NUTRITION OF THE DAIRY EWE

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INTRODUCTION

Dairy sheep production is an important economic resource in many Mediterranean countries. During 1990 21 million ewes were milked for a total milk production of 1641 million liters in European Union countries. In recent years, milk production from ewes has become increasingly important in some European countries where in the past this activity was unknown. This is in part the result of the quotas of European Union on cow's milk production.

Proper feeding strategies of the lactating ewe cannot be based simply on what is known for dairy cows. Even though much of the information available for dairy cattle is valid for dairy sheep, it is necessary to be aware of the differences between the two species to avoid using improper feeding strategies for the lactating ewe.

DAIRY SHEEP ARE NOT JUST DAIRY COWS TEN TIMES SMALLER

Recommendations for feeding dairy sheep are often derived from dairy cows, whose nutrition and feeding management have been more extensively studied. Even though both sheep and cattle are ruminants and have many similarities, they tend to have different feeding strategies and they are also different in several physiological functions.

Some of the most important differences between the two species are related to their body size. Dairy sheep are, in general, 10-12 times smaller than dairy cows. Many studies have shown that in both species the total volume of the gastrointestinal (GI) tract varies between 13-18% of the body volume (Parra, 1978, cited by Van Soest, 1994). As adult ruminants increase the size, GI tract volume increases in direct proportion to body weight. This means that the GI tract of a 60 kg sheep is, on average, 10 times smaller than that of a 600 kg cow. However, as the body weight increases, there is a less than proportional increase in energy requirement for maintenance. Maintenance energy requirements are usually proportional to the 0.75 power of body weight ($BW^{0.75}$, often called metabolic weight, MW). This means that maintenance requirements of a 600 kg (MW= 121.2 kg) cow are only 5.6 times higher than those of a 60 kg (MW= 21.6 kg) sheep. If we divide the weight of the GI tract by the maintenance energy requirements it is possible to estimate the digestive capacity (kg of GI tract available per unit of energy requirements). The digestive capacity curve in figure 1 shows that cattle tend to have more kg of GI tract available per unit of energy required for maintenance than sheep, i.e. they can "store" more feedstuff in the GI tract for each Mcal of energy required for maintenance than a sheep.

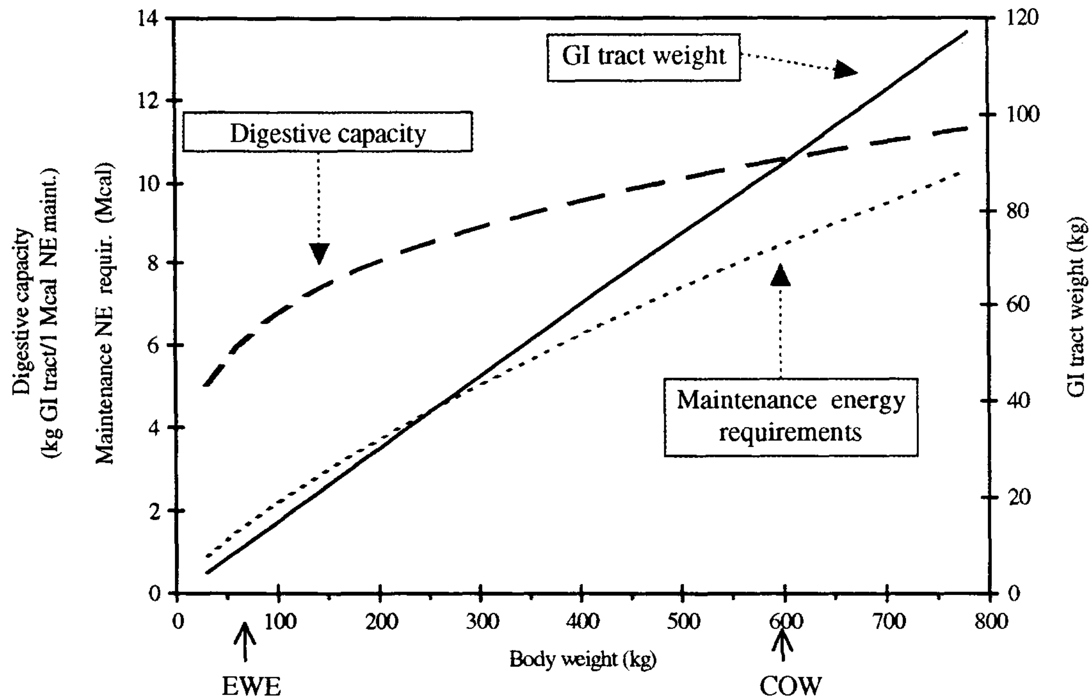

Figure 1- Effect of body weight on gastrointestinal tract (GI) size, maintenance energy requirements (net energy, NE) and digestive capacity.

Fiber can be fermented in the rumen only if it is stays there for a sufficient time (several hours). The longer it stays, the more it is digested (up to a limit!). In practice, if sheep and cattle are fed with the same fibrous feedstuff, cows tend to have higher digestibility because they have more room and they can keep the feedstuff in the rumen for a longer time (Table 1). This difference in digestibility is maintained even when in both species the intake is much higher than that typical of dry animals (Blaxter et al., 1966).

Table 1. Apparent digestibilities and retention times for ruminants fed medium quality timothy hay (Uden et al., 1982; Uden and Van Soest, 1982)

Item	Goats	Sheep	Heifer
Body Weight	29	30	555
Intake of dry matter			
g/d	1637	1525	7775
g/kg BW	56	51	14
g/kg $BW^{0.75}$	131	119	68
Digestibility (%)			
Dry matter	47	47	54
NDF	44	44	52
Retention time of forage particles			
Rumen (hr)	28	35	47
Whole GI tract (hr)	52	70	79
Ratio: rumen/whole tract	54	50	59

BW = body weight NDF = neutral detergent fiber

There are important practical implications related to these facts. To compensate for their low digestive capacity, sheep have to speed up the passage of feedstuff in the rumen (high passage rate). Therefore, sheep need to eat more feed per day (as % of BW) than cattle to satisfy their requirements. Since the feed stays in the rumen for a shorter period (shorter retention time), each kg of feed is less completely digested. Despite this, due to the higher intake of dry matter, the total amount of nutrients digested per day is usually increased. This explains why high producing dairy sheep may have a level of intake between 5 and 7% of their body weight, while high producing cows usually do not exceed 4%.

Another way sheep face this problem is to select more (Van Soest, 1994). Since sheep have less room for the feed per unit of requirement than cattle and they have to speed up the passage rate, they tend to choose feeds or parts of feeds that are of good quality and high digestibility. Even if the feed stays for a shorter time in the rumen, its digestibility is sufficiently high to allow the animal to meet its energy requirements.

Sheep differ from cattle in chewing activity too. Sheep require between 9 and 16 more time than cows to eat and ruminate 1 kg of dry matter (De Boever et al., 1990). Sheep have to chew more than cattle because they are smaller animals and their chewing activity is less powerful. Sheep also have to grind the particles more finely than cattle to allow them to pass through the rumen and other compartments of the foregut (Van Soest, 1994). This behavior was clearly shown when lactating dairy cows (Holstein) and dairy sheep (Sarda) were fed a pelleted total mixed ration as the only feed (Table 2). While sheep spent more than an hour to ruminate 1 kg of dry matter, cows had very little rumination. Indeed, while sheep were doing well with this diet and were producing a good amount of milk, cows had milk fat depression and showed clear signs of acidosis.

Table 2. Intake and chewing activity of cows and sheep fed with a pelleted total mixed ration as only feed (Rossi, 1994, cited by Van Soest et al., 1994)

		Dairy cows	Dairy sheep
Intake	(kg of DM/day)	8.4	1.2
Eating time	(min/day)	110.7	56.0
Rumination time	(min/day)	19.4	78.5
Total chewing time	(min/day)	130.1	134.5
Eating efficiency	(min/kg of DM)	13.1	46.3
Rumination efficiency	(min/kg of DM)	2.3	64.9
Total chewing efficiency	(min/kg of DM)	15.4	111.2

Since there is a limit in the amount of time a ruminant can spend chewing, intake tends to be limited by the particle size of coarse diets containing long hay more in sheep than in cattle. This fact, and the lower digestive capacity of sheep, explain why grinding often increases intake of forages and why the response is stronger in sheep than in cattle. Greenhalgh and Reid (1973) compared the intake of sheep and cows fed 3 types of diets (high quality (A) and medium quality (B) dehydrated ryegrass and a mix of medium quality ryegrass with barley (C)) presented in either long or ground and pelleted form.

Their results (Table 3) show that grinding and pelleting: a) increase intake more in sheep than in cows; b) increase intake more in young animals than in adult animals; c) increase intake more in medium quality diets than in higher quality diets (B> A > C). Even in ground diets, however, the total digested dry matter intake is higher in high quality diets than in low quality diets.

Table 3 - Effects of grinding and pelleting various diets on intake in sheep and cattle (Greenhalgh and Reid, 1973, modified).

			SHEEP			STEERS		
		Age (months)	6	18	36	6	18	36
		Body weight (kg)	49	72	83	272	464	614
DIET	FORM	INTAKE						
A	Long *	g/kg of BW	21.9	18.1	23.8	20.5	16.5	15.7
	Ground & pelleted**	difference in %	+59	+46	+29	+18	+21	+5
B	Long*	g/kg of BW	17.8	15.2	18.0	19.6	15.9	13.7
	Ground & pelleted**	difference in %	+76	+74	+61	+31	+21	+30
C	Long*	g/kg of BW	22.0	17.5	24.6	20.5	19.7	17.3
	Ground & pelleted**	difference in %	+49	+25	+11	+20	0	0

A= perennial ryegrass, 2nd cut, harvested 7 weeks after the 1st cut (NDF 59%, CP 19%, ADL 3.3%)
B= perennial ryegrass, 2nd cut, harvested 12 weeks after the 1st cut (NDF 64%, CP 16.6%, ADL 4.1%)
C= 60% hay B and 40% milled and pelleted barley
* = long (baled) for cows, coarsely chopped (5 cm screen) for sheep
** = ground (1.44 cm screen) and pelleted through a 16 mm die

Intense rumination activity in sheep can also have important implications when the diet includes grains. Rumination reduces the particle size of grain and increases rumen digestibility of grain and therefore of starch. Sheep tend to chew grains more finely than cattle. This may explain why diets with high digestibility (> 66%) tend to be digested better by sheep than by cattle, while with low digestibility diets cattle are more efficient (Mertens and Ely, 1982).

In conclusion, compared to cows sheep:

a) have to eat more to satisfy their maintenance requirements. This results in higher passage rate of feed and lower fiber (forage) digestibility
b) tend to have more selective feeding behavior
c) are more affected in their intake by particle size and fiber content of the forages
d) have to spend more time eating and ruminating each kg of feed
e) tend to have higher digestibility of grains and high energy diets.

REQUIREMENTS OF THE LACTATING SHEEP

Energy requirements

Energy requirements of the lactating dairy sheep are calculated as those of lactating ewes of other breeds. The data for this type of animals come from different organizations. Table 4 reports French (INRA,1989), Australian (CSIRO,1990) and

British (AFRC,1993) requirements. Because it was written primarily for meat and wool-production sheep, the NRC (1985) does not specify energy requirements for milk production. For dry ewes sheep NRC (1985) tends to have higher requirements for maintenance than other systems (footnote in table 4). CSIRO (1990) is peculiar because its energy requirements for maintenance grow in proportion to milk yield. The rational behind this is that when the "sheep machine" is producing milk, in addition to the energy necessary to produce each kg of milk she requires some extra maintenance energy. Indeed, when animals (not only ruminants) produce milk they have higher intakes and they require extra energy to process the extra feed (Ortigues and Doreau, 1995). This leads to higher requirements of maintenance during lactation than during the dry period.

Table 4 - Energy requirements for housed mature sheep (Mcal of ME/d) *

FCM **	50 kg of live weight				60 kg of live weight				70 kg of live weight			
(6.5%)	AFRC	INRA	CSIRO		AFRC	INRA	CSIRO		AFRC	INRA	CSIRO	
(kg/d)	total	total	total	maint.	total	total	total	maint.	total	total	total	maint.
0	1.53	1.45	1.60	1.60	1.76	1.66	1.83	1.83	1.99	1.87	2.05	2.05
1	3.28	3.19	3.48	1.77	3.51	3.40	3.71	2.00	3.73	3.60	3.94	2.22
2	5.10	4.92	5.36	1.94	5.31	5.13	5.60	2.17	5.53	5.34	5.82	2.40
3	6.98	6.66	7.25	2.11	7.18	6.87	7.48	2.34	7.37	7.07	7.70	2.57
4	8.94	8.39	9.13	2.28	9.10	8.61	9.36	2.51	9.27	8.81	9.59	2.74

* NRC (1985) = maintenance requirements (Mcal of ME/d): 50 kg = 2.00; 60 kg = 2.20; 70 kg = 2.40
** 6.5% FCM (6.5% fat-corrected milk) = actual milk yield x (0.3688 +0.0971 x % butterfat) (Pulina et al., 1989).

The requirements reported in table 4 include some activity allowance for housed sheep. If the ewes are grazing, an additional allowance should be made for their extra movement. On average, grazing activity increases maintenance requirements by 20% if the ewes are on good quality flat pastures and by 35-40% in more extensive, hilly pastures (CSIRO, 1990). If the ewes have to walk long distances to go to the pasture, a more precise calculation can be done considering the following values (CSIRO, 1990):

Activity	Unity	Live weight			
		50 kg	60 kg	70 kg	80 kg
Walking (horizontal component)	(Mcal per mile)	0.04	0.05	0.06	0.07
Walking (vertical component)	(Mcal per mile)	0.60	0.73	0.85	0.96

Protein requirements

The calculation of protein allowances for lactating ewes represents a difficult and not always successful task. Proteins supplied by the diet are in part fermented in the rumen and in part digested in the intestine. The fraction fermented in the rumen (degradable intake protein, DIP) is used by bacteria (if proper amounts of fermented carbohydrates are present) and allows their growth. Ruminal bacteria then pass to the intestine, where they represent a major source of good protein for the ewe. The requirements of the ewe are then satisfied in part by feed protein that is not fermented in the rumen and is digested in the intestine(undegradable intake protein, UIP) and, in part, by bacterial protein digested in the intestine. The problem is that the amount of protein fermented in the rumen (and as consequence the amount of UIP) and the ability of bacteria to use that protein is affected by many variables like type and amount of feed eaten (usually related to milk production), feeding frequency and amount of energy fermented in the rumen. In practice, this means that it is difficult to say exactly how much protein will be needed to meet the requirements of a lactating ewe. People feeding cows also face these problems but more information is available for lactating cows than for lactating ewes. Thus, most of the information we use is based on information derived from dry ewes or from dairy cows and they may not reflect actual requirements and feed utilization of dairy ewes. The French (INRA 1989), the Australian (CSIRO, 1990) and the British (AFRC, 1993) systems express protein requirements in terms of metabolizable protein requirements while the NRC (1985) uses crude protein (CP). The use of metabolizable protein may give more precise estimates but requires information often not available. In practical situations, crude protein can be still used as base for balancing the diet of dairy ewes. The sheep NRC (1985) gives practical estimates of protein requirements for maintenance of dry females:

Body weight (kg)	50	60	70	80
Crude protein requirements (g/d)	95	104	113	122

Crude protein requirements for milk production are around 120-125 g of CP per kg of milk with 5% CP. If the milk has a different crude protein composition, CP requirements for its production should be proportionally corrected.

Optimal crude protein intake and concentration in the diet can vary substantially depending on the intake of the animals, the type of protein and energy used in the diets and the feeding method. NRC (1985) suggests CP concentration between 13% (90 kg BW) and 14.5 % (50 kg BW) for ewes producing with 1.74 kg/d and between 14% (90 kg) BW and 16.2% (50 kg BW) for ewes producing about 2.6 kg/d. These values may be adequate in many situations. However, in many other cases, diets with up to 18.0-18.5% of crude protein can give an extra boast to milk production, especially when protein sources with low rumen degradability are given. This is supported by some experimental results, both in early lactation (Gonzalez et al., 1984) and in late lactation (Pulina et al., 1990; Cannas et al, 1995). Animals with high levels of production need to have diets with more UIP proteins. In these ewes, in fact, microbial protein may not be able to completely satisfy the high protein demand of the ewe. An example of the effects of protein intake and source on milk yield is given in figure 2.

Fiber and non structural carbohydrate requirements

No information seems to be available to define minimum fiber requirements of lactating sheep. Pelleted complete diets with NDF as low as 32% and small particle size were fed ad libitum as the only feed to dairy ewes (Pulina et al., 1995). The level of intake was about 4.75% of body weight and the ewes had similar milk production to the ewes fed with more fibrous diets. It is important to notice that if concentrates are fed separately from fiber sources they may cause acidosis even when the diet contains more fiber. The optimal fiber intake to maximize milk production is not known. When dairy goats were fed diets containing 14% to 26% ADF, they ate the same amount of diet and produced similar quantities of milk compared to those fed higher fiber diets, while milk fat content was increased in the more fibrous diets (Santini et al., 1991).

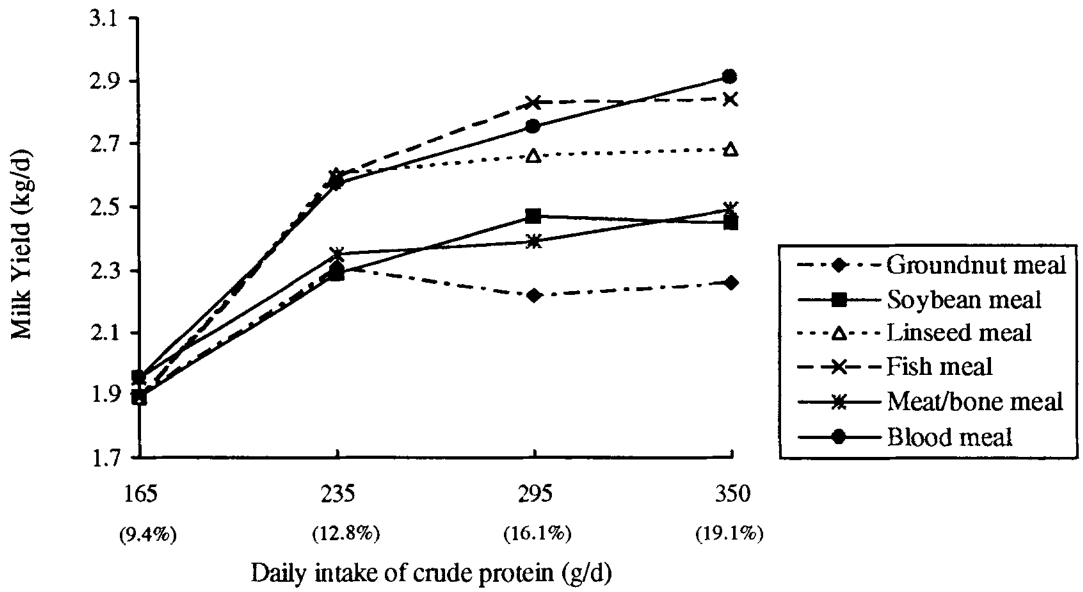

Figure 2 - Effect of different amounts and source of protein in ewes (67 kg BW) in the first month of lactation. The lower protein level corresponds to a basal diet of hay, barley and molasses. Dry matter intake was restricted to 1.8 kg per day for all diets. Numbers in brackets represents CP concentration in the diets (adapted from Gonzalez et al., 1982, and from Robinson, 1987b).

Non structural carbohydrates (NSC) are composed mainly by starch and sugars and are supplied mostly by grains. They tend to decrease when the fiber content of the diet increases. NSC are a very important energy source for the ewes and their rumen bacteria. However, excess NSC may induce severe acidosis and other digestive and metabolic problems (Ørskov, 1986). High roughage diets (60: 40 forage to concentrate ratio) gave much lower milk yield than low roughage diets (20: 80 forage to concentrate ratio, lower NSC content) in Finnsheep ewes in the first weeks of lactation (Brown and Hogue, 1985). However, in dairy goats in the fourth month of lactation milk, yield was only slightly higher when 45:55 forage to concentrate ratio diets were compared with 75:25 ratio diets (Kawas et al., 1991). Diets ranging from 14% to 21% CP were compared at two levels of NSC (as average, 29% vs 40%) (Cannas et al., 1995) in mid-lactation lactating dairy sheep. The ewes fed the diets with the lowest NSC concentration had higher intake (2411 vs 2195 g/d) and produced more milk (1428 vs 1252 g/d). This may have been the result of too much starch in the rumen causing sub-clinical acidosis. Indeed, milk fat, milk lactose and milk pH were slightly lower in the high NSC diets. It is also possible, however, that with the high NSC diet the energy was used more for body fat deposition than for milk production, due to a likely high propionate production, following a mechanism proposed by Ørskov (1986).

The practical implication of these trials is that during early lactation large amounts of grain may help the ewe in negative energy balance to produce more milk, while later on large amounts of grain (and then of NSC) may be detrimental. If the NSC diet content suggested for dairy cows is used for dairy sheep, it should be considered that rumen digestibility of the NSC tends to be higher in sheep (that intensely chew grains) than in cows, while fiber digestibility tends to be lower. This means that for similar NSC content in the diet (i.e. similar forage to concentrate ratios) sheep should have a lower acetate to propionate ratio than cows of comparable levels of production.

PRACTICAL FEEDING OF THE LACTATING EWE

First part of the lactation (first 8-10 weeks)

The first part of the lactation has been studied intensely because of its interest in wool and meat breed. Milk production in this period, in fact, dramatically affects lamb growth and body weight at weaning. In the case of dairy sheep, milk production in early lactation strongly affects the amount of milk produced in mid and late lactation. Both lactation length and total milk production per lactation are usually positively influenced by high milk yield at peak of lactation.

In the first 4-6 weeks of lactation, intake is usually fairly low but the requirements of the ewes are very high. Peak intake usually occurs some weeks after the peak of lactation. This brings the ewe into a negative energy balance. Milk production, then, relies, in part, on utilization of body reserves. The lower the body reserves, the lower the amount of milk that can be produced from fat mobilization (Robinson, 1987a).

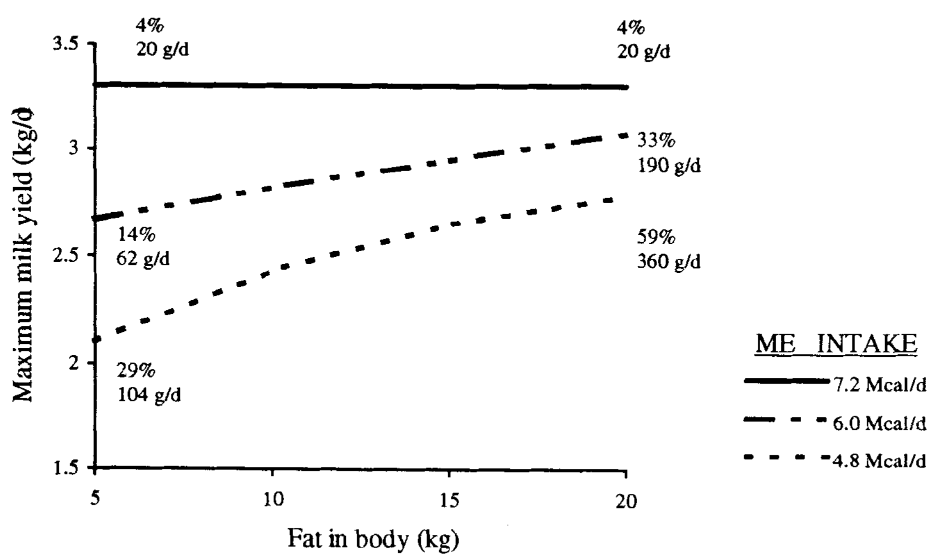

Figure 3 - Effect of body fat reserves and daily intake of metabolizable energy (ME) on maximum milk yield in ewes in the first weeks of lactation. The numbers represent the % of milk obtained from body fat mobilization and body weight losses in grams per day (from Robinson, 1987a, modified).

An important aspect of dairy ewes feeding is to allow the animals to begin the lactation with an appropriate amount of fat reserves (Louca et al., 1974; Robinson, 1987a). Excess body fat in this period, however, may negatively affect intake (Stern et al., 1978). It is critical to provide diets that maximize intake, to avoid excessive negative energy balance and fat mobilization. Figure 3 clearly demonstrates the critical importance of body fat reserves and energy intake in this period. Milk production in ewes consuming highlevels of energy is independent of body condition, while milk production of animals consuming low or medium energy rations is strongly affected by it .

Very high intake (almost 7% of body weight) was obtained even in the first weeks of lactation of ewes nursing triplets when pelleted concentrate was fed ad libitum with a fixed amount of hay (Hogue, 1994). This strategy promoted high growth rate of the lambs and even some body weight gain of the mothers (Table 5) but the gain may be costly.

Table 5 - Observed feed intake and body weight gains of triplet-rearing ewes and their lambs (Hogue, 1994).

Feed consumption of the ewes [a] (kg DM/day)			Daily gain (41 days) (grams/day)	Number of animals
Hay [b]	1.3	Ewes	250	14
Pellets [c]	3.1	Lambs[d]	322	42
Total	4.4	3 lambs	966	

[a] mean body weight at the beginning of the trial (1-2 weeks postpartum): 64.35 kg [b] limit fed
[c] high energy lamb pellets, fed ad libitum [d] lambs had access to pellets in a creep

A fairly easy and practical way to make sure the ewes have enough body fat reserves at the onset of the lactation is to monitor their body condition throughout the pregnancy and to adjust the diet. At lambing, dairy ewes should have a body condition score around 3.5 (Figure 4) (INRA, 1989). Lower values may lead to reduced milk yield caused by insufficient fat reserves, while higher values may cause lower intake and reduced milk yield.

Second part of the lactation

Dairy sheep nutrition in the second part of the lactation (from the 8th-10th weeks until drying) has not been investigated as completely as the early lactation period. It is clear that dairy sheep breeds have not been subjected to the same intense genetic selection that has occurred in dairy cows. This means that the persistency of lactation is often not as good as in cows. In many dairy sheep breeds, after the first months of lactation, the ewes tend to use the nutrients more for body fat deposition than for milk production. This mechanism is even more evident when ewes of meat/wool breeds are used to produce milk. In later lactation dairy sheep (Manchega breed) remarkably increased their milk yield when treated with bovine somatotropin (bST), as shown in table 6 (Fernandez et al.,1995).

Table 6 - Milk yield and composition from ewes administrated sustained-release bST (Fernandez et al., 1995).

	bST- weeks 3 to 8 of lactation			bST weeks 11 to 23 of lactation *		
	0 mg	80 mg/14 d	160 mg/14 d	0 mg	80 mg/14 d	160 mg/14 d
Milk yield, ml/d	997	1198	1337	618	873	947
6% FCM, ml/d	1072	1301	1467	770	1071	1169
Milk fat, %	6.7	6.8	6.9	8.6	8.4	8.4
Milk fat, g/d	66	80	92	50	71	77
Milk protein, %	5.2	5.1	4.9	6.0	5.5	5.2
Milk protein, g/d	51	59	65	36	47	48

* for experimental purposes, from week 18 on the ewes were milked only once per day. This markedly reduced the difference in milk production between the control and the treated animals.

Dairy cows treated with bST behave as genetically superior cows (Peel and Bauman, 1987) and tend to use the nutrients more for milk production than for body fat deposition. It is possible that the high response of bST treated ewes is a sign that there is a lot of "room" for genetic improvement of milk production. Basically this hormone is bringing them to a hormonal status that in the future may be achieved by genetic selection.

The practical experience of Sardinian shepherds tells us that feeding large amounts of grain in the second part of the lactation makes the ewes very fat but does not increase or maintain milk yield. This is probably due to the stimulating effect of the volatile fatty acids produced by grain fermentation (mainly propionate) on body fat deposition, as previously discussed in the section regarding NSC. A better feeding strategy would be based on the maximization of forage intake, the use of by-products with fast-fermented fiber (e.g. soy hulls) and the use of supplements with high levels of protein with low degradability (fish meal, blood meal, roasted soy bean meal). Moreover, the use of protein supplements during the mating season can improve reproductive parameters of lactating ewes (Molle et al., 1995). If grain is fed, slow fermenting starch sources like corn and sorghum grains would be a better choice than the rapidly degradable wheat, barley or oat grains.

FEEDING HOUSED LACTATING EWES

The lactation of dairy ewes can last between 7 and 10 months. This means that for part of the lactation the ewes are fed stored feeds (hay, silage, concentrates).

The quality of the forages fed to lactating ewes is extremely important, especially if hay or silage are a large part of the diet. Even though data for sheep similar to those for cattle (Mertens, 1983) are not available, it is clear that milk yield and forage quality are closely related. High quality forages and small amounts of concentrate supplements allow milk production levels that cannot be obtained with low quality forages, no matter how much concentrate is given.

A major problem of stored forages is how to feed them. Many different feeding strategies are used on commercial dairies. The simplest strategy is to feed loose hay during the entire day and some concentrate supplements at milking. The most complex involves feeding total mixed rations (TMR). Some pros and some cons can be defined for each of the techniques.

Loose hay is often used as the only source of fiber in the diet. Because of the low digestive capacity of sheep, high intake of hay can be achieved only if its quality is high (low fiber content). If hay quality is low (high fiber content), intake will be low and this can lead to low milk yield and a higher probability of acidosis even when moderate levels of concentrate are used. One way to increase the intake of hay is to allow the animals to select. The lower the quality of the hay, the higher should be the amount of hay the ewes are allowed to discard. In table 7 there are some estimates of practical refusals for optimal lactational performance in goats. Even if the numbers do not necessarily apply to the same extent for dairy sheep, it appears that to satisfy the requirements of lactating small ruminants it is necessary either to provide high quality hay or to accept extensive selection and large refusals. It is often more expensive too feed low quality forages with high levels of refusals than to emphasize the production of excellent forages.

Table 7 - Estimates of practical refusals for optimal lactational performance in goats (Van Soest et al., 1994)

Forage	Predicted [a] digestibility (%)	Refusals (%)	Digestibility of ingested forage (%)	Utilization [b] (%)
Alfalfa hay	65	15	69	59
	58	25	66	50
	50	35	60	39
Grass hay	70	20	75	60
	60	35	69	45
	50	50	60	30

[a] From composition of the offered forage [b] Digested matter actually ingested as percent of amount offered

In the case of silages, if they are finely chopped the ability of the ewes to select is very limited. With this type of feed, however, intake can be increased by reducing the particle size (Apolant and Chestnutt, 1985), unless other factors limit intake (bad flavors and taste and molds caused by bad fermentations). Finely chopping should not be considered a tool to force sheep to eat poor quality feeds or an excuse to overlook the quality of the forages.

When the forages are given in a total mixed ration, it is not wise to follow the same suggestions given for dairy cows. Sheep are more selective than dairy cows and their intake is more affected by particle size. We do not want to have much selection in a TMR for sheep. If the ration is coarsely chopped, it is likely that the ewes will first eat all the concentrates. This may lead to acidosis even when the average diet does not have too much starch, as sometimes is observed in Italian dairy sheep enterprises (A. Fantini, D.V.M., personal communication). When "cow-like" TMR diets are used for dairy sheep, another problem often observed is low intake and low milk yield. This usually occurs because the particle size that maximizes intake and milk yield in dairy cows is too coarse for lactating ewes. The strategy used by some nutritionists is to allow more grinding of the forages in the mixer wagon. The result in most of the cases is a sharp increase in both intake and milk yield. This observation is supported by some experimental evidence. Brown and Hogue (1985) compared TMR diets with two forage to concentrate ratios

(60:40 and 20:80) in which the forage (alfalfa hay) was ground either through a 32 mm screen or a 8 mm screen. Milk yield increased 25% in the 8 mm diets, without any change in intake. More extreme grinding may be beneficial too. In a trial at Cornell, Dorset and Finn ewes were fed grass hay that was ground through a 12 mm (coarse), 2.4 mm (medium) and 1 mm (fine) screen (Cannas, 1995). The reduction of the particle size increased intake, milk yield and milk protein yield and markedly decreased rumination activity, while milk fat yield was not affected (Table 8). It seems that sheep can produce well even when fed diets that are very finely ground. On farms, it is almost impossible to have diets ground as fine as in that trial. Dairy sheep producers should not be worried about grinding feeds too finely for lactating ewes. Particles that are too coarse are a much more likely problem.

Table 8 - Effect of dietary particle size on feeding behavior and milk production in lactating ewes in the 6th week of lactation (Cannas, 1995)

	DIET			
	FINE	MEDIUM	COARSE	sem
Dry matter intake ((g/d)	4005	4132	3767	147
Rumination (min/d)	45 ^{a}	165 ^{a}	431 ^{b}	38
Milk yield (g/d)	2400	2492	1991	192
Milk fat (%)	7.86 ^{ab}	7.03 ^{a}	9.08 ^{b}	0.56
Milk fat (g/d)	187.7	185.1	178.6	18.9
Milk protein (%)	4.37	4.13	4.26	0.11
Milk protein (g/d)	105.3 ^{a}	109.7 ^{a}	83.8 ^{b}	8.1

^{abc} Means with different subscript differ (P<0.05)

Diets: 54.9% grass hay, 30.1% cracked barley; 13.0% soybean meal, 2% mineral supplements (CP 16.4%, NDF 41.6%, ADL 3.05%); **Hay ground through**: 1 mm screen (FINE diet); 2.4 mm screen (MEDIUM diet); 12 mm screen (COARSE diet).

FEEDING GRAZING LACTATING EWES

Pasture management and grazing techniques in producing ruminants have been extensively analyzed in many books and reviews and are beyond the scope of this paper. A major problem in feeding grazing lactating ewes is the choice of the amount and of the quality of the supplements. This section will try to give some criteria on supplement management.

Nutritional indicators to choose proper supplements

The main problem we face with grazing animals is that it is very difficult to estimate both their intake and the composition of their diet. For this reason, any decision on quality and quantity of supplements is often the result of a pure guess. A practical and often more effective approach may be based on the utilization of the information available to the dairy sheep breeder to estimate the nutritional status of the ewes and to define the characteristics of the supplements. The indicators that can be used are milk yield and quality, body condition and health status of the animals, and quality and quantity of the pasture.

Milk yield is the most important of these indicators. It is reduced very quickly when pasture quality and availability are reduced and readily goes up if the proper supplement is given. Milk fat is a good index of the fiber composition of the diet. It tends to go up when fiber intake is increased and to go down when a large amount of NSC are supplied. Milk protein is high when there is a proper amount of proteins reaching the intestine, either because there is high production of bacteria in the rumen (large amount of carbohydrate and protein fermented in the rumen) or because large amount of UIP proteins are supplied.

The nutritional status of the ewes can be monitored by body condition scoring . This technique is very useful to check if the ewes are losing too much body fat in the first part of the lactation of if they are overeating and becoming too fat in the second part. The proper body condition score of the ewes in their different physiological stages is given in figure 4 (INRA, 1989). If the flock is large, body condition can be monitored on only some of the ewes (about 20 % of the ewes in medium size flocks and 10-15% in larger ones). Supplements can then be dosed according to the body condition score of the animals.

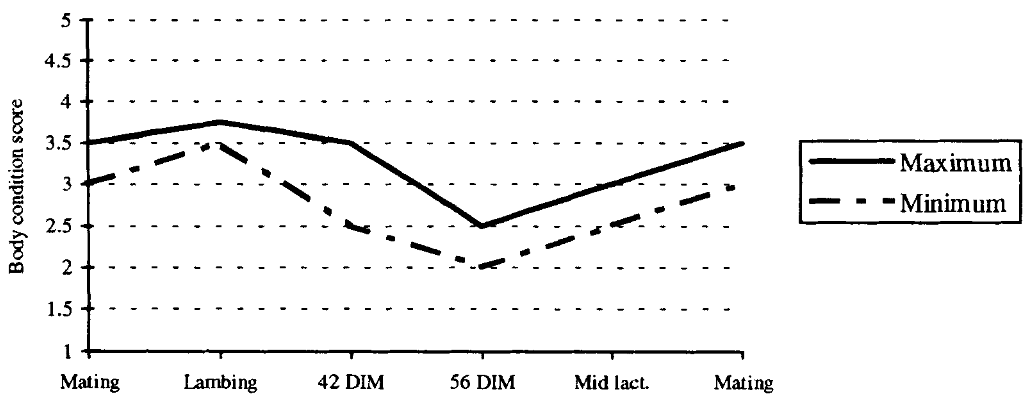

Figure 4 - Target body condition score during the production cycle of dairy ewes (based on INRA, 1989). DIM = days in milk.

The feces are another good indicator of the nutritional status of the ewes. Liquid or loose feces often result from excessive protein in the diet. Ewes grazing on young pastures rich in soluble proteins (first spring growth or regrowth after the harvest) have often this type of feces. The use of readily fermented carbohydrates (molasses, barley, oat) can reduce these problems because bacteria need energy to use a large amount of the fermented proteins (Stephenson et al., 1992). These type of pasture are usually low in fiber. The addition of some hay to the diet may overcome this problem. Excess starch and subsequent acidosis can also produce liquid or loose feces. In this case, however, it is often possible to notice small particles of undigested grains in the feces. Excess NSC in the diets and acidosis are also indicated by the classic typical behavioral signs. Additional fiber in the diets is the proper way to avoid this problem. Pellet-like dry feces are an index of lack of degradable protein in the rumen (low fiber-digesting activity and high fiber content in the feces), low starch or excess of fiber.

In dairy cows urea content in the milk is considered a good indicator of the protein status of the animals (Roseler et al., 1993). In lactating ewes some studies have indicated its usefulness as a predictor of the protein status of the ewes (Egan et Kellaway, 1971, Cannas et al., 1995). Milk urea is highly correlated with the protein content of the diet (Figure 5). It may then possible to use milk urea as an indicator of the protein content of the diet eaten by ewes on pasture. Milk urea is currently tested in Sardinia as a predictor of the nutritional status of the lactating ewes by the local Breeders Association (Associazione Regionale Allevatori). If a sufficiently reliable estimate of the protein content of the diet is known, supplements may be chosen accordingly.

Concentrate feeding

The most common method to supply concentrates to dairy ewes is to give them during milking (twice per day). If the amounts of grain or starchy feeds given each time is large (400-700 g), the ewes will likely have a surge of propionate production in the rumen. This may lead to reduced fermentation of fiber and stimulation of body fat deposition. In the worst cases, acidosis (grain overload) may occur. Even if the amount of grain fed per animal is not excessive, it is likely that some of the more aggressive animals will eat too much grain. These are the animals at the highest risk.

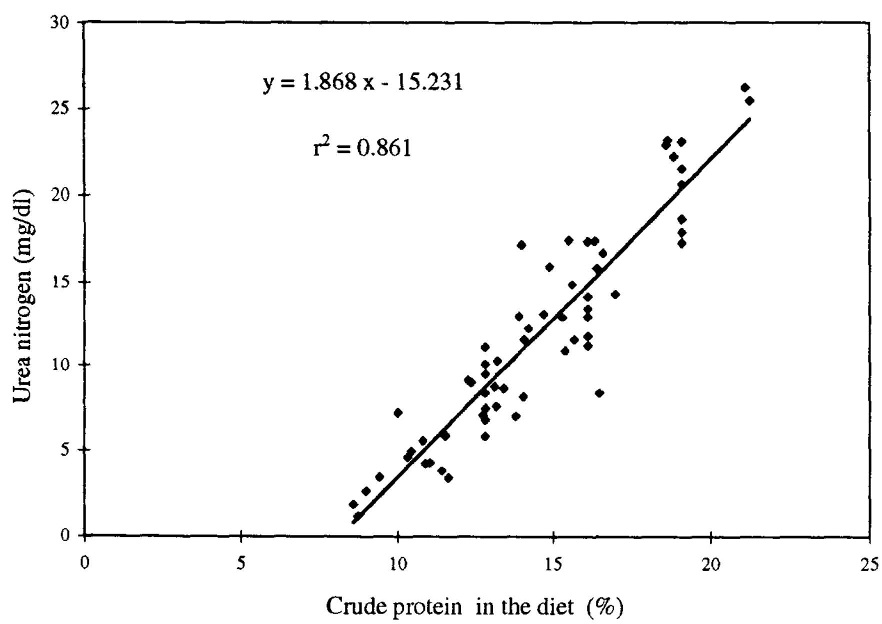

Figure 5 - Relationship between crude protein of the diet and milk or blood urea nitrogen in housed lactating ewes fed diets with several different energy concentrations and sources of proteins (elaborated by the author from data of Cannas et al., 1995, Gonzalez et al., 1982, Gonzalez et al., 1984; Ngongoni et al., 1989). If milk or blood urea nitrogen are used as predictors of CP % in the diet, the following equation should be used :
$Y = 0.461 X + 9.033$, where Y= CP in the diet (%) and X= milk or blood urea nitrogen (ml/dl). Blood or milk urea nitrogen = blood or milk urea * 0.4665.

In these cases, if the same daily amount of grain is supplied in several meals, the surges of propionate production are less likely (Ørskov, 1986) and then the risks of low rumen pH, excessive fattening and acidosis are much lower. However, in practical situations supplying the concentrates more frequently than twice per day may be impractical.

In the case of highly fermentable grains like barley, wheat and oat, using whole grains instead of processed ones (cracked, steam-flaked, ground) is definitely beneficial for sheep (Vipond et al., 1985; Ørskov, 1986). Whole grains stimulate rumination and slow down ruminal fermentation. Sheep chew grains more finely than cows and large losses of whole grains in the feces are unlikely. When slowly fermenting starch sources (corn and sorghum grains) are given, some cracking may be beneficial, especially in animals with high intake and passage rate.

The high passage rate of feed in lactating ewes pose limits to the utilization of some by-products with slowly digested fiber and small particle size. Some of them (brewer grains, distillers) may be eaten in large amounts but may be poorly digested (Van Soest et al., 1994).

The utilization of bicarbonate can be beneficial when high grain diets are feed. Rumen pH was increased and maintained above the level inhibitory to fiber digestion when a mix of sodium bicarbonate (64%) and potassium bicarbonate (34%) was added at the rate of 3.5% of the dry matter to the diet of lambs fed large amounts of barley grains, (Mould et al., 1983).

Acidosis and other digestive disorders are frequent in Sardinia (Italy) during the winter, when the ewes are at peak lactation but the pasture is scarce due to the low temperatures. In this period, ewe are usually fed with large quantities of hay and concentrates. Often, however, the intake of hay is low due to its poor quality. In these cases, acidosis is frequently observed even when only 400-600 g/d of concentrates are supplied. With the aim of solving this problem, Rossi et al. (1991), developed a "safe" pelleted feed. This feed is made of a mixture of energy and protein sources plus about 30% finely chopped dehydrated alfalfa or grass. The amount of fiber and its particle size have been calibrated to stimulate high daily intake, sufficient rumination and slower rates of intake than regular pelleted concentrate. Its average energy concentration ranges between 1.55 and 1.70 Mcal of NE_L if no fats are added. This product has been used as the only feed as long as 20 weeks (Rossi et al., 1991) or as pasture supplement without giving any type of digestive or metabolic problem (Cannas et al., 1992; Calamari et al.,1991). When used as a complete feed its intake ranged between 5.5% to 7% of the body weight and always induced much higher milk yield than in the traditional diets. This type of feed is currently produced by three large feed companies with several formulations. In the last two years it has become very popular among Sardinian dairy sheep producers. It has been used mostly in periods when the pasture is scarce or is very young (high in soluble proteins and low in fiber). It has been beneficial in increasing milk production and in reducing many of the diseases related to nutritional stresses (e.g. mastitis and lameness).

CONCLUSIONS

Feeding programs for lactating ewes should consider the peculiar characteristics of sheep. There are substantial differences between sheep and cattle in feeding behavior and digestive capacity. These differences are particularly important when ewes with high levels of production are considered. Since very few studies have been conducted with high-producing ewes, much more research is needed. In particular, more knowledge is needed to define energy and protein requirements of lactating ewes in the second part of lactation and fiber and NSC optimal level throughout the lactation. In order to determine the quality and the quantity of supplements required by grazing lactating ewes, it is important to use the available nutritional indicators and to develop new ones.

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IMPRESSIONS OF DAIRY SHEEP PRODUCTION IN THE U.K. AND FRANCE

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We were fortunate to obtain a grant from the Babcock Institute for International Dairy Research and Development of the University of Wisconsin-Madison to travel in the U.K. and France from June 18 to July 2, 1995 to view their dairy sheep industries. The specific goals of our visits were:

1. Visit dairy sheep producers to learn of technology which could be applied to Wisconsin dairy sheep production.
2. Locate sources of superior dairy sheep genetics for possible purchase and importation to Wisconsin.
3. Study genetic improvement programs for sheep in place in both countries for their potential for implementation in Wisconsin.

Our trip included visits to nine commercial dairy sheep farms (four in the U.K. and five in France), a dairy sheep research farm in France, four sheep A.I. centers (one in U.K. and three in France), a meat sheep research farm in France, the offices of both the Meat and Livestock Commission and the National Sheep Association in the U.K., the Royal Highlands Agricultural Show in Edinburgh, Scotland, and the National Sheep Institute at Rambouillet, France. We were assisted greatly with arrangements by Olivia Mills, Secretary of the British Dairy Sheep Association, Henry Lewis of the U.K. Meat and Livestock Commission and Francis Barillet of the French National Agricultural Research Institute's (INRA) station near Toulouse. We were joined in France by Kristin Tondra, a veterinary medicine student from the University of Minnesota, who served as a very valuable French interpreter for me (Dave Thomas). This allowed Yves the ability to speak with our hosts in his native French without having to break the conversation to interpret for me.

One week in each country was not enough time to learn all there is to know about their dairy sheep industries, and some of the impressions we came away with may not be true of the real situation. However, we had a very intense visit with a packed schedule every day, and we feel that we gained a tremendous understanding of dairy sheep production in these two countries.

The U.K. and France were chosen as the countries for our visit for several reasons. Each of us were familiar with both countries - I had traveled in both countries before, and Yves had worked and traveled previously in the U.K. and, of course, was very familiar with his native France. With Yves' French language skills, communications would not be a problem. We had good personal and professional contacts in both countries that were willing to assist in the planning of our visit. Sheep dairying is a relatively recent farming enterprise in the modern U.K., and the problems U.K. producers dealt with were apt to be similar to the problems facing U.S. dairy sheep producers (e.g. availability of improved genetics, dairy sheep management, milking technology, marketing). France is the largest producer of sheep's milk for commercial processing, and their dairy sheep industry is highly organized and utilizes the latest in technology. The French dairy sheep industry would be an example of where the U.S. industry may be in the future.