DAIRY SHEEP NUTRITION

John Cant[1], Christoph Wand[2], Heather Aitken[2], and Scott Cieslar[1]

[1]University of Guelph and [2]Ontario Ministry of Agriculture, Food and Rural Affairs Guelph, Ontario, Canada

Introduction

In a paper given to the North American Dairy Sheep Symposium, Treacher (1989) concluded that, in the continued absence of costly research into dairy ewe nutrition, dairy sheep farmers should record “feed inputs, the nutritional quality of feeds and the quantities and quality of milk produced”. During the summer and fall of 1999, we followed Treacher’s (1989) advice on two flocks in the fledgling Ontario dairy sheep industry. Our observations will be used to illustrate some of the points to be made in this paper regarding the calculated approach to formulating rations for the grazing, high-producing milk ewe.

Lactation

If lambs are separated from the ewe wthin 24 h of birth and machine-milking commences twice daily, milk production over the next 100 to 200 d will follow the typical lactation curve observed in other ruminants – a rise in daily production for the first 20 to 40 d and a steady decline thereafter (Figure 1). Typically, however, the difficulties of rearing lambs artificially precludes separation from the dam so lambs are allowed to suckle for the first 30 d or so of lactation. Thus, weaning coincides with peak lactation and daily milk production can be expected to decrease from that time on (Figure 1b). Protein and fat from the East Friesian breed are fairly stable at 5 to 6 % of milk volume until late lactation when daily milk yield falls to 1000 ml/d and less. Lactose percentage changes very little.

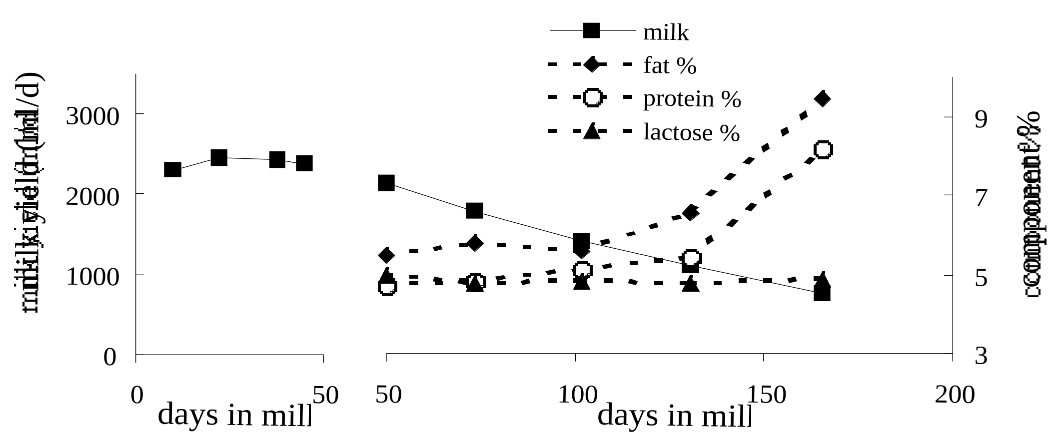

Figure 1. Milk production and composition during lactation in the dairy ewe (a from Bocquier et al., 1999; b from Ontario flock).

There are concerns that leaving the milking up to the lambs during early lactation can limit daily milk yield. Ewes would peak at less than their potential production and, because of the natural decline in milk yield post-peak, total lactational yield could be severely compromised. A partial-milking practice in which ewes were milked once daily at 8 a.m. during the suckling period resulted in an additional 412 ml/d milk for ewes suckling single lambs and

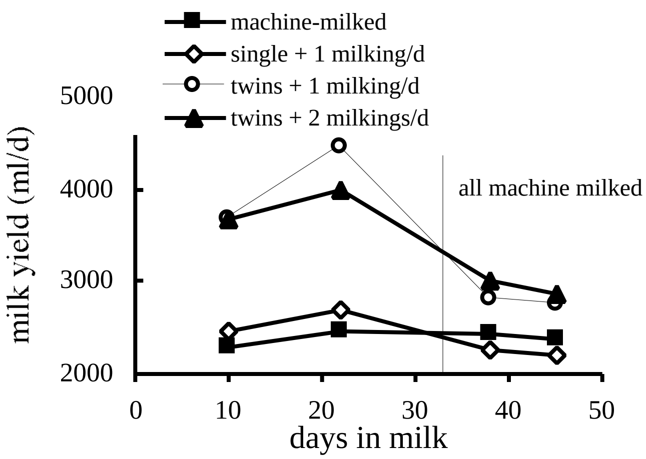

Figure 2. Total daily milk production (suckling + machine-milking) by ewes suckled and/or milked by machine during the first 32 d of lactation (from Bocquier et al., 1999).

177 ml/d for those with twins (Bocquier et al., 1999). Partial milking brought total daily milk yields of ewes with singles up to the level observed in ewes milked solely by machine from the onset of lactation (Figure 2). Ewes with twins, though, were actually stimulated to produce more milk than the completely machine-milked ewes during the first 30 d. At weaning, their milk production dropped off drastically but the advantage of a higher peak carried through to later lactation. The drop in yield at weaning is a common phenomenon (Treacher, 1989;) which indicates that some aspect of suckling is a stronger stimulator of milk production than is obtained with normal milking practices. Possibly the number of milkings per day is a limiting factor. A lamb will suckle 6 to 12 times per day and in the dairy cow, it was shown that 6 milkings per day resulted in 22% more milk produced than on a 3X per day routine (Bar Peled et al., 1998).

Bocquier et al. (1999) tried a second machine-milking during the suckling period at 5 p.m. daily which was preceded by 6 h of separation of ewes from their lambs. These ewes gave 904 ml/d milk for sale during the suckling period. However, total daily milk yield was not increased by the second, more intensive machine milking (Figure 2) and lamb growth rate was reduced from 315 to 271 g/d (Bocquier et al., 1999). One milking per day throughout the suckling period appears to be a successful strategy to avoid underachievement of peak yield and ensure high yields for the remainder of lactation.

Energy and Protein Requirements

There are many factors that determine how much milk a ewe will produce each day. The goal of lactation is to produce as much milk as the suckling lambs demand. Thus, the mammary glands and supporting tissues will attempt to obtain enough nutrients from blood to produce the quantity of milk being removed daily from the udder. If feed intake of the ewe cannot provide all of these nutrients then fat stores will be mobilized out of adipose tissue. However, with machine-milking, it is possible to exceed upper biological limits of the milk-producing system, whether they be mammary capacity, digestive capacity, adipose responsiveness or some other tissue function. As a consequence, the early-lactation ewe is generally unable to consume enough feed to meet energy demands of high milk production and is losing body weight, mostly from fat stores. Nutrition can be used to manage rate of loss of body condition in early lactation as well as level of milk production, especially at peak. Protein and fat content of milk can also be influenced by nutrition but these issues are beyond the scope of this paper. The reader is referred to Kennelly and Glimm (1998) for a discussion of bovine milk composition. The late, declining part of a lactation curve is due to hormonally directed decreases in mammary capacity so nutrition, unless it is inadequate, has little impact. If inadequate, though, milk production and lactational persistency will suffer. Nutrition should be used in late lactation to manage replenishment of body fat reserves.

Table 1. Metabolizable energy (ME) and crude protein (CP) costs of lactation in the ewe. Each column should be summed to arrive at a total nutrient cost. Body weight (BW) is in kg, gain and loss are in kg/d, milk yield is in ml/d

	ME cost (Mcal/d)	CP cost (g/d)
maintenance	0.101 x $BW^{0.75}$	4.456 x $BW^{0.75}$
activity (if grazing)	0.15 x maintenance	0
lactation	milk yield x (fat % x 9 + protein % x 5 + lactose % x 5)/64,000	milk yield x protein %/56.1
body weight loss	10.5 x BW loss	446 x BW loss (max = 151)
body weight gain	11.0 x BW gain	446 x BW gain

To assist in ration formulation for the lactating ewe during these different stages of lactation, and especially the grazing ewe who will obtain only a portion of her dietary nutrients from supplemented ingredients, we have outlined energy and protein costs for the various processes of milk production (Table 1). These costs should be summed up to determine total dietary energy and protein needs for a given level of production. There is no formally published set of nutrient requirements for the lactating dairy ewe in North America. However, there are similarities with other ruminants that have been studied in more detail which were exploited to arrive at our estimates of energy and protein needs. The sources will be reviewed here.

The sheep NRC (1981) publication suggests that daily metabolizable energy (ME) costs for body weight (BW) maintenance in sheep are 93 kcal/kg $BW^{0.75}$. However, it is known that the lactating animal has a higher maintenance expenditure than her non-lactating counterpart because of larger guts and livers (Fell et al., 1972; Smith and Baldwin, 1974). NRC (1981) has an estimate of 101.4 kcal/$kg^{0.75}$ for lactating goats and Sutton and Alderman (2000) go even higher to 103.7 kcal/$kg^{0.75}$. We selected 101 kcal/$kg^{0.75}$ as representative of the maintenance expenditures in a lactating dairy ewe (Table 1). Activity in the grazing animal will add 15% onto the estimated maintenance cost.

Metabolizable energy costs for lactation in goats are estimated as 1246.12 kcal/kg 4% fat-corrected milk (NRC, 1981) and, for cows, as 1233 kcal/kg (NRC, 1989). A more universal approach is to consider fat and protein percentages individually because of the variation possible in either component. In Table 1, ME values of 9, 5 and 5 kcal/g were applied to milk fat, protein and lactose contents, respectively, and a 64% efficiency of ME incorporation into milk was assumed. A standard milk lactose percentage of 4.8 can be used if analyzed values are unavailable.

Each kilogram of BW lost in support of lactation is assumed to spare 9.2 to 12.5 Mcal ME for the non-dairy ewe (NRC, 1985). This is a large range but it does not include the 8.2 Mcal ME/kg BW assumed for the dairy cow (NRC, 1989) or the 7.25 Mcal/kg for the dairy goat (NRC, 1981). Sutton and Alderman (2000) report a vlue of 10.5 Mcal ME/kg BW lost which is intermediate to the NRC (1985) sheep values so it was selected by us as most reasonable (Table 1). Gain of a kilogram of BW takes slightly more ME at 11.0 Mcal (Sutton and Alderman, 2000).

Dietary crude protein (CP) requirements were calculated from metabolizable protein (MP) assuming a true digestibility of 85% and biological value of 66% (NRC, 1985). The daily maintenance MP requirement of lactating goats has been set at 2.5 g/kg $BW^{0.75}$ (Sutton and Alderman, 2000) and 2.82 $g/kg^{0.75}$ (NRC, 1981). Because of the tendency to overfeed protein, we selected the former estimate for our calculations (Table 1). Activity, such as walking during grazing, does not use up any additional dietary protein.

Although NRC (1981) calculated the MP requirement for milk production as 51 g/kg 4% fat-corrected milk, other publications use the milk protein yield as the starting point (Table 1), assuming efficiencies of conversion from absorbed protein of 66% (NRC, 1985), 68% (Sutton and lderman, 2000) or 70% (NRC, 1989). Contrary to popular belief, feeding additional protein beyond what is calculated to be needed for nitrogen balance in the ewe does not result in greater yields of protein in milk (Korman and Osikowski, 1999). Milk protein production in the dairy cow is more related to dietary energy supply than dietary protein supply (Hanigan et al., 1998).

Each kilogram of BW gained or lost is expected to contain 256 g MP in cows (NRC, 1989) and 247 g MP in goats (Sutton and Alderman, 2000). We selected 250 g/kg as reasonable (Cowan et al., 1981) and include the restriction that a maximum of 85 g MP/d (Sutton and Alderman, 2000) can be mobilized from body stores in early lactation.

Pasture Supplementation

To evaluate or formulate a feeding programme for ewes, one must have some idea of how much dry matter (DM) is or will be consumed daily. This is very difficult when animals are grazing so extrapolations from stall-feeding observations are a main recourse. Treacher (1989) reported a maximum DM intake of 5.7 % of BW at week 8 of lactation and typical values ranging from 3.6 to 4.2 %. Using daily Cr_2O_3 dosing and fecal collection for 10 d every month, we estimated forage intakes of 2.0 to 4.2 kg DM/d in ewes supplemented with 1.1 kg DM/d concentrate in the milking parlor. These intakes averaged 4.8 % of BW in total.

Prediction of DM intake is often based on BW alone but more precise estimates also consider milk production, fat or energy content of the milk and stage of lactation (Holter et al., 1997). To our knowledge, no such equations exist for the grazing, lactating dairy ewe.

A 70-kg ewe grazing pasture with a digestibility of 70% will consume approximately 4.5% of her BW in DM daily, which is 3.15 kg/d. To produce 4000 ml/d milk containing 6% fat and 5% protein, according to Table 1, she needs to consume 2.44 Mcal ME/d for maintenance functions, 0.37 for grazing activity and 6.44 for milk production. This is a total of 9.25 Mcal/d. Crude protein requirements are 108 g/d for maintenance plus 356 g/d for lactation, equalling 464 g/d in total. At 3.15 kg/d DM intake, 2.94 Mcal ME/kg DM and 14.7% CP are required. The pastures we observed on Ontario farms had 2.71 Mcal ME/kg DM and 18.9% CP (Table 2). Thus, ME, and not protein, appeared to be limiting dairy ewe performance. However, chemical analysis of a sample of pasture, no matter how well procured, does not accurately represent the quality of forage actually consumed because of selective grazing by ewes. Table 2 shows the composition of a representative sample of pasture and of the forage that disappeared over 3 days of grazing from that same pasture. The grazed material had a higher protein and fat content and was lower in NDF, ADF and lignin. Selection thus allows for improved animal productivity from pastures but maintaining forage quality over the whole season may prove difficult when plant species are not completely grazed. Even though ewes selected forage of a higher TDN and ME content than was available on average, these pastures alone were unable to provide the ME needed for production of 4000 ml milk/d.

Energy supplementation can be provided by whole grains. Protein supplementation should not be considered given the ease with which high-protein forage species can be cultivated and the selective consumption of high-protein plant parts by sheep. However, rumen-undegradable protein supplementation may be warranted because the proteins in fresh forages are highly degradable in the rumen and, if in excess, may not provide metabolizable protein to the ewe. Feedstuffs high in undegradable protein include fish meal, blood meal, corn gluten meal and roasted soybeans. Treacher (1989) documented 600 to 940 ml/d improvements in milk yield with fish and blood meal supplementation of forage-fed ewes.

Tabel 2. Chemical composition of forage pasture or taken off pasture by grazing.

% of DM	ungrazed pasture	disappeared pasture
crude protein	18.9	23.1
soluble protein	4.78	5.09
ND-insoluble CP	7.40	9.90
AD-insoluble CP	1.79	1.91
NDF	59.9	55.6
ADF	33.3	26.0
lignin	2.87	2.29
fat	2.99	3.26
ash	8.68	8.92
TDN[1]	70.9	73.4
ME	2.71	2.82

[1]calculated from Weiss et al. (1992)

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