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# 10 Nutrition during Lactation

T.T. TREACHER[1] AND G. CAJA[2]

[1]51 Western Road, Oxford, UK; [2]Facultad de Veterinaria, Universidad Autonoma de Barcelona, Bellaterra, Spain

## Introduction

In the majority of sheep production systems, sheep are kept for meat or wool production and ewes rear their lambs until weaning, at 3 or 4 months of age. During this period, lamb growth is largely determined by milk intake. Early lactation is the period of highest nutrient requirements in the ewe's whole productive cycle, and failure of management at this time has a major impact on lamb growth. This generally affects the profitability of the system and, in lambs retained as flock replacements, can reduce lifetime performance.

In a number of countries, mainly in Asia and Europe, ewes' milk is an important direct source of animal protein in the human diet. In Afghanistan, Greece, Iraq, Somalia and Syria, more than 30% of the total production of milk, from cows, buffalo, sheep and goats, comes from ewes. In France, Greece, Italy and Spain, large numbers of dairy sheep are kept to produce milk for high-quality, expensive cheeses. In dairy systems, ewes generally rear their lambs before milking is started. The length of both suckling and milking periods varies widely, from 1 month of suckling and 5 or 6 months of milking, in the traditional Mediterranean system, to 3 months suckling and a month of milking in, for example, central Europe. The various dairy systems are discussed in Treacher (1987).

## Composition of Ewes' Milk

Typical figures for the mean composition of ewes' milk (g $kg^{-1}$ liquid milk) are: fat 71, protein 57, lactose 48, ash 9 and solids-not-fat 115 (Ashton *et al.*, 1964). At the start of lactation, the contents of fat and protein are high. They decrease to the peak of lactation and then increase through the remainder of lactation, as yield decreases. Lactose content shows little variation, as the of milk intake have to be corrected for the increase in body-water content (Dove and Freer, 1979).

In older lambs, the overestimation of milk intake resulting from the ingestion of drinking water or solid food, especially herbage, is overcome by using a 'double-isotope' procedure, in which $D_2O$ is injected into the lamb to estimate its total water turnover, while the proportion of this coming from milk is estimated by injecting the ewe with TOH and monitoring the transfer of TOH to the offspring (Dove, 1988).

The major disadvantages of the tracer-based methods are the possible environmental and regulatory consequences of administering radioisotopes (TOH) to animals and the difficulty and cost of $D_2O$ analysis. Nevertheless, these methods are the most accurate for estimating milk intake and have a further advantage in nutritional studies in that changes in the protein and fat content of both ewe and lamb can be estimated from their body-water contents.

## Factors Affecting Milk Production

### Effect of genotype of ewe

Variation in milk yield between and within breeds is very wide. In meat breeds selected for lamb production, yield at the peak of lactation varies between 2.0 and 4.0 kg day$^{-1}$, with total yields in 3 months of lactation varying from 150 to 200 kg in ewes with twin lambs and from 90 to 160 kg in ewes with singles. In small local breeds and some wool breeds, notably Merinos, yields are lower. Differences between dairy breeds are larger. Unselected local breeds may produce less than 100 kg during 6 months of milking, after rearing a lamb for about 1 month, while highly selected breeds, such as the East Friesland and Assaf, which are milked throughout a longer lactation, have yields of 600–1000 kg. Between these extremes are a number of European dairy breeds, including Lacaune, Manchega, Churra, Latxa, Manech and Sarde, which now have significant numbers of ewes in selection schemes and have yields, after rearing a lamb for a month, of 150–250 kg in approximately 200 days of milking.

### Nutrition in pregnancy

Almost all the development of secretory tissue in the ewe's udder occurs in the last third of pregnancy, with a very small amount – approximately 5% – occurring in the first month of lactation. Severe undernutrition in the last weeks of pregnancy results in a small udder, which has little colostrum present at lambing, and a delay of several hours in the initiation of full lactation. This may have a major effect on lamb survival, especially as the lambs are likely to be small and lacking body reserves at birth. Experiments in which underfeeding was severe (reduction of 17–32% in twin birth weight) found reductions of 7–35% in milk yield over the whole lactation (Wallace, 1948; Treacher, 1970).

Nutrition earlier in pregnancy (see Robinson *et al.*, Chapter 9, this volume), before the period of mammary development, may affect milk production via placental size and secretion of placental lactogen. Growth of the placenta, which is completed by 90 days of pregnancy, can be affected by severe underfeeding. If nutrition in late pregnancy is good, this does not lead to a reduction in lamb birth weight, but Davis *et al.* (1980) and Dove *et al.* (1988) found effects of mid-pregnancy feeding on milk yield and lamb growth, even when birth weight was not reduced. This may be related to nutritional effects on placental size and hence placental lactogen concentrations. In sheep, plasma lactogen concentrations increase until close to the end of pregnancy and are affected by placenta size and by the number of fetuses carried.

If there is underfeeding in early lactation, milk production may be affected by the amount of body reserves available for utilization after lambing. Although undernutrition in pregnancy increases the utilization of body reserves before lambing, the level of reserves is also affected by deposition and utilization of fat occurring before mating and in early and mid-pregnancy. The effects of body reserves at lambing on feed intake and on the level and efficiency of milk production are discussed below.

## Effect of number of lambs suckled

Ewes suckling twins generally produce 40% more milk than ewes with singles at the same level of nutrition (Treacher, 1983). Differences reported in the literature range from negligible to increases of 70%, with the majority in the range of 30–50%. In ewes with twins, the peak of lactation is not only higher but is reached sooner – in the second or third week of lactation, compared with the third to fifth week in ewes with singles (Wallace, 1948). Yield decreases slightly more rapidly in ewes with twins and, by week 12 of lactation, the difference in yield between ewes with twins and singles is negligible (Fig. 10.1).

The small amount of information on yields from ewes suckling larger litters of three or four lambs shows wide differences, which may, in part, reflect the small numbers of ewes studied. Differences between ewes suckling triplets and those suckling twins range from negligible (Wallace, 1948) to increases of 30% (Loerch *et al.*,1985). This occurs almost entirely in the first month of lactation, with little difference, or even slightly lower yields, in mid- and late lactation (Peart *et al.*, 1975), possibly related to problems with sore teats and lamb rejection (Gallo and Davies, 1988).

Increases in milk production in ewes suckling twins or larger litters result mainly from the number of lambs suckled. This reflects the increased stimulus resulting from the increased frequency and duration of suckling by two or more lambs. It is not affected by the number of fetuses carried in pregnancy. For example, Loerch *et al.* (1985) found that ewes suckling triplets produced 28% more milk than ewes allowed to suckle only two lambs after carrying triplets in pregnancy. The potential milk yield of ewes suckling singles is not expressed and their production

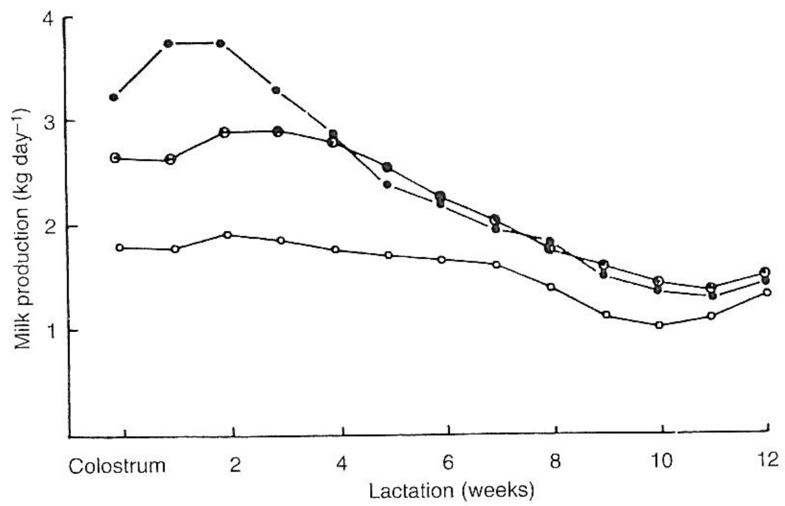


**Fig. 10.1.** Mean lactation curves of ewes: ●, triplet-suckled; ⊖, twin-suckled; ○, single-suckled (reproduced from Peart *et al.*, 1975, by courtesy of the editor and publishers, *Journal of Agricultural Science, Cambridge*).

reflects the voluntary intake of milk by the lamb. This is supported by differences in yields in ewes suckling lambs of different genotypes, as a result of mating with different breeds of ram or of cross-fostering of lambs at birth between ewes of different breeds. This response may be mediated through initial differences in lamb birth weight (e.g. Moore, 1966), but, in other cases (e.g. Peart *et al.*, 1975), the increase appears to result from differences in appetite between lamb genotypes. Although Slen *et al.* (1963) suggested that the yield of ewes suckling twins reflected their potential, increases in yield in ewes suckling triplets show that the potential may be slightly greater.

All the information discussed above relates to management systems where lambs have continuous access to ewes, except when this is altered during measurements of milk yield. In dairy systems, management during the suckling period, before milking is started at about 1 month after lambing, may be different, with lambs separated from the ewes for some part of the day. Gargouri *et al.* (1993) found a reduction of 20% in yield in the first month of lactation when suckling was restricted to two periods of 15 min compared with unrestricted access (see Fig. 10.2). The restricted suckling regime also reduced fat content and increased crude protein content of the milk.

## Effect of milking

In dairy systems, the start of milking at the end of approximately 1 month of suckling results in a dramatic reduction in milk yield, which persists for the remainder of the lactation (Labussière and Pétrequin, 1969). Figure 10.2 shows reductions of 55% and 29% between the fourth week of suckling and the first week of milking in ewes with previously unrestricted and restricted access of lambs, respectively. In the period of machine milking, yields in both groups were almost identical.

## Pattern and Level of Intake in Lactating Ewes

Voluntary intake of feed by ewes normally increases rapidly at the start of lactation and then continues to rise for several weeks. Foot and Russel (1979) measured intakes of a high-quality chopped, dried grass (DM digestibility (DMD) 70%) over the full cycle of pregnancy, lactation and dry periods. Intake in the first week of lactation was 10% higher than the intake 2 weeks before lambing. Intake increased rapidly in weeks 2 and 3 of lactation and then continued to rise at a slower rate to a maximum in week 8, approximately 4 weeks after the peak of lactation. In ewes suckling twins and singles, maximum daily intakes were 3.0 and 2.5 kg DM, respectively (44 and 37 g DM $kg^{-1}$ of weight post-lambing, respectively), 85% and 47% above their intakes in week 1 of lactation. Thereafter intake decreased slowly until weaning, after which it declined by 20%.

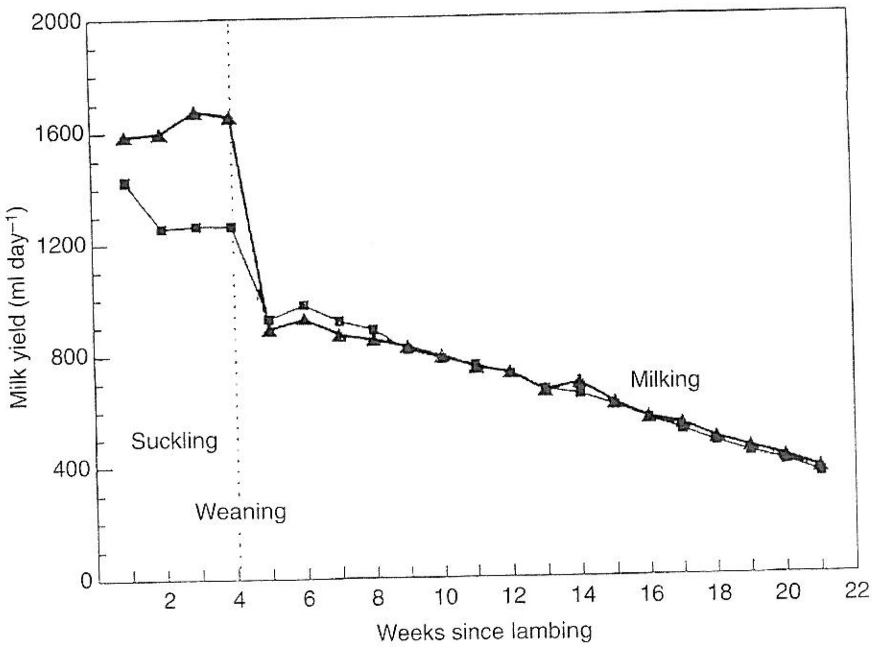


**Fig. 10.2.** Effects of extent of access by lambs to the ewe: ▲, unrestricted access; ■, access restricted to two 15 min periods per day, on the milk yield of Manchega ewes during suckling and subsequent machine milking (adapted from Gargouri *et al.*, 1993).

These large increases in intake in early lactation, as a result of the great increase in metabolic demand for milk production, are accompanied by major effects on the digestive system. The weight, size, nitrogen content and enzyme activity of reticulorumen, abomasum and small intestine increase. The small intestines reach a maximum weight 30 days after lambing and the rumen and abomasum later, at about 50 days. These changes enable the lactating ewe to maintain the same diet digestiblity in spite of large increases in intake. If food intake is restricted in early lactation, these changes to the digestive tract are reduced.

While the pattern of intake described above is typical of ewes offered high-quality long forage, it is clear that on other diets and at pasture different patterns and levels of intake may occur. On a low-quality forage, intake rises slowly and may not peak before weaning occurs 3 or 4 months after lambing (Hadjipieris and Holmes, 1966). At pasture, grazing pressure, availability of herbage and changes in pasture digestibility and sward structure, which are often rapid, all affect the level and pattern of intake. Generally, peak intakes by lactating ewes at pasture in spring occur within 4 weeks of lambing, unless herbage availability is very restricted by either poor pasture growth or high grazing pressures. Gibb *et al.* (1981), for example, found that a peak daily intake of 3.75 kg organic matter (OM) (44 g OM $kg^{-1}$ live-weight (LW) post-lambing) occurred in week 3 of lactation in ewes suckling twins and grazed at a daily herbage allowance of 60 g DM $kg^{-1}$ LW of ewe, while at an allowance of 30 g DM $kg^{-1}$ LW a lower peak intake of 2.30 kg OM (27g OM $kg^{-1}$ LW) was delayed to week 5 (see Plate 10.1).

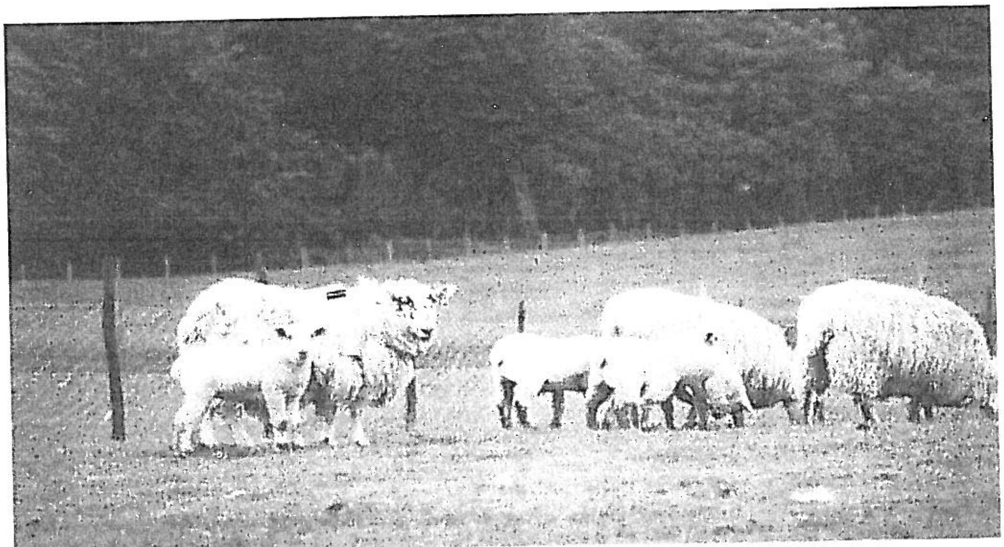

**Plate 10.1.** Border Leicester × Scottish Blackface ewes and their lambs grazing perennial ryegrass pastures in Lanarkshire, central Scotland. The ewe on the left is carrying equipment that allows the estimation of the intake and nutritive value of the pasture in relation to the nutrient requirements for lactation.

Penning *et al.* (1991) and Morris *et al.* (1994) found that lactating ewes grazing swards with surface height in the optimum range (4.5–12 cm) for maintaining near-maximal intakes reached peak intakes of 2.6–3.0 kg OM (38–46 g $kg^{-1}$ LW) in week 4 of lactation, approximately 20% higher than the intake in the first week of lactation. On shorter swards, the patterns of intake varied from a peak at 8 weeks to an almost constant intake over this period.

Body condition at lambing does not have a major effect on absolute intake by lactating ewes. Peart (1970), Foot and Russel (1979) and Gibb and Treacher (1980) found that non-significant differences in intake occurred in ewes differing in live weight at lambing by 10–15 kg or by 1.0–2.0 units of body-condition score (on a scale of 1–5).

## Requirements in Lactation

### Responses to intake of energy and protein

The model described by Robinson (1980) provides a useful starting-point for considering responses in milk production by the ewe to intake of energy and protein and hence nutrient requirements of the ewe during early lactation. Figure 10.3 demonstrates three important principles relating to the response to variation in intake of ME and metabolizable protein (MP):

**1.** For a particular level of ME intake there is a critical protein intake, below which milk yield will decrease.
**2.** The minimum ratio of crude protein (CP) to ME increases with increasing level of milk yield.

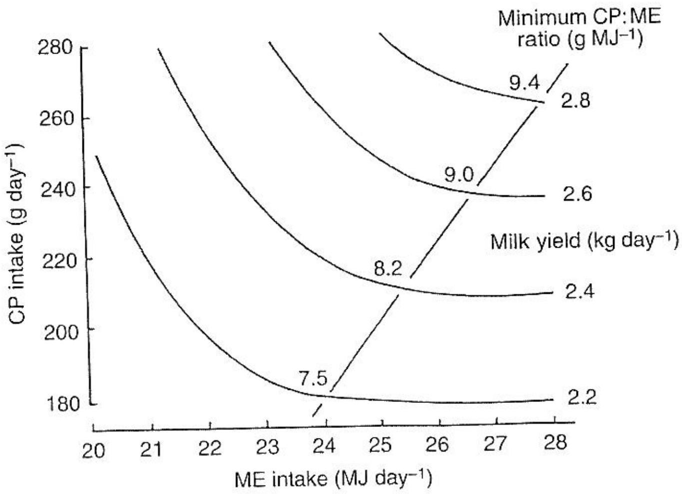


**Fig. 10.3.** Response in milk yield to alterations in dietary CP and ME for 70 kg ewes suckling twin lambs (reproduced with permission from Treacher, 1983).

**3.** An increase in MP intake without a change in ME intake will result in an increase in milk production and mobilization of body reserves, if the ewe has not reached her potential yield.

This model demonstrates that, in early lactation, when energy requirements are high and voluntary intake has not reached its peak, protein intake is likely to have a critical effect on milk production. The extent of the response to protein intake, however, depends on the level of body reserves in the ewe in early lactation. This is discussed further below.

Although this model was derived from data from a single experiment, there are many experiments that confirm its principles. Figure 10.4 from Robinson (1990) shows responses of milk yield in a series of experiments in which increasing amounts of soybean meal and fish meal were added to low-protein basal diets while maintaining a constant intake of energy. At each energy level, the addition of protein to the basal diet increased milk production. At an ME intake of 18.3 MJ day$^{-1}$, the maximum response occurred with an intake of CP of 300 g day$^{-1}$ and was not increased by a greater intake of protein. At intakes of 22.5, 25.0 and 28.3 MJ ME day$^{-1}$, the maximum response occurred at protein intakes of 350, 450 and 450 g CP day$^{-1}$, respectively.

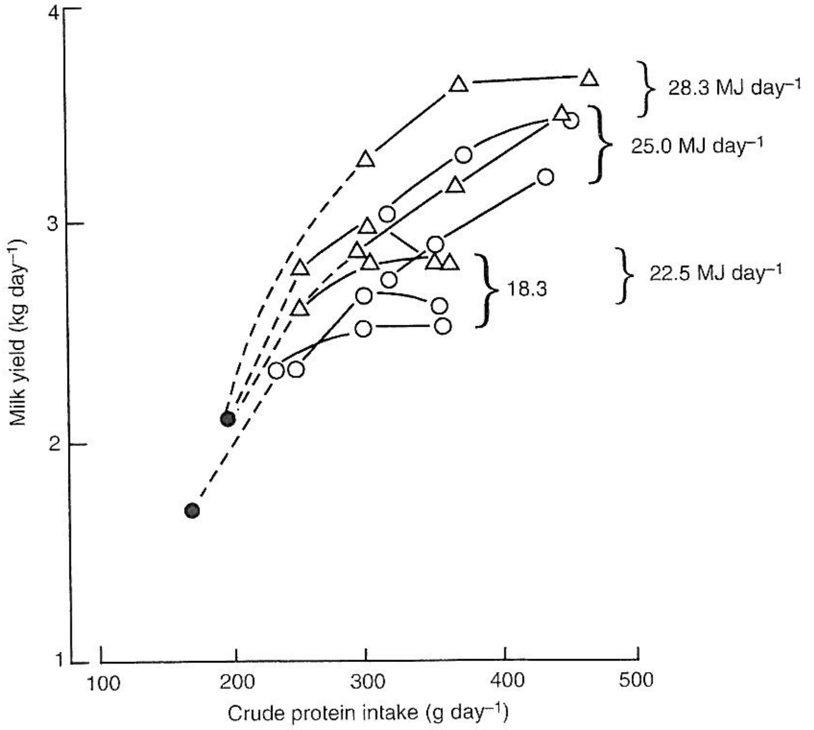


**Fig. 10.4.** The effect of metabolizable energy intake (18.3, 22.5, 25.0 and 28.3 MJ day$^{-1}$) and protein sources on the milk yield of Finn Dorset ewes in early lactation: ●, basal diet of hay and barley; ○, basal diet with different proportions of barley replaced by soybean meal; △, basal diet with different proportions of barley replaced by fish meal. (Adapted from Robinson, 1990.)