Nutritional management of the Australian sheep flock

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Summary

New technology such as on–farm fibre measurement, radio–frequency ear tags and automatic drafting will facilitate more precise management of sheep flocks including targeted nutrition. Increasing value of sheep meat makes reproductive efficiency a more important contributor to on–farm profit for specialist wool enterprises than it has been in the past. Severe under–nutrition in most Australian sheep flocks during at least part of the year is the major reason for reproductive inefficiency. It is increasingly evident that chemical treatment of internal parasites will not provide a single sustainable solution and that nutritional management can play an important role in sustaining resistance and resilience. The combination of developments in technologies and the current status of the Australian sheep flock provide a well–defined challenge and significant opportunity for improved nutritional management.

Key words: sheep, targeted nutrition, reproductive efficiency, parasite management

Introduction

Feeding the whole flock, or even complete classes such as weaners or ewes, is not always economical and tends to be regarded as a necessary evil during drought or during predicted periods of feed shortage in order to maintain year round stocking rates. Although feeding for survival is the most common reason for supplementary feeding of sheep in Australia, it is well established that strategic nutrition can have a major effect on reproductive performance, wool quality, and animal health. Production feeding and sheep feedlotting for year–round production or for out–of–season finishing is increasingly common in parts of Western Australia but is not widespread in eastern Australia. With increasing prices for sheep meat, and with the Australian sheep flock at a very low level after the drought, there are a number of opportunities for more intensive sheep production management and this will bring increasing dependence on strategic nutrition.

Selection and culling decisions for commercial sheep flocks in Australia are still commonly based on the age of an animal rather than its fleece value or potential carcass value. The consequence is that there are relatively low rates of flock replacement and little perceived benefit in having efficient reproductive performance in order to produce a large pool of animals from which to select replacements. The preference for many wool producers is still to have no twins in order to simplify lambing management and minimise peri–natal mortalities. The average lamb marking percentage for the Australian flock over the last 5 years is 75% (Connell *et al*. 2002; Ashton and Berry 2003) compared to 113% in New Zealand (Economic Service 2002) where there is greater emphasis on income from meat.

It is well known that with increasing level of nutrition there is a broadening of fibre diameter and reduced return per kg of fleece produced. Even although fleece weight increases with improved nutrition this often does not compensate for lower price per kg associated with increased micron. Increased fibre diameter in response to better nutrition and the view of many producers that twins are not desirable are considered to be the main reasons that feeding for survival is far more common than nutritional management to meet optimal production targets. Strategic supplementation of large sectors of the Australian sheep flock are likely to produce significant improvements in productivity. The challenge is to identify those opportunities for nutritional management that will be most profitable for producers.

The Australian sheep industry has traditionally been considered as two separate industries: a wool industry and a sheep meat industry. There has therefore been a tendency to look for a limited range of benefits in response to experiments involving supplementary nutrition either in terms of improved wool production or of meat production. Similarly, experiments to study the effect of nutrition on resistance and resilience to parasites have often not included measurement of benefits in terms of wool, meat and reproductive

efficiency. Many of the benefits resulting from improved nutrition at strategic points in the life of a sheep may have lifetime and inter–generational benefits and it is important the we account for these potential 'costs' of under–nutrition when strategies for nutritional management are developed.

The development of electronic sheep management systems as part of the Sheep Cooperative Research Centre 'e–sheep' project will create new opportunities for the sheep producers to segment the flock on complex pre–set criteria such as rate of weight change, current body weight as well as wool production and past reproductive performance and current reproductive status of individual animals. This means that nutritional management in the future can be based on the requirements of sub–sets of the flock depending on their need for additional nutrients and their potential to respond to supplementation. Tools such as GrazFeed (Freer *et al.* 1997; Horizon Agriculture, Roseville, NSW 2069) and GrassGro (Moore *et al.* 1997) assist decisions on strategic supplementation of sub–sections of the flock but there is also likely to be an increased need for specialist ruminant nutritionists in the Australian sheep industry.

The purpose of this paper is to review some of benefits of meeting nutrition–related targets for efficient sheep production, and the criteria for selecting animals for strategic nutritional supplementation and likely to respond in terms of improved health and productivity. The benefit of appropriate nutrition can apply to many aspects of production and it is often not cost effective to feed all animals in the flock. The paper also considers the use of new technologies that will make it easier to monitor performance and segment for targeted nutrition.

Overview of supplementation at different stages of a sheep's life

Nutrition can influence productivity through effects on existing body weight and condition (static effects) and through rate of weight gain (dynamic effects). There can also be longer term effects through under–nutrition during critical stages of development such as foetal development or maturation of the immune system that have effects for months, if not years. Nutrition can affect overall productivity of the flock through reducing age at first pregnancy, increasing reproductive efficiency and decreasing age of turnoff for meat production. Figure 1 summarizes the critical stages of growth and development when nutrition plays a key role in wool and meat production, reproductive efficiency and resistance or resilience to parasites. Many effects are inter–generational as the body condition and nutrition of the ewe during pregnancy and lactation has an effect on the lamb's growth as well as development of its immune system. Perhaps the most critical stage is pre–partum nutrition as the hormonal changes and nutritional drain on the ewe can severely compromise the maternal immune system as well as survival of the new–born lamb.

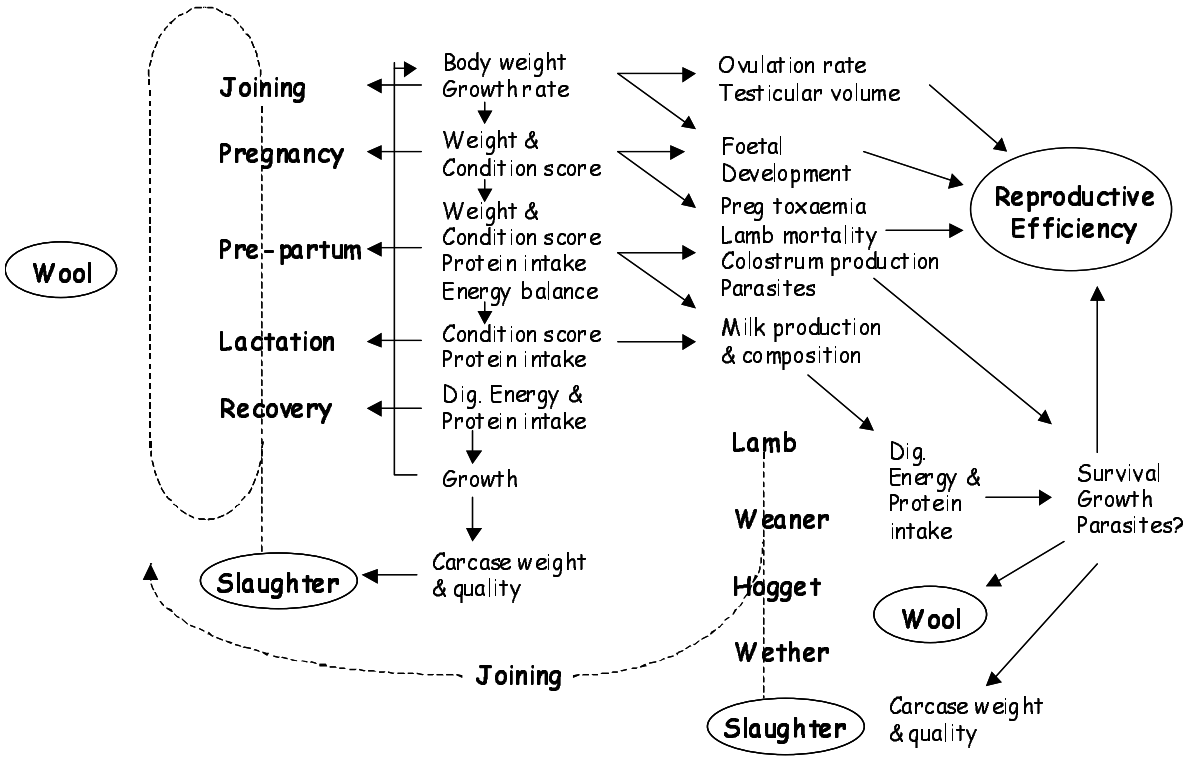

Figure 1 Summary of the effect of body condition and nutrition at different stages of growth and development on reproductive efficiency, parasite management and wool and meat production.

Strategic nutrition to improve reproductive efficiency

Ovulation rate

Ovulation rate sets the potential number of lambs that can be born and is therefore a crucial determinant of fecundity. Apart from genetic factors determining ovulation rate the weight of the ewe relative to her potential mature size (static effect) and the rate of growth or plane of nutrition immediately prior to ovulation (dynamic effect) both have a significant effect on ovulation rate. Figure 2 shows ovulation rates in relation to liveweight of ewes at time of ovulation and the effect of short–term supplementary feeding immediately prior to ovulation. These data show the importance of previous nutrition through weight and condition score at time of joining with the rams; there is approximately 45% increase in ovulation rate for animals weighing 55 kg compared to 40 kg) and a further increase of around 11% if the heavier animals are gaining liveweight at the time of joining with the ram. By far the most important aspect is to have the ewes in good condition for joining because those in poor condition and low body weight are less likely to ovulate and are less likely to increase ovulation rate in response to feeding at that time.

Consistent improvements in ovulation rate have been reported as a result of feeding lupin grain to ewes prior to joining with the ram, and it has been suggested that lupins increase ovulation rate by providing large quantities of protein that have a 'para–pharmacological' effect (Egan 1984). However, studies by Rowe *et al.* (1985) (see Figure 3) and Teleni *et al.* (1989) indicate that the response in ovulation rate can be largely explained through increased intake of metabolizable energy. Since ME intake and glucose entry rate are closely related (Lindsay 1970) it is not surprising that increased ovulation rate has also been found to be correlated with supplements that increase glucose entry rate.

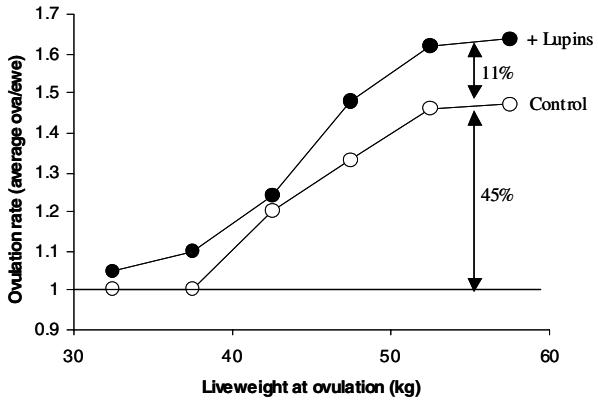

Figure 2 Effect of liveweight of medium wool Merino ewes on ovulation rate. The open circles show data for ewes fed chaff to maintain liveweight and closed circles indicate data for ewes fed 750 g/d lupins for 10 days prior to ovulation (Rowe *et al.* 1985).

Testicular growth in rams

Figure 4 shows the effect of different levels of nutrition on the liveweight change of rams and the corresponding effect on the growth or attrition of their testes. Testicular volume is an important determinant of sperm production and of the number of ewes that a ram is able to serve in a breeding season. The role of nutrition is therefore important in reproductive efficiency and in being able to get the most out of the best rams.

As in the case of ovulation rate in ewes, there has been considerable debate over the possibility that particular nutrients may be required to produce increases in ovulation rate and testicular growth in rams. The hypothesis that increased ovulation and testicular growth rates require specific nutrient(s) was largely based on the fact that supplementation with lupin grain normally produces significant responses by both reproduction organs. Murray *et al*. (1990) showed that change in

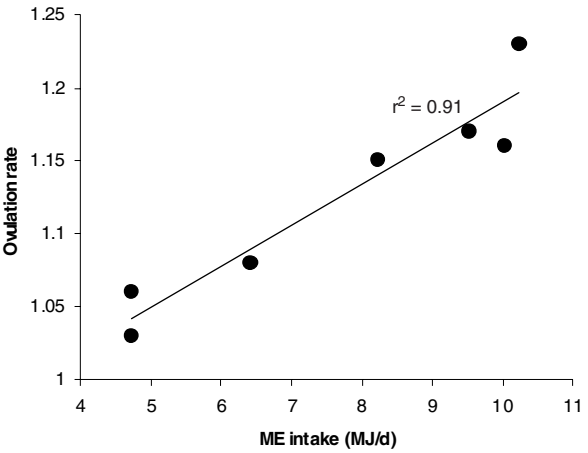

Figure 3 Relationship between ME intake provided by supplements containing varying concentrations of protein and ovulation rate of Merino ewes (Rowe *et al.* 1985).

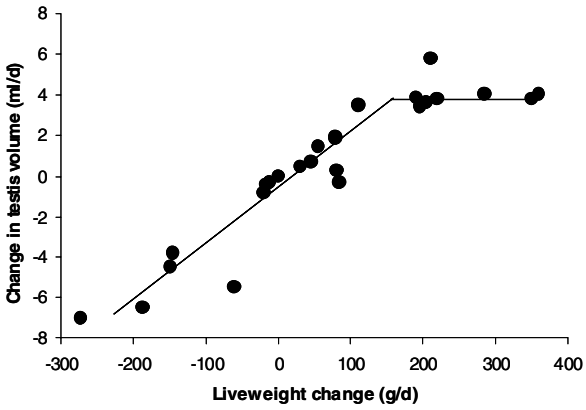

Figure 4 Relationship between liveweight change in rams fed a range of dietary supplements, and the growth or attrition of their testes (Murray *et al.* 1990).

testicular volume was closely related to weight change irrespective of the source of nutrients, varying from lupins and barley to abomasal infusions of protein or glucose.

The data summarized in Figure 4 indicate that provided that growth rates of rams exceed 100 g/d, prior testicular growth and development will be close to optimal.

Nutrition during pregnancy

Careful nutritional management of ewes during pregnancy is probably the best opportunity for using strategic pasture management and supplementation to improve the productivity of the flock. Not only is it an important time in terms of foetal development, it determines the ewe's subsequent ability to produce a healthy lamb and adequate milk for its survival and growth. There are numerous studies on lamb mortality and Alexander (1984) has provided excellent reviews of the risks and management options. It is interesting that although ewe nutrition has an influence on lamb size and consequently on lamb survival, it appears that under most commercial production systems lamb weights fall between 3 and 5 kg and that within this range there is no adverse effect of size on mortality (Alexander 1984; Holst *et al.* 2002). One of the major determinants of lamb survival is nutrition of the ewe as reflected in condition score at parturition, and results of three studies are summarized in Figure 5. For Merino ewes, peri–natal lamb mortalities are likely to be over 50% if twin–bearing ewes approach lambing with body condition scores below score 2 and it is likely that 2.5 represents a safe 'target'. For single–bearing ewes, condition score pre–partum does not have as dramatic an effect on lamb mortality but there still appear to be benefits in ewes being in condition score 2 or better. Although there may be periods during gestation that are more important than others in the development of the placenta and foetus, it seems that the best strategy is to maintain adequate nutrition throughout pregnancy in order to minimize risk of retarded foetal development and maximize value of the ewe's wool clip and post–partum performance of ewe and lamb. Although pre–partum condition score appears to account for much of the lamb losses there is a range of reported mortalities between 10 and 30% even when ewes have higher than condition score 2. Holst *et al.* (2002) suggest that spinal and cranial meningeal lesions may be the reason for variable mortalities in ewes that are in adequate condition. Meningeal lesions are considered to be due to low feed intake immediately pre–partum and the consequent slow clearance of progesterone resulting in dysfunctional parturition (Holst *et al.* 2002).

In addition to measurements of body condition score, Parr *et al.* (1986) and Oddy and Holst (1991) found that blood glucose concentration may provide a useful test for identifying those ewes requiring additional nutrition and/or special treatment during pregnancy.

The economics of feeding supplements to all ewes to ensure that those with low condition score reach appropriate targets is rightly questioned by most producers. The benefits of scanning for twin foetuses and ensuring that all ewes with twins receive better nutrition than singles often do not justify the costs. It is clear that segmentation of the flock has got to be more precise, so that only those animals really needing improved nutrition are isolated for expensive supplementation or special grazing management.

Nutrition in late pregnancy

During final stages of the third trimester of pregnancy and just before lambing there is significant growth of the foetus and considerable demands on the ewe. The rapidly growing foetus and placental tissue has a significant requirement for protein and the ewe appears to satisfy this demand for protein ahead of other

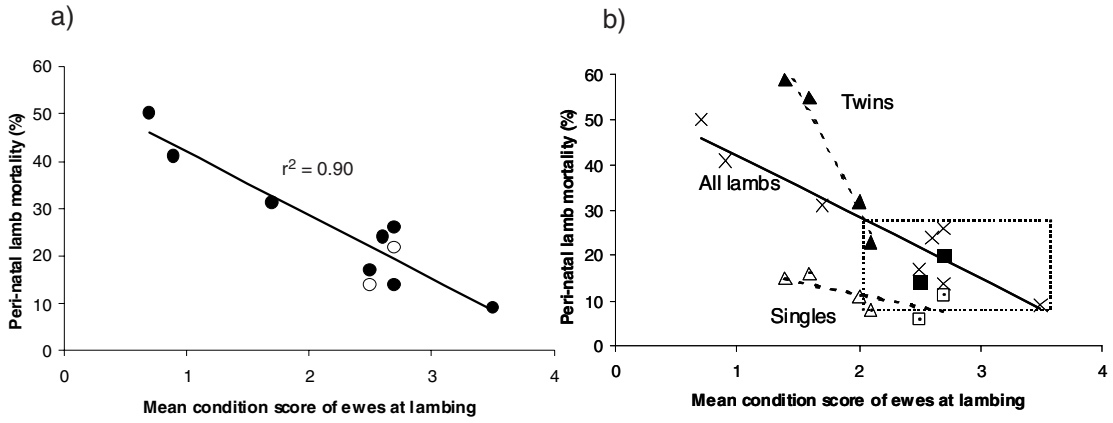

Figure 5 Relationship between mean condition score of ewes at time of lambing and peri–natal lamb mortality.
a) mortality as % of ewes lambing based on data from McClymont and Lambourne (1958) represented by closed circles and from Holst *et al.* (2002) by open circles
b) open symbols are for singles and closed symbols are for twins; data shown as triangles are from King *et al.* (1990), as squares from Holst *et al.* (2002), and as crosses from McClymont and Lambourne (1958).

demands such as for its own tissue maintenance or wool production. Under–nutrition during late pregnancy leads to rapid mobilization of the ewe's body reserves and the resulting ketosis can lead to pregnancy toxaemia. In addition to the risk of pregnancy toxaemia there is evidence that adequate nutrition in the last week of pregnancy can allow lambs to attain 'normal' birthweights even when ewes have been underfed during pregnancy (Oddy and Holst 1991) and that nutrition during this period can also significantly increase colostrum production (Robinson *et al.* 2002; Murphy *et al*. 1996). Increased susceptibility of the ewe to internal parasites during this period before lambing adds to the importance of carefully managing nutrition at this time.

Pregnancy toxaemia can be prevented by ensuring that dietary protein and glucogenic precursors are sufficient so that the ewe is not dependent on mobilizing tissue reserves. Ewes in over–fat condition during late pregnancy are more susceptible to pregnancy toxaemia and this is likely to be associated with reduced drive to maintain feed intake particularly in the event of a period of cold weather. Lack of detailed monitoring of the ewes in late pregnancy and failure to respond to declining pasture condition, insufficient protein intake and/or a cold period can result in pregnancy toxaemia and significant losses.

Increased nutrition of the ewe for as little as 7 days prior to parturition can lead to a significant increase in colostrum production. Robinson *et al.* (2002) summarized the results of O'Doherty and Crosby (1997) to show that colostrum production was closely related to ME intake. The data from Robinson *et al.* (2002) and results of Australian studies based on lupins (Murphy *et al.* 1996) and maize (Banchero *et al.* 2002) in Figure 6 clearly show the importance of ME intake immediately prior to lambing in terms of colostrum production, and the effect that this is likely to have on the survival and health of the lamb.

Nutrition for resistance and resilience to parasites

In a recent review of the role of nutrition in development of resilience and resistance of sheep intestinal parasites, Steel and Knox (2003) concluded that resilience to gastrointestinal parasites can be improved through supplementation with either ME or metabolizable protein. Although there are clearly situations where there are specific requirements for protein and even specific amino acids it appears that in many situations animals gaining liveweight are likely to be able to resist and tolerate parasites far more effectively than animals maintaining or losing weight.

There is also clear evidence that the late pregnancy, peri–parturient, period can be associated with a significant susceptibility to internal parasites. The increase in faecal egg count during the peri–parturient period is not only a signal of greater effects of parasites in the ewe but also indicates an increased risk of parasitism for new–born lambs grazing the more heavily infected pastures. Nutrition, and particularly metabolizable protein, can play an important role in reducing the impact of the peri–parturient rise (Houdijk *et al.* 2000) but practical recommendations about body condition and nutritional targets to minimize that rise are not yet clearly defined.

Survival during periods of cold stress

Cold stress associated with wind and rain, particularly immediately after shearing, can pose a significant risk for all classes of sheep. Hutchinson and McRae (1969) reported that the main animal factor associated with susceptibility to cold stress following shearing was actually rate of weight loss of animals prior to shearing rather than body condition per se at time of shearing. Monitoring weight change of sheep prior to shearing and ensuring that there is minimal weight loss or having animals gaining weight appears to be an important target for precision sheep production. It is interesting that nutritional management to reduce the risk of dark cutting meat due to pre–slaughter depletion in glycogen in sheep and cattle is to have animals gaining weight prior to leaving the property for the abattoir (Pethick *et al.* 1995).

Tensile strength of wool

The diameter of wool fibre varies with nutrition and during periods of undernutrition the fibre diameter can change to the extent that the tensile strength of the wool

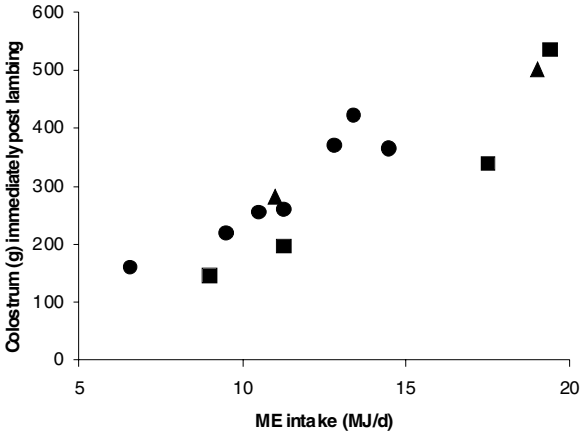

Figure 6 Relationship between metabolizable energy intake and colostrum production immediately post lambing. Results from Robinson (2002) shown as circles; Murphy *et al.* (1996) as squares, with assumed ME intake of 11 MJ/d from pasture and 19 MJ/d with lupin supplement allowing for substitution effect; Banchero *et al.* (2002) as diamonds with ME intakes estimated from literature values of 9 MJ/kg DM for lucerne hay and 12 MJ/kg DM for maize, both 90% DM as fed.

is reduced and market value is discounted. The magnitude of the discount and the impact on the price of wool is most severe when fine micron wool is tender. It is therefore very important to maintain nutrition as constant as possible throughout the year. This goal can be achieved through careful grazing management to reduce access to pasture when it is plentiful and of a good quality through use of very high stocking rates, and the use of lower stocking rates and supplementary feeding during periods when pasture is scarce and/or of low nutritional value. Maintaining constant rates of wool growth and therefore near–constant fibre diameter and good tensile strength requires a relatively even level of nutrition. In addition it is advisable to maintain animals in sufficiently good body condition so that they are able mobilize tissue in order to meet short–term demands as a result of fluctuating nutrition.

One of the difficulties of maintaining tensile strength is the need to constantly monitor pasture conditions in relation to the requirements of the animal. Accurate monitoring of pasture conditions requires training and calibration in order to assess feed on offer and its nutritional value. The Prograze course (Bell and Allan 2000) run by the NSW Department of Agriculture has made a very valuable contribution in assisting producers and advisors to be able to accurately assess feed on offer. Provided that feed on offer is accurately estimated, the decision support program GrazFeed provides assistance in predicting animal performance and whether or not supplementation is needed to meet liveweight targets. Even with accurate estimation of pasture on offer there is always significant variation between animals due to differences in parasite burden and other aspects of genetic diversity. This variation between animals makes it difficult to manage all animals in a flock with the same precision and one of the tools that may assist with this task is the development of animal–activated weighing systems capable of separating animals on the basis of weight change. Under grazing conditions weight change may be the most sensitive 'integrator' of nutrition, environmental and disease/parasite factors and, therefore, of great assistance in the fine–tuned management of fibre diameter.

The physiological state of ewes through the reproductive cycle also has a major effect on the wool growth. Corbett (1979) reported that wool growth was reduced by 20% during the last two months of pregnancy of about 3 to 10% of the annual fleece production. It appears that during the first 14 weeks of lactation wool growth is around 15% lower than in non–lactating ewes and this can represent a reduction of 5 to 8% in annual fleece production (Corbett 1964). The most severe depression in wool growth and the greatest effect on fibre diameter appears to be in the final stages of pregnancy when the foetus requires protein for growth and the ewe is preparing for lactation and colostrum production. Given the competing demands for protein during this peri–parturient period, the best way to manage the risk of reduced wool growth and low tensile strength may be to shear prior to lambing and this strategy is widely used.

Feeding for production

The vast majority of prime lamb operations in Australia are designed for pasture finishing. Such systems almost always depend on the earliest possible lambing date that the season will allow in order to have the best chance of finishing as many lambs as possible on pasture before the 'end of the season'. The two risks associated with this strategy involve the pressure on ewes lambing right at the start of the growing season, and sometimes before this break, and the fact that not all lambs are finished to specification by the end of the growing season. A further disadvantage of squeezing the production cycle into the growing season is that all lambs in a particular district tend to be ready for sale at approximately the same time and this oversupply tends to depress the market. In recent years, lamb producers in Western Australia have tackled the extreme seasonality of supply, associated with the well–defined winter rainfall system, by using more grain–based production feeding to finish lambs at the end of the season or out of season. With sheep meat prices increasing as a result of strong demand it is likely that grain finishing lambs will increase in importance and the Sheep Cooperative Research Centre will be conducting research to support this development.

The Australian cattle industry relies very heavily on the feed lot sector to ensure year–round supply of beef and a predictable quality. Sheep have an advantage over cattle in their ability to efficiently use whole cereal grain. With no need to process the grain and therefore little in the way of capital costs and infrastructure to start grain feeding, it is an option for many sheep producers and particularly for those in the grain growing areas.

Adding value to cast–for–age ewes through finishing them prior to sale is something that few wool specialists contemplate. Most cast–for–age ewes are sold 'off–shears' with little expectation that they will attract good prices. It is well known that older cattle have a greater propensity to deposit intramuscular fat (marbling) than younger animals (Pethick *et al.* 1997). It is likely that older sheep are also more likely to deposit intramuscular fat. In specialist meat production operations the cost of feeding an animal to reach 'old age' and start depositing intramuscular fat is expensive. However, when wool production and breeding are the primary purpose for running ewes these animals may present a potentially valuable resource to produce a marbled product at the time they are culled from the flock. Tenderness of meat declines with age of the animal and this factor will almost certainly have a negative impact on the quality of a 'marbled' product. It is possible that problems related to tenderness can be partially overcome through electrical stimulation and

post–slaughter aging. There are also likely to be benefits in finishing and adding weight to older ewes prior to slaughter since processing costs per kg of saleable meat will be significantly reduced.

Nutrition and animal welfare

An aspect of nutritional management that is of increasing importance is animal welfare. Severe undernutrition is a clearly defined aspect of animal welfare that is often covered up by a good cover of wool in the case of sheep. However the appearance of weak and dying animals is a serious issue even in times of drought when the difficulty of providing adequate feed is well understood by the community. Further issues of welfare are associated with use of cereal grain and problems related to acidosis. Under intensive feeding systems there is always a proportion of animals that does not adapt to the change in diet or confined feeding system. Management of these non–feeders is an important welfare issue as well as a production cost. However, by overcoming the nutrition–related welfare issues, producers are also likely to make more money. Identifying animals requiring special treatment is critical if they are to be adequately managed. Liveweight and liveweight change again offer the most sensitive way of identifying animals in need of attention and recent technological developments in animal–activated weighing and drafting systems will make nutritional management far more precise.

Animal activated weighing and drafting systems

Systems for better monitoring weight and weight change in grazing and intensively–fed animals have been mentioned above. There is already a number of weighing systems linked to automatic drafting gates that are capable of separating animals on the basis of liveweight. There are also prototype systems that will record weights of animals as they move over a weighing scale. With the increasing sophistication and decreasing costs of computer–based technology it is almost certain that cost–effective systems can be developed for regular monitoring of animal weight and weight change via automated systems. The use of 'electronic' radio–frequency transponder (RF) ear–tags in combination with automated weighing systems will greatly enhance the potential of the technology.

Within the next two to three years it will be possible to set up walk–through weighing systems to weigh and record information on sheep as they move to or from water or feed or as they move from one paddock to another. Combined with this capacity to measure and monitor will be a range of automatic drafting options based on weight or other criteria so that animals requiring supplementary feeding or other treatment can be separated. Similar technology is already available in the dairy and beef industries but will have equal, if not greater, application in the sheep industry. Its adaptation to the sheep industry comes at an ideal time as the decreasing cost of the technology and its increasing robustness will make it available to commercial as well as seed stock producers.

The ability to segment the flock based on weight, weight change or other measures such as wool characteristics, litter size, past lambing performance, parasite resistance, and susceptibility to cold stress provides one of the greatest opportunities and challenges for ruminant nutritionists. It means that there are likely to be numerous situations where very specific nutritional management is required to achieve well–defined production outcomes. By identifying the appropriate animals to feed and the targets to be achieved it is almost certain that nutritional management of the sheep flock will become an essential component of precision and profitable production.

Supplementary feeding and the role of the nutritionist

Providing appropriate and cost–effective nutritional solutions for different classes of sheep with different production targets will mean understanding the risks of acidosis, the need for balanced mineral and protein and the costs and benefits of formulated feeds compared to whole grain supplements. There are also aspects of animal behaviour related to learning about new feeds and feeding systems that can mean the difference between success and failure in supplementary feeding systems. The decision support program GrazFeed used in combination with Prograze provides an excellent basis for determining cost effective strategies for supplementary feeding. Even with these programs there will be an important role for professional nutritionists in assisting producers make appropriate decisions when faced with these reasonably complex decisions.

Under grazing conditions it is likely that supplements fed weekly will be the most practical way to ensure that there is an even distribution of intake across all animals. A system of weekly feeding also allows different levels of supplements to be determined based on the response of animals to changing pasture conditions and supplementary feeding. The ability to draft animals based on electronic identification also allows for drafting and segmentation for incremental feeding management. Animals fed low levels of grain during a previous week could, if indicated, be drafted into a group being fed higher levels during the next week. Similarly animals reaching target levels for weight or weight gain could be excluded from future supplementary feeding.

General principles and conclusions

A two–part working hypothesis is suggested for further discussion and field evaluation. Firstly, that most nutritional management targets are met when animals are gaining weight (over 100 g/d) and/or are in 'moderate' condition score (above 2.5). Under these conditions of moderate growth there are not likely to be significant additional gains in reproductive performance, enhanced immune system function, or reduced risk of mortality following shearing in response to additional nutrition. It is accepted that breeding ewes will invariably lose weight during lactation and will need to gain weight during a recovery period. Secondly, that a diet providing the basis for above maintenance ME intake, balanced where needed with minerals, N, S and protein, will meet the requirements for most nutritional targets. There are few situations where any special dietary formula is needed, but there appear to be two exceptions to the simple requirement for a well–balanced diet based on provision of adequate ME. The first is the need for protein during late pregnancy and the second is for protein intake to enhance resilience to certain internal parasite infections.

While this working hypothesis can be challenged and refined, it is important that we recognize that there are clear and relatively simple guidelines for implementing better nutritional management in many sheep flocks. The challenge for nutritionists is to accurately determine the most cost effective options and the appropriate times for nutritional intervention in order to achieve appropriate production targets. The decision support programs GrazFeed and Grassgro will assist in achieving weight gain targets under grazing conditions, particularly when used in combination with animal–activated walk–through weighing systems to monitor actual weight changes.

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