comparison between the methods are covered, followed by a review of milk volume and composition in different situations and non-nutritional factors affecting lactation. Third, the energy and protein requirements for lactation, the response of ewes to variation in energy and protein intake and the voluntary food or forage intake during lactation are reviewed. Last, a discussion of milk intake by lambs, the relationship between milk and solid food intake and the influence of sustained lactation on lamb growth concludes the review.

Methods of Estimating Milk Yield

A clear distinction must be made between the measurement of milk production from animals maintained for dairy purposes and the yield of milk available for consumption by suckling young. The latter estimates are of considerable importance to many aspects of studies on variation in lamb growth and on systems of ewe management (Doney et al., 1979). McCance (1959) described three main criteria which the adopted methods must satisfy before the results can be accepted as reliable estimates. First, the estimated value must be representative

of the actual rate of secretion over a given test period. It is essential the udder be emptied to the same extent both at the start and end of the period over which the measurement is made. Second, the actual rate of milk secretion during the test periods must not differ significantly from that in other periods over which the estimate is to be extrapolated. Since most recorded lactations show a curvilinear pattern with increasing peak and decreasing phases, this criterion can never be absolutely satisfied. Third, methods adopted to measure milk yield must not significantly affect the rate of secretion either in the short or the long term.

Suckling and Test-Weighing Method

The test-weighing method, also called weigh-suckle-weigh, of estimating milk yield of suckled animals by measuring the amount of milk consumed after a short interval of separation or a series of such intervals has been used by many authors (Owen, 1957; Doney et al., 1979). Lambs are separated from their mothers or ewes are fitted with udder covers (so that the lamb-to-mother relationship is not interrupted). During a 24 h period lambs are allowed to suckle during different, smaller periods. Prior to and after each suckling period each lamb is weighed and the sum of its weight increments in 24 hours is considered as the milk yield of its dam for the day of the test (Doney et al., 1979).

Hand or Machine-Milking Method

The oxytocin technique provides measurement of potential ewe milk production (McCance, 1959). However, it may overestimate lamb consumption by 20% (Coombe et al., 1960; Moore, 1962). This technique involves milking the ewe either by hand or machine after injection with oxytocin. Oxytocin is a hormone released by the pituitary gland that acts at the level of the mammary gland; it produces the release (let down) of milk. Doses required to elicit emptying of the udder in sheep have been investigated by several authors covering a range of 0.1 to 10 international units (IU, McCance, 1959; Semjan, 1962)). In all cases, a linear response between dose rate and the degree of emptying was found. Authors recommend that a second dose be given after response of the first has ceased (Peart, 1983). McCance (1959) working with normally suckled sheep found a second dose of 5 IU following first injection of the same amount rarely allowed more than an additional 20 milliliters (ml) of milk to be withdrawn. Therefore, the experimental error introduced by using only a single dose would rarely exceed 5% of the observed value. Ewes are milked out and separated from the lambs for a period that varies between two and six h. Ewes are then milked again, milk production for the period is recorded and daily milk production calculated. Rate of secretion is apparently faster the first 2 h, and the effect lessens as lactation declines (McCance, 1959).

It is recommended that oxytocin injection be done intravenously for a faster response. However, Geenty (1980) found no difference in

milk yield when dosing sheep intramuscularly compared to intrajugular injection.

Body-Water Dilution Technique

Tritiated water dilution measures body water turnover of lambs in the field during a given time period (Macfarlane et al., 1969). Most milk is greater than 80% water and the burning of hydrogen in the milk solids yields a volume of water near that of solids themselves. Therefore, measurement of water turnover in the young provides a close estimate of milk intake (Macfarlane et al., 1969). A disadvantage of this estimate is that it cannot account for non-milk sources of water intake which can lead to considerable overestimation when milk ceases to be the sole source of water (Wright and Wolff, 1976). Wright and Wolff (1976) created the double isotope method to eliminate this overestimation. They concluded it is possible to estimate not only individual milk intake but also changes in relative body composition, water turnover and, in some circumstances, pasture intake of water with this method.

Comparison of the Methods

Comparison of the weighing method with the oxytocin method suggests the latter method gives higher estimates (Treacher, 1983). Doney et al. (1979) found the oxytocin method gave higher estimates of yield in the first week of lactation, especially in ewes suckling single lambs. However, by the third week there were no significant differences between estimates made by the two methods. Estimates were not affected by level of milk production, number of lambs suckled or

genotype of the ewe. From a practical point of view, the oxytocin method is more convenient, less tedious and less time-consuming than the lamb-suckling technique. Weight increases due to suckling are too small to be measured accurately at 10 wk after birth and this is another disadvantage of the weighing method (Coombe et al., 1960). Geenty et al. (1985) concluded the oxytocin method overestimates milk consumed by lambs during the initial two to three wk of lactation, particularly in breeds such as the Dorset with high milk production. Estimates of lamb water turnover gave better predictions of feed intake and hence lamb growth. Geenty and Sykes (1986) found the machine milking technique following oxytocin administration gave estimates which were, on average, 2.4, 8.9 and 18.8% higher for groups of ewes on low, medium and high forage allowances, respectively, compared to the suckling technique.

Peart (1983) stated

Whilst a knowledge of factors responsible for variation in milk production by ewes and milk intake by lambs is essential for the interpretation and development of management systems for sheep, it must be recognized that all techniques for estimating these characters are subject to some systematic bias or to variable errors introduced by the experimental management. Nevertheless valid estimates for most applied purposes may be obtained by any of the three methods; the choice being dependent on the experimental objectives and the available resources.(1)

(1) Peart, J. N. (1982) Lactation of suckling ewes and does. In: I Coop (Ed.) Sheep and Goat Production. World Animal Science, v. C1. Elsevier, Amsterdam. pp. 121-122.

Lactation PerformanceMilk Yield

Many estimates have been made to quantify the milk production of different breeds of sheep using different measurement techniques. These estimates vary according to breed, location, level of nutrition, number of lambs born or reared, breed of ewe, age of dam, body weight, moment of the lactating period when the estimate is measured and the technique used in the measurement. These differences must be taken into account when comparisons are made between sources of information (Peart, 1982). A summary of selected milk yield studies is presented in Table 1.

Table 1. Selected milk yield studies reported in the literature.

Author/Year	Breed (Birthtype)	Lactation Test Period (wk/wks)	Milk Yield (kg·d ⁻¹)
Wallace (1948a)	Suffolk	1-7	1.59
		1-12	1.39
	Border Leicester x Cheviot	1-7	2.09
		1-12	1.81
Review of authors listed by Wallace (1948a):			
a. Fuller & Kleinheinz	Oxford, Southdown, Dorset, Merion, Montana, Shropshire	1-7	1.27
b. Neidig & Iddings	Hampshire, Southdown	1-7	1.24
c. Pierce	Merino	3	1.21
		9	.65

Table 1--continued

Author/Year	Breed (Birthtype)	Lactation Test Period (wk/wks)	Milk Yield (kg·d ⁻¹)
	Suffolk	3 9	1.76 1.07
	Border Leicester	3 9	2.49 1.37
d. Barnicoat	Southdown Cross	2-5 14	1.50 .65
e. Bonsma	Merino	1-12	.75
	Merino Cross	1-12	1.13
Barnicoat et al. (1949a,b)	a. Romney (twin) (single)	1-12	1.84 1.36
	b. Romney (single)	2-10	1.36
	c. Romney (single)	2-10	1.45
	d. Romney (single)	1-12	1.30
	e. Romney (single)	1-12	1.50
	f. Romney (twin) (single)	1-12	1.70 1.28
Thomson & Thomson (1953)	Sutherlandshire Cheviot	1-13	.55-.98
Burris & Baugus (1955)	Hampshire (twin) (single)	1-12	.94 .89
Barnicoate et al. (1956)	Romney (twin)	1-3 1-12	1.56-2.18 .99-1.53
	(single)	1-3 1-12	1.19-1.45 .82-1.16
Gardner & Hogue (1964)	Ramboillet x Columbia (twin) (single)	1-13	2.08-2.33 1.61-1.88
(1966)	Hampshire (twin) (single)	1-12	2.47 2.16
	Correidale (twin) (single)	1-12	2.15 1.44

Table 1--continued

Author/Year	Breed (Birthtype)	Lactation Test Period (wk/wks)	Milk Yield (kg·d ⁻¹)
Folman et al. (1966a)	Awassi medium producing dairy flock	1-8	2.52
	Awassi high producing dairy flock	1-8	3.36
(1966b)	Awassi mutton flock	1-8	1.55
Treacher (1970)	a. Dorset Horn	1-9	1.32
	b. Dorset Horn	1-9	1.43
	c. Scottish half-bred	1-6	.99
	d. Dorset Horn	1-6	1.38
	e. Dorset Horn	1-6	1.21
	f. Dorset Horn	1-9	1.45
Wilson et al. (1971)	Dorset x Merino	1	1.47
		3	1.85
		10	1.08
Peart (1967)	Blackface (twin) (single)	1-10	1.79-2.01 1.44
(1968a)	Blackface	3	2.00
		12	.84
(1968b)	Blackface (twin) (single)	1	1.87-2.34 1.23-1.38
Peart et al. (1975a)	Texel x Blackface	1-12	1.88
	Blackface	1-12	1.52
(1975b)	Finnish Lanrace x Blackface (twin) (single)	1-12	2.10 1.49
(1979)	Scottish Blackface (twin) (single)	1-14	2.12 1.47
	East Friesland x Scottish Blackface (twin) (single)	1-14	2.63 1.85
Torres-Hernandez & Hohenboken (1979)	Dorset Cross	1-15	1.16
	Cheviot Cross	1-15	1.20
	Finnsheep Cross	1-15	.94
	Romney Cross	1-15	1.06

Table 1--continued

Author/Year	Breed (Birthtype)	Lactation Test Period (wk/wks)	Milk Yield (kg·d ⁻¹)
Robinson et al. (1979)	Finnish Landrace x Dorset Horn (twin)	2-4	3.05
Cowan et al. (1981)	Finnish Landrace x Dorset Horn (twin) LP	1-6	3.32
	(twin) HP	1-6	3.50
Gonzalez et al. (1982)	Finnish Landrace x Dorset Horn (twin)		1.92
Hinch et al. (1983)	Booroola x Romney (single)	1-2	1.38
	(twin)	1-2	1.97
	(triplet)	1-2	2.23
Loerch et al. (1985)	Finn Crossbred (twin)	3	2.73
	(triplet)	3	3.06
Geenty (1979)	Romney (twin)	1-9	1.85
	(single)	1-9	1.28
	Dorset (twin)	1-9	3.50
	Dorset (single)	1-9	2.09
	Romney x Dorset (single)	1-9	1.85
	Dorset x Romney (single)	1-9	1.70
Geenty (1980)	Dorset (single)		
	Suckled	1-15	1.89
	Dary with oxytocin	5-15	1.21
	Dary without oxytocin	5-15	1.02
Geenty et al. (1985)	Dorset (single)	1-5	2.09
	Romney (single)	1-5	1.39
	Romney x Dorset (single)	1-5	1.75
	Dorset x Romney (single)	1-5	1.84
Geenty et al. (1986)	Dorset (single)		1.85

Milk Composition

The composition of ewe's milk is given in Table 2. Differences may be due to breed of ewe, suckling intensity and nutrition. Peart et al. (1972) found significant differences in energy and protein production between single and multiple suckled ewes. Production was significantly higher for twin and triplet than single suckled ewes. Geenty (1979) reported no significant differences in milk composition for two successive years for three different breeds. Significant breed differences were apparent for the non-fat components, with Dorsets being higher than Corriedales and Romneys having the lowest values. Protein and fat levels for crossbred ewes were similar to the means of their parent breeds. Robinson et al. (1979) found an increase in the N content of the milk when fish meal was included in the diet of Finnish Landrace X Dorset Horn ewes and a subsequent N reduction when fish meal was removed. The same authors reported ewes given fish meal tended to produce milk with a higher N content than those given either soybean or groundnut meals. Milk crude protein, fat and lactose percentage were not altered by protein content of the diet; however, g of crude protein in milk was higher for ewes given a high protein diet compared to a low protein diet (Cowan et al., 1981). Supplementing ewes in late lactation with soybean meal increased milk yield but decreased fat content of milk (Gonzalez et al., 1982).

Table 2. Composition of ewe's milk (2.5 weeks postpartum).^a

Item	Amount
Dry Matter	18.2%
Fat (5-10%)	7.1 g·100 g ⁻¹ milk
Protein (true)	4.5 x 5.49 = 24.7% DM basis
Lactose	4.8 x 5.49 = 26.4% CM basis
Ash	0.85 g·100 g ⁻¹ milk
Fiber	0.00 g·100 g ⁻¹ milk
Caloric value (GE)	110 kcal·100 g ⁻¹ x 5.49 = 6.04 Mcal·kg ⁻¹ milk DM basis
Minerals (g·100 g ⁻¹)	
Na	0.040
K	0.150
Ca	0.200
Mg	0.016
P	0.150
Cl	0.075
Citrate	0.170
Trace minerals (mg·l ⁻¹).	
Fe	0.60-0.70
Cu	0.05-0.15
Mn	0.06
Al	1.70
Zn	2.00-3.00
Vitamins (mg·l ⁻¹ , except where noted)	
A	1,450 IU·l ⁻¹
E (α-tocopherol)	15
Thiamin	1.0
Riboflavin	4.0
Niacin	5.0
B6	0.7
Pantothenic acid	4.0
Biotin	0.05-0.09
Folacin	0.05
B12	0.006-0.010
Ascorbic Acid	40-50

^aNRC (1985) Nutrient requirement of sheep. National Academy Press, Washington, D.C. Sixth Revised Edition. p. 51.

Non-Nutritional Factors Influencing Yield

Influence of Suckling Stimulus

Under similar circumstances twin-suckled ewes produce approximately 40% more milk than single-suckled ewes (Peart, 1982). Hinch and Kyle (1983) reported ewes rearing one, two and three lambs produced 97, 138 and 156 l of milk, respectively, during a 70 d lactation. Influence of rearing rank was most pronounced in early lactation. Milk production of single and twin-reared ewes tended to peak at day 20 at approximately 2 and 2.5 l·ewe⁻¹·d⁻¹, respectively, and then declined.

Suckled yield of ewes rearing twins was 18 to 30% higher than those rearing singles (Geenty, 1980). Ewes with twin lambs normally reach peak yield in the second or third week of lactation compared to the third to fifth week in ewes with singles. However, persistency is slightly lower in ewes with twins, and by 12 wk of lactation differences in milk production between ewes with one or two lambs are negligible (Treacher, 1983). Number of lambs suckled has a greater effect on milk yield than nutrition during pregnancy or lactation. Peart et al. (1972) found differences in total yield between suckling groups were mainly due to differences during the first three to four weeks of lactation. There is evidence initial milk yield of ewes is influenced by number of lambs born or total weight of the concepta (Peart et al., 1972).

Suckling and milking are the most potent natural stimuli that cause milk ejection. Visual and auditory cues associated with milkers and milk routines may also affect milk ejection (Tucker, 1985). Ewes

that are not adapted to milking (e.g., suckled sheep) may be stressed. This varies between animals. Sheep are very susceptible to any change in management or environment, and it has been observed that minor disturbances will depress measured milk production (Peart, 1982).

Hormones

Maintenance of intense lactation requires maintenance of alveolar cell numbers, synthetic activity per mammary cell and efficacy of the milk ejection reflex. A hormonal complex controls lactation, but unless milk is removed frequently from the udder, synthesis of milk will not persist despite an adequate hormonal status. Hormones required for maintenance of milk synthesis include prolactin, growth hormone, ACTH (or glucocorticoids), TSH (or thyroid hormones), insulin, and parathyroid hormone. Oxytocin is essential for milk removal. An essential component of the milk ejection reflex is the binding of oxytocin, specifically and with high affinity, to protein receptor sites on the myoepithelial cell and expulsion of milk from the mammary gland. The number of oxytocin receptors increases to maximal amounts during first lactation, then probably persists for the lifetime of the myoepithelial cell (Tucker, 1985).

The importance of the estrogen hormones produced by the placenta in the development of the udder during pregnancy in the ewe suggests a mechanism by which the number or genotype of fetuses may affect udder development and, hence, the milk yield potential (Delouis, 1981).

In a commercial context, current interest centers on the ability of bovine growth hormone (GH) to stimulate consistent increases in milk

is thought to be partly mediated via the nutrient-partitioning actions of GH. Stimulation of milk production by GH administration indicates an effect on the mammary gland capacity for nutrient uptake and synthesis of milk components. Whether this stimulation is exerted directly by binding of GH to receptors of alveolar cell membranes or whether it is mediated by local formation of a specific somatomedin remains to be investigated (Riis, 1983). The likelihood that rapid advances in biotechnology would eventually make large quantities of recombinant-DNA-derived GH available gave impetus to a re-examination of the galactopoietic role of GH. It also stimulated research into the biological action of the hormone in the lactating animal, mainly dairy animals (Johnsson and Hart, 1986).

Peel et al. (1981) first examined effects of pituitary bovine GH during early, but not peak, lactation in high-yielding cows typical of the United States dairy industry. They reported a 10 to 15% increase in milk yield in two studies. In general, the effect of GH on milk composition appeared to be small in relation to the marked changes in total output of milk fat, protein and lactose. However, several studies have reported significant increases in the concentration of milk fat and a tendency for protein concentration to decrease in GH treated cows (Peel et al., 1982). These changes appear to be primarily associated with early lactation (Johnsson and Hart, 1986). Since endogenous GH secretion and food intake appear to be linked in ruminants, the possibility of a feedback inhibition of appetite by GH treatment at a time of decreasing metabolic demand in late lactation may have implications for the repletion of body fat

reserves in preparation for the following lactation (Johnsson and Hart, 1986). As stated by Riis (1983), GH is apparently more important than other lactogenic hormones for adaptation of mammary gland metabolism after lactation is initiated in cows.

Lactating animals have lower glucose and insulin concentrations than non-lactating ones. Low glucose concentration in lactating animals is a result of the rapid uptake and utilization of this nutrient in the mammary gland. Decline of the plasma insulin level after parturition may be a result of lower glucose concentration (Riis, 1983). Low insulin concentration in lactating cows inhibits glucose uptake and utilization in adipose, muscle and most other body tissues. Like nervous tissue, the mammary gland is insensitive to insulin (Hove, cited by Riis, 1983).

Secretion of pituitary prolactin and placental lactogens during mammary gland development determines the production capacity of the gland at the start of lactation. Pituitary prolactin is presumably very important for the initiation of lactation. Placental lactogen is secreted from the fetal placenta, and its secretion, therefore, ceases at parturition.

The role of pituitary prolactin after initiation of lactation is not clear (Riis, 1983). Inhibition of prolactin affects milk production in ewes but not in cows and goats (Hooley et al., 1987). Growth hormone is apparently more important than prolactin, or it may replace prolactin as a stimulating factor for maintenance of milk production in cows and goats (Riis, 1983).

Other Factors Influencing Milk Production

Owen (1957) reported estimates for heritability of milk production of suckling ewes of 0.50 and 0.61. In a genetic selection experiment, Pattie and Trimmer (Cited by Peart, 1982) recorded a 10% increase in milk production in a line of Merino ewes which were selected on the basis of lamb weaning weight.

Differences in milk production among breeds of sheep have been reported. Coop et al. (1963) found that Border Leicester X Romney ewes produced 20% more milk than Romneys. Geenty (1979) showed up to 88% greater milk production by Dorsets compared with Romneys.

Lactation yields in successive lactations are influenced by both parity and age at first lambing. Yields increase from the first to third lactations by 5 to 40% (in ewes lambing for the first time at two years of age), then remain relatively constant until the sixth lactation, after which a decline occurs except under very good management and feeding (Mason et al., cited by Treacher, 1983). Yield in the first lactation is lower, partly as a result of a shorter lactation, than in ewes that lamb for the first time at two years of age, but the subsequent lactation yields are similar (Treacher, 1983).

Nutrition of the Lactating Ewe

Plane of Nutrition

The most important factor influencing milk yield of the ewe is the plane of nutrition during lactation (Jagusch et al., 1972). They found that restricted nutrition for one week following parturition

delayed peak lactation yields by several days, while restriction for four weeks created a depression.

Barnicoat et al. (1949) suggested that a high plane of nutrition during late pregnancy was necessary to sustain milk yields by ewes in late lactation (also a conclusion of Wallace, 1948). However, they concluded that nutrition during lactation was the primary factor influencing both initial and total milk yield.

Peart (1967) evaluated milk production of Blackface ewes fed three different levels of nutrition during late pregnancy and then fed ad libitum during lactation. He found Blackface ewes attained maximum daily milk yields three to four weeks after parturition. At this point twin suckled ewes yielded about 50% more milk than single suckled ewes. Thereafter, milk yields declined but at different rates; from about the eighth week of lactation milk production from twin and single suckled ewes were similar. He suggested that 1) nutrition is not limiting during lactation; 2) a principle effect of malnutrition during pregnancy may be to inhibit the growth potential of the lamb; and 3) the effect on actual milk production is a result of an inability of the small lamb to exploit the milking potential of the ewe.

Energy and Protein Requirements

Energy and protein requirements for ewes during lactation have been published by the National Research Council (NRC 1985). Wide variations exist in the estimations of energy requirements for maintenance and for efficiency of conversion of metabolizable energy to milk energy.

Lactation is the period of highest nutrient requirement in the ewe's annual production cycle. Although a minor restriction of nutrient intake in some instances may not greatly reduce milk production, it will result in loss of liveweight and body condition of the ewe (Peart, 1983). Therefore, evaluation of energy requirements for lactation is very difficult (Treacher, 1983). Energy requirement for milk production is defined as the part of the total energy requirement that is strictly proportional to the amount of milk produced; the rest is attributed to maintenance and is generally considered proportional to metabolic body weight (Moe and Tyrrell, 1975).

Requirements the last six to eight wk of lactation are based on the assumption that milk production during that period is approximately 30 to 40% of the production during the first eight wk. Thus, nutrient intake the last six to eight wk of lactation may be reduced (NRC, 1985).

Energetic efficiency of milk production in the ewe was investigated by Gardner and Hogue (1964). They estimated that 65 to 83% of metabolizable energy (ME) intake is converted to milk energy during the first 12 weeks of lactation. Higher values were obtained for ewes suckling twins than ewes with single lambs (NRC, 1985). Graham (1964) reported heat production for lactating ewes was greater than for non-lactating, non-pregnant ewes, which pointed to an elevated basal metabolic rate during lactation.

Geenty and Sykes (1986) reported maintenance energy requirements during lactation of $0.057 \text{ Mcal ME} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}$ and efficiency of use (K_1)

