The Use of Nutrition to Increase Sheep Performance
P. R. Kenyon

Abstract: In many production systems, sheep performance has increased over time as farmers have aimed to improve profitability. However, systems based on grasses only can be insufficient to allow for high levels of animal performance. This has resulted in increased interest in the use of specialist crops and supplements. There is now information available for farmers on the potential performance levels that can be achieved using these alternative feed sources. However, farmers need to examine carefully the cost effectiveness of these, before using them. Further it is possible that in the future management guidelines will be developed in pregnancy for farmers to utilise to increase the performance of future generations. Further work is required to determine if consistent responses can be found.

Key words: alimentation, performance, ruminant

O Uso da Nutrição para Aumentar o Desempenho de Ovinos

Resumo: Em muitos sistemas de produção, o desempenho de ovinos aumentou ao longo do tempo na medida em que os agricultores procuravam melhorar a rentabilidade. No entanto, os sistemas baseados apenas em pastejo podem ser insuficientes para permitir elevados níveis de desempenho animal. Isto resultou no aumento do interesse na utilização de culturas especializadas e suplementos. Agora há informações disponíveis para os agricultores sobre os níveis de desempenho potenciais que podem ser alcançados com essas fontes de alimentação alternativas. No entanto, os agricultores precisam examinar cuidadosamente a eficácia antes de usá-los. Além disso, é possível que no futuro orientações de manejo possam ser desenvolvidas na gestação para os agricultores utilizarem no melhoramento do desempenho das gerações futuras. Mais pesquisas são necessárias para determinar se respostas consistentes podem ser encontradas.

Palavras-chave: alimentação, o desempenho de ruminantes

1 Sheep Research Centre, Institute of Veterinary, Animal and Biomedical Sciences, Massey University
Introduction

Sheep farming in most areas of the world is undertaken under pastoral grazing conditions as pasture is often the cheapest source of nutrition. The effects of pasture allowance and quality on animal performance are well established. However, as farmers have strived to increase production levels the use of some pasture species can limit performance. This has resulted in increased interest and use of specialised herbage/crops and supplements such as grains.

The aim of this brief review is to discuss how nutrition and differing types of feeds can potentially affect sheep production in both the short and long term. Comment, where suitable, is made on the potential economic considerations required when devising nutritional regimens to improve productive performance.

The majority of references used in this review are from studies undertaken under temperate and Mediterranean conditions.

Breeding Successfully at a Young Age

In many production systems the ewe lamb is not bred in her first year, instead bred for the first time to lamb at two years of age. However, breeding the ewe lamb at 8 - 9 months of age, rather than waiting another year, can increase profitability (Young et al., 2010) and lifetime reproductive performance (Kenyon et al., 2011).

There are many factors that affect the potential success of ewe lamb breeding (Kenyon, 2012) however, one of the biggest drivers of success is live weight (or body condition) at breeding (Dyrmundsson, 1973a; 1981; Gaskins et al., 2005; Kenyon, 2012) therefore, any factor that affects the growth of the ewe lamb in its first 7 - 10 months of life can have a huge impact on its ability to breed successfully.

For successful management ewe lambs should be a minimum of 60-70% of their mature weight at breeding. In addition, its live weight (Schreurs et al. 2010) and increase in total live weight during pregnancy (Mulvaney et al., 2010ab, 2012; Corner-Thomas unpublished) are important drivers of success.

Poor live weights of the young dam at weaning can have negative consequences for the following year’s performance (Kenyon, 2012). Given that the conceptus mass of a single bearing ewe lamb is likely to be in the range of 8 - 10 kg, and that the young dam needs to continue to grow herself in pregnancy it has been suggested that for high levels of performance the ewe lamb needs to be gaining around 130 g/d in total live weight throughout pregnancy (Kenyon, 2012).

Combined these live weight and total live weight gain targets indicate that nutrition is the significant driver behind the successful breeding of ewe lambs and that these young females need to be well fed prior to breeding and throughout pregnancy and lactation.

Ram lambs can be used for breeding soon after puberty (7-9 months of age). The purpose of breeding from a young ram is to reduce the generation interval to increase the rate of genetic gain. However, some traits (phenotypes) may not have had time to express themselves by such a young age.

Therefore most rams are not used for breeding in their first year of life. In addition, it is well established that young rams can display poorer breeding performance compared to mature rams (Dyrmundsson, 1973b, 1987; Kenyon et al 2007). Before ram lambs can be used for breeding they must have obtained puberty, with live weight being the major driver of this attainment.

Therefore as with ewe lambs, nutrition from an early age affects whether or not ram lambs can be used for breeding in their first year of life. Further, after breeding the young ram has often lost a considerable amount of live weight. Thus their nutritional...
management post breeding is very important if their mature weight and future reproductive performance is not to be negatively affected.

Effect of Live Weight and Live Weight Change on Ewe Ovulation Rate

It is well established that ewes of greater live weight (the static effect) and/or those offered higher levels of nutrition (gaining live weight over a three to six week period, often called the flushing or dynamic effect) prior to breeding are more likely to be multiple-bearing (Smith et al., 1991; Scaramuzzi et al., 2006).

The relationship between ewe live weight and ovulation rate is curvilinear; with every additional gain in live weight resulting in a smaller additional increase in ovulation rate (i.e. a diminishing returns relationship) before no further gain occurs (Smith et al., 1991). In addition, it is apparent that heavier ewes are less likely to respond to the dynamic effect than are lighter ewes (Smith et al., 1991).

Utilising these principals, farmers can specially target those ewes that are most likely to display increased performance additional nutrition prior to breeding, from an ovulation rate perspective, and therefore use their limited feed source most efficiently. Similarly it has been shown that ewes of greater body condition score have higher reproductive performance although, the data also suggests that above a body condition score of 3.5 there is little further gain.

Therefore as with live weight, farmers can target the poorer condition ewes prior to breeding as the ones most likely to respond to additional nutrition (Kenyon et al., 2004) and thus not waste feed on ewes which will not respond. A further nutritional effect on ovulation rate is known as the ‘acute effect’. It has been shown that a short term feeding with a supplement such as lupin grains during the luteal phase can increase reproductive performance (Scaramuzzi et al., 2006). However, in unsynchronised flocks this effect would be difficult to utilise.

Nutritional Management to Increase Breeding Performance

As outlined above, feeds that result in a positive change in live weight prior to the breeding period should increase reproductive performance. Therefore, based on this principal, it is not surprising that both the amount of herbage offered and the quality of the herbage offered to ewes pre-breeding affects reproductive success (Robinson et al., 2002; Kenyon and Webby, 2007; King et al., 2010).

The term ‘focussed feeding’ has also been used to summarise the potential to utilise nutrition just prior to breeding to increase reproductive success (Martin et al., 2004).

Farmers can conserve herbage for use prior to breeding, as long as the herbage maintains its quality. In addition, the level of protein and energy in the diet affects ovulation rate and farmers can use grains (e.g. lupins) and concentrate pellets as a supplement feed source to improve reproductive performance (Smith et al., 1991; Downing et al., 1995; Nottle et al., 1997; Scaramuzzi et al., 2006; Vinoles et al., 2009).

However, these supplements can add an additional economic cost to the farming system in terms of the feed itself and facilities required to feed out such supplements. Therefore farmers need to determine if the gain in reproductive performance from these supplements outweighs their cost. It is likely that it is the lighter, poorer condition ewes that are most likely to respond to these supplements. Therefore farmers could consider targeted use of the supplements.

Some legumes can be phyto-oestrogenic (i.e. red and sub-clover and lucerne (alfalfa)) resulting in depressed reproductive performance of ewes when grazed in pure swards (Smith, 1982; Adams, 1995;
Waghorn et al., 2002; Ramirez-Restrepo and Barry, 2005). However, in a mixed sward these effects can be diluted, if present at all. It is recommended that phyto-oestrogenic plants in pure swards are avoided in the four to six weeks prior to breeding and during the breeding period.

However as these plants tend to be of high quality they can be used well before the breeding period as a means to increase ewe live weight and therefore increase ewe reproductive performance though a live weight effect. Plant breeders have and are breeding cultivars of these herbages that are less oestrogenic. In some production systems, the native herbage can be of very poor quality.

In this scenario, higher ewe reproductive performance levels above those observed on these poor quality native herbages can still occur, by using potentially oestrogenic plants for just a short period. For example, King et al. (2010) reported the use of lucerne prior to breeding increased ovulation rates compared to a poor quality grass. However any potential advantage is very much dependant on how oestrogenic the plant is.

There are also a number of alternative herbages farmers can use to specially lift ewe reproductive performance. Chicory can be used to increase the proportion of multiple ovulations (King et al., 2010). Lotus sp. have also been shown to result in increased ewe reproductive performance (Luque et al., 2000; Min et al., 2001; Ramirez-Restrepo and Barry, 2005; Banchero and Quintans, 2006; Vinoles et al., 2009). A significant proportion of this lotus effect is likely due to the condensed tannins in the plant (Ramirez-Restrepo and Barry, 2005; Banchero et al., 2012). Brassica crops such as turnips and kale have the potential to increase ovulation rates when fed to ensure ewes are gaining live weight (Kenyon and Webby, 2007). The perennial shrub tagasaste (Wilkins, 1997) and the tree willow (McWilliam et al., 2005; Pita, 2005; Musonda et al., 2009) also have the potential to positively influence reproductive rates in ewes, especially under conditions of restricted pasture availability.

Mycotoxins produced by fungi on plants or on dead herbage can negatively affect ewe reproductive performance (Waghorn et al., 2002; Kenyon and Webby, 2007). Farmers need to be aware of these and make appropriate management decisions to minimise their impact. Various mycotoxins affect reproductive performance and will vary between differing environments.

The ram plays an important role in ensuring reproductive success. Ensuring rams are well fed for up to eight weeks pre-breeding and potentially using supplements are means to ensure sperm production is near maximal (Martin and Walkden-Brown, 1995, Martin et al., 2004). However, farmers need to take care that they do not overfeed rams as this can have a negative consequence, especially when combined with poor levels of physical exercise (Martin et al., 2004).

**Nutritional Management in Pregnancy**

The optimal nutritional management of the ewe in pregnancy is dependent on; the ewe’s live weight and/or body condition, the stage of pregnancy, the number of fetuses carried and feed availability at present and predicted feed availability in later stages of pregnancy. An optimal scenario would be for the ewe to be of body condition 3 to 3.5 at breeding and fed to maintain this in the first two trimesters of pregnancy.

Then in the last third of pregnancy she should be offered increased levels of nutrition to ensure her total live weight increased with expected conceptus mass, resulting in a body condition of 2.5 to 3.0 at lambing.

However, many farming systems do not allow for this especially, when ewes are fed under pastoral
conditions. It is common in many systems to offer ewes slightly below levels of maintenance in early pregnancy to ensure that there is adequate feed available for the later stages of pregnancy. Under a scenario of sub-optimal nutrition, in at least some part of pregnancy, farmers should base nutritional decisions on the number of number of fetuses carried and body condition of the ewe.

Ewes carrying just one fetus and/or in good body condition are more able to buffer in the later stages of pregnancy than multiple bearing ewes and/or ewes of poor condition. Therefore an important nutritional tool is ultrasound pregnancy scanning. A proficient scanner can also estimate the stage of gestation which is also an additional source of information when prioritising nutritional needs. Alternatively mating harnesses and crayons on rams can be used to determine when a ewe is bred.

The nutritional demand for pregnant ewes does not begin to significantly increase above the level of non-pregnancy maintenance until six weeks pre-breeding with a dramatic increase in the last three weeks (Nicol and Brookes, 2007). Therefore, prior to the period six weeks before lambing, ewes can be held at maintenance. However, it might be appropriate to offer multiple bearing ewes a slightly above maintenance level of feeding in mid-gestation as they can often struggle to consume their theoretical requirements in late pregnancy especially, with bulky feed stuffs. In addition, mid-pregnancy is the period of placental development and in multiple bearing ewes it is important not to restrict this.

In the last six weeks of pregnancy the most efficient use of feed occurs when singleton and multiple bearing ewes are feed separately to meet their respective requirements. While it is accepted triplet bearing ewes have a greater theoretical demand than twin bearing ewes they can frequently fail to actually consume more than twin bearing ewes (Morris and Kenyon, 2004) due the physical constraints, when fed solely herbage. Therefore many farmers may managed these groups together, unless feeding levels are very poor and in this scenario triplet bearing ewes should be a priority group.

It is well established that poor nutrition in late pregnancy can result in: lighter lamb birth weights and weaning weights, lambs with less energy and vigour, reduced colostrum and milk production, and lower lamb survival (Robinson et al., 2002; Kenyon and Webby, 2007). Ryegrass white clover grazing guidelines indicate that multiple bearing ewes should not be forced to graze below 1200 to 1400 kg DM/ha in the last few weeks of pregnancy which is equivalent to a post grazing sward height of 4cm (Morris and Kenyon, 2004; Kenyon and Webby, 2007; Kenyon et al., 2012, 2013). While the results of the “Lifetime wool’ project in Australia suggested that performance increased as average food on offer (FOO) increased to 2000 kg DM /ha (Oldham et al., 2011).

Grains and concentrate supplements can also be used in late pregnancy to lift lamb birth weight, improve colostrum production, lamb thermoregulatory capability and lamb growth (Hinch et al., 1996; Robinson et al., 2002; Banchero et al., 2007, 2009; Kerslake et al., 2009, 2010; Kenyon et al., 2010b). However, in all production systems farmers need to determine if the costs of utilising these supplements are justified in terms of the animal performance levels observed. Under adequate herbage grazing conditions the additional benefit of supplements can be minimal and therefore may not be cost effective (Hinch et al., 1996; Kerslake et al., 2009; Kenyon et al., 2010).

Lactation is the period of peak nutritional requirement for the ewe, especially if she is multiple rearing (Nicol and Brookes, 2007). Therefore if ewe and lamb performance is to be optimal, the ewe needs to be offered unrestricted feeding conditions. These are most likely to occur under ryegrass white
cover pasture covers above 1400 kg DM/ha with daily allowances of at least 6 kg DM/d (Kenyon and Webby, 2007).

However, there is growing evidence to suggest that even under so-called optimal ryegrass/white clover grazing conditions multiple bearing ewes can struggle to reach their potential. Kenyon et al. (2010a), Hutton et al. (2011) and Corner-Thomas et al. (unpublished) have all reported that a herb mix containing chicory, plantain, red- and white clover resulted in greater ewe and lamb performance to weaning in multiple bearing mature ewes and single bearing ewe lambs. Grazing ewes on lucerne has also been shown to improve ewe and lamb performance to weaning (Rattray et al. 1982 Corner-Thomas et al. unpublished). An alternative approach if the farming facilities allow, is creep grazing.

This is the concept where the lambs while still suckling from their dam, have access to either herbage or grain / concentrate supplement that their dams do not have. This has been shown to increase lamb performance (Moss et al., 2009).

**Lambs Post Weaning**

The faster a lamb grows to target slaughter live weights the greater the efficiency of the system. In addition, greater live weight gains of replacement ewe lambs increases the chance that they can be bred successfully in their first year. While, improved live weights of young rams will also increase their reproductive performance, if they are utilise for breeding. Daily herbage allowance, post grazing mass/height and herbage quality are all nutritional drivers of lamb growth (Kenyon and Webby 2007).

Many systems are grass based and under these systems lamb growth rates are often disappointing at around 80 - 150 g/d (Kemp et al., 2010). These relatively poor growth rates often occur due to the relatively low feeding value of grass species (Waghorn et al., 2007) and the fact that grasses can lose quality in the summer/autumn which often coincides with the post weaning period (Litherland and Lambert 2007). Therefore many farming systems utilise specialised herbage for growing lambs faster (finish lambs).

Improved lamb growth rates have been observed on many specialised herbage including: brassicas, including leaf turnips (Lindsay et al., 2007), birdsfoot trefoil (Restrepo et al., 2005), chicory (Fraser et al., 1988; Fraser and Rowarth, 1996; Scales et al., 1995), lucerne (Scales et al., 1995; Fraser et al., 2004), plantain (Moorhead et al., 2002), white- (Fraser and Rowarth, 1996; Marley et al., 2005; Lindsay et al., 2007) and red-clover (Fraser et al., 2004; Marley et al., 2005).

If utilising of these specialised herbage/crops, farmers need to consider the cost effectiveness of these, especially if they are not perennial. In addition, some of these herbage i.e. chicory and plantain for example cannot be grazed year-round or only have short use period (i.e. leaf turnips), which is another ‘cost’ of utilising specialised herbage for finishing lambs. To improve the potential year-round use of herbs recent studies have examined the potential of a herb mix containing chicory, plantain and red- and white-clover. This herb mix has resulted in improved lamb growth rates in spring, summer and autumn (Golding et al., 2008, 2011; Wilson, 2009; Sinhadipathige et al., 2012).

**The Effect of Maternal Nutrition on the Offspring’s Performance**

**Fetal development and growth to weaning**

The impacts of maternal nutrition on fetal growth and lamb live weight to weaning have been reviewed (Robinson et al., 1999; Greenwood and Thompson, 2007; Kenyon, 2008; Reynolds et al., 2009; Greenwood et al., 2010). Combined these reviews
suggest that nutrition in early pregnancy is less likely to affect the offspring’s early growth and live weight to weaning than nutrition in the later stages of pregnancy, unless the restriction is severe.

Greenwood and Thompson (2007) suggested that any potential effects of early- and mid-gestation maternal nutrition on early offspring growth may be alleviated by adequate levels of nutrition in late pregnancy. It also is apparent that above pregnancy maintenance levels of maternal nutrition has little additional impact on the offspring’s early live weight.

Live weight and growth post weaning and carcass characteristics

The reviews of Kenyon (2008) and Greenwood et al. (2010) suggest that early- to mid-pregnancy nutrition has little effect on growth and live weight of the offspring post-weaning. Prolonged periods of poor nutrition throughout pregnancy or severe under nutrition in the late pregnancy, are required to influence post-weaning live weight however, even when present, the effects have been relatively minor. While the effects of above pregnancy maintenance level of nutrition, on the offspring’s mature live weight, have not been observed.

Maternal nutrition in pregnancy has the potential to influence carcass weight and composition in lambs although few economically important effects have been noted (Wu et al., 2006; Greenwood and Thomson, 2007; Ashworth et al., 2009; Greenwood et al., 2010). It appears that maternal nutritional restriction needs to be severe and prolonged if it is to economically affect the carcass composition of the offspring.

Reproductive performance

There is some evidence in the literature to indicate maternal nutrition can alter the development of the fetuses reproductive organs (Rae et al., 2001; Rhind et al., 2001, Rhind, 2004; Kenyon, 2008). However, actual ‘productive’ effects in both adolescent and adult offspring’s reproductive performance have not been inconsistently observed. It appears they are more likely to present under conditions of poor maternal nutrition (Gunn et al., 1995; Parr et al., 1986; Rae et al., 2002; Van der Linden et al., 2007, 2010; Kenyon, 2008; Paten et al., 2011).

Therefore there is the potential to develop maternal nutritional strategies to alter the resulting male and females offspring’s reproductive capability (Rhind et al., 2001; Rhind, 2004; Bell, 2006; Kenyon, 2008; Ashworth et al., 2009; Asmad et al., 2012; Dupont et al., 2012).

Lactational performance

Maternal nutritional has also been shown to influence the development of the fetal mammary gland (van der Linden et al., 2009) and the offspring’s milk production at their first lactation (van der Linden et al., 2009; Paten et al., 2013), resulting in heavier grand-offspring at weaning (van der Linden et al., 2009, 2010). Although this affect was not present at their second lactation (Blair et al., 2010). These recent results suggest it may be possible to develop maternal nutritional regimens in pregnancy to consistently alter the offspring’s milk production.

Other production effects

There is also evidence to indicate that maternal nutrition can affect other traits of the offspring. Improved ewe nutrition in the mid- to late-pregnancy period appears to be the most consistent means of increasing the offspring fleece weight while decreasing fibre diameter (Behrendt et al., 2006, 2011; Curnow, 2006; Kenyon 2008, Thompson et al., 2011). However it is likely that developing maternal nutritional treatments to alter the offspring’s fleece characteristics is only economically worthwhile in fine wooled breeds. There is some data to suggest
maternal nutrition in pregnancy can alter the offspring’s susceptibility to internal parasites although the results are somewhat inconsistent (Paganoni, 2005; Rooke et al., 2010; Asmad et al., 2011; Paten et al., 2011). Maternal nutrition in pregnancy has also inconsistently affected the behaviour of the offspring (Erhard et al., 2004; Hernandez et al., 2009ab, 2010). Combined these sections indicate that in the future it may be possible to develop maternal nutritional regimens that result in increased levels of performance in the offspring. Further work is required to develop these nutritional manipulations to ensure a consistent effect is observed. In addition it is yet to be determined if it is cost effective to manipulate the dam in pregnancy to alter the performance of future generations.

Conclusion

This brief review has outlined how nutrition of the animal can affect performance in both the short and long term. Farmers have for many years known the effects of herbage quality and allowance on animal performance and they have used this information to maximise performance.

As farmers have strived for even higher levels of performance in their flocks, they have utilised specialist crops / supplements to achieve this. However, before using these, farmers should consider how they will fit into their farming system as a whole, and the cost effectiveness of these. Finally, it is possible that in the future farmers may be able to use nutrition of the ewe in pregnancy as a means of altering the performance of future generation.

Literature Cited


Banchero, G. E., Quintans, G., Lindsay, D. R., Milton, J.T.B. 2009. A pre-partum lift in ewe nutrition from a high-energy lick or maize or by grazing Lotus
uliginosus pasture, increases colostrum production and lamb survival. Anim. 3: 1183-1188.


Kenyon, P.R., Hickson, R.E., Hutton, P.G., Morris, S.T., Stafford, K.J., West, D.M. 2012. Effect of


Paganoni, B.L. 2005. Increasing feed-on-offer to Merino ewes during pregnancy and lactation can increase muscle and decrease fat, but does not affect the faecal worm egg count of their progeny. MSc degree, University of Western Australia.


Thompson, A.N., Ferguson, M.B., Gordon, D.J., Kearney, G.A., Oldham, C.M., Paganoni, B.L. 2011. Improving the nutrition of Merino ewes during pregnancy increases the fleece weight and reduces the fibre diameter of their progeny’s
wool during their lifetime and these effects can be predicted from the ewes live weight profile. Anim. Prod. Sci. 51: 794-804.


