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Nutritional management for reproductive efficiency

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Abstract

Nutrition influences reproductive efficiency and the survival of lambs and weaners but the costs of supplementary feeding or maintaining low stocking rates are not justified by the resulting income from higher lamb weaning rates and reduced weaner mortality. The current practice of segmenting the ewe flock using ultrasound scanning to determine the number of foetuses still results in groups of ewes with a wide range of condition scores and with widely differing nutritional requirements. This report describes an approach to precision management of pregnant ewes and weaners that is based on the e-sheep platform of technologies and uses computer-directed drafting for nutritional management of individual animals and walk-through weighing to monitor changing nutritional status. It is estimated that the cost of feeding a thousand-ewe flock can be reduced from $14,000 for feeding all animals to $3300 for targeted feeding of 25% of ewes requiring additional nutrition and 20% of weaners at risk of dying. The cost of the targeted feeding strategy is more than justified by the value of additional 12-month-old animals, which is $9000. The e-sheep precision nutrition system is not attractive to industry at this stage because of the cost of the e-sheep infrastructure, the perceived complexity of the technology and the requirement for further research, but it is expected to be a commercial option within three years.

Introduction

Nutritional improvement of body weight and growth rate increases ovulation rates of ewes and survival of lambs and weaners. For example, ewes weighing 55 kg have a 45% higher ovulation rate than those weighing 40 kg; an additional 11% increase can be attained if the ewes are gaining body weight at the time of joining (Rowe, 2003). A recent review by Walker et al. (2003) indicates that lamb mortality can be as high as 20–30% for single lambs and 30–40% for twin lambs. Although condition score and weight of ewes at the time of lambing are important determinants of lamb survival (McClymont and Lambourne, 1958), weight change during the peri-parturient period can also have an impact (Oddy and Holst, 1991). The mortality of weaners in the first year after weaning was between 8% and 27% for nine commercial flocks in Victoria (Campbell et al., 2004), which is consistent with estimates for WA (Lloyd-Davies et al., 1988). Weaners below average bodyweight have an increased risk of dying. It is thus evident that nutritional management of ewes and weaners is the key to managing the number of lambs born as well as lamb and weaner mortality. Apart from reproductive efficiency, good nutritional management of the ewe during pregnancy has additional benefits in terms of better lifetime wool production from lambs that do not suffer nutritional stress *in utero* (Kelly, 2005).

Despite the importance of nutrition for reproductive performance, it has been difficult to develop cost-effective methods of nutritional management that ensure high lambing rates and survival of lambs and weaners. Precision sheep management based on data for each animal and the ability to feed each ewe or weaner according to its requirement has been beyond the reach of studs, let alone commercial production systems. The e-sheep technology platform creates an opportunity to develop new systems for the nutritional management of the Australian sheep flock. This report examines the need for precision nutrition for managing the ewe flock and describes various options, some of which can be used immediately and others that are still in the process of development.

Segmenting the ewe flock during pregnancy: culling and feeding

Many producers scan their ewes between day 40 and day 90 of pregnancy to determine those that are pregnant and the number of foetuses present. Based on this information, the empty ewes are often sold and the remaining ewes are drafted into two groups, of which the twin-bearing ewe group is destined to receive better nutrition than the single-bearing ewe group. Data from four commercial flocks, the first three of which are part of the AWI's *Lifetime Wool* initiative, are shown in Table 1. These data illustrate three important issues associated with the conventional practice of separating twin-bearing ewes immediately after scanning and culling empty ewes.

Nutritional requirements vary considerably within groups of sheep

The data in Table 1 show a large range in the body weights of sheep in each potential management group. For example, the range in the weight of twin-bearing ewes on property 1 was 38–62 kg at joining. Ewes at the lower end of the range (38–45 kg) and carrying twin-lambs would require a high level of nutrition throughout pregnancy, while average nutrition would be sufficient for heavier ewes (55–62 kg). However, under most management regimens, the improved level of nutrition would be applied to all twin-bearing ewes irrespective of their weight or condition score, which adds to the cost of nutritional management.

Do groups of twin-bearing ewes warrant specialised feeding?

A second issue is that of whether groups of sheep are large enough to make differential management of twin-bearing ewes economically viable. In the case of property 4, which had a relatively small proportion of twin-bearing ewes, it may be of marginal benefit to separate ewes into different paddocks. As each group separated out for special nutritional management requires its own paddock or preferential treatment under rotational grazing, the number of groups that can be singled out for special nutritional treatment is limited.

Do not make decisions based purely on scanning data

The decision about which group the ewe should be allocated to is normally made immediately after pregnancy scanning. It is rare for the scanning data to be recorded for use in subsequent management decisions or for any data apart from the scanning result to be considered when drafting. Therefore, it is highly likely that some of the lighter ewes that are not pregnant will be those that raised twin-lambs during the previous year. Culling these animals is unlikely to benefit the long-term reproductive performance of the flock. It is also possible that animals with valuable wool or meat production traits will be culled if access to a full set of production data is absent. The process of segmentation and culling based on a single parameter such as a pregnancy status is not ideal but dividing the flock up into too many small groups is also impractical. The ultimate solution is to be able to manage the nutrition of each ewe according to its current requirements and past record of production without having to split up the flock into separate management groups. The e-sheep platform provides the basis on which to develop this solution as a cost-effective and practical alternative for managing the ewe flock.

Table 1. Average weight and condition score at joining for ewes with different numbers of foetuses when scanned between days 77 and 95 of pregnancy.

Property		Number of ewes	Group average		Weight Range	
			Weight	Condition score	Low	High
1	Twin	154	48	2.8	38	62
(482 ewes)	Single	299	46	2.8	34	64
	Empty	29	46	2.8	39	52
2	Twin	90	44	2.7	34	58
(390 ewes)	Single	167	43	2.6	31	56
	Empty	133	41	2.5	26	55
3	Twin	50	48	3.3	41	58
(503 ewes)	Single	433	45	3.2	40	67
	Empty	20	45	3.2	38	58
4	Twin	21	40	2.9	30	52
(426 ewes)	Single	371	37	2.8	30	51
	Empty	34	36	2.6	30	43

Management of weaners for survival

All flocks of weaners have a wide range of body weights and condition scores. Lloyd-Davies et al. (1988) reported that starting weights for 208 weaners varied from 10–16 kg. Of the 10% mortality rate, most deaths occurred in the lower liveweight group. In larger-scale studies referred to by Lloyd Davies et al. (1988), 85% of weaner mortalities occurred when animals weighed less than 14 kg and 45% of losses occurred when animals weighed less than 18 kg. It is clear that there is a relatively small number of animals in the weaner flock that have a high risk of mortality. However, the cost and difficulty of identifying and separating out the at-risk animals and feeding them so that they remain above threshold weights and growth rates is such that this does not occur on most properties, and losses of between 10% and 20% are regarded as normal.

Cost-effective nutritional management of weaners to reduce mortality relies on feeding those animals at risk without having to feed the whole weaner flock. In fact, feeding the whole weaner flock will not solve the problem because the heavier animals will consume most of the feed. Animals that start a feeding program with below average weight also have below average growth rates (Lloyd-Davies et al., 1988).

Precision nutrition management

Design and hardware

Two hardware components of the e-sheep technology platform form the basis of precision nutritional management: walk-through weighing as a means of monitoring weight and weight change, and an automatic drafting gate able to direct sheep requiring additional feed so that they have access to a self-feeder. The components of the system are shown in Fig. 1. The first Sheep CRC prototype feeding systems were based on the Tru-test weighing system and Prattley drafting unit. The Tru-test indicator is used to integrate information from the electronic tag reader with programmed instructions for the Prattley drafting system. The indicator can be programmed manually on-site or remotely via a computer and CDMA modem. Currently, the Tru-test indicator cannot simultaneously collect weights via walk-through weighing and draft animals according to pre-determined criteria. Further development is underway to facilitate simultaneous access to both modes of operation, as there are significant benefits in having a single unit for both monitoring and drafting/feeding functions.

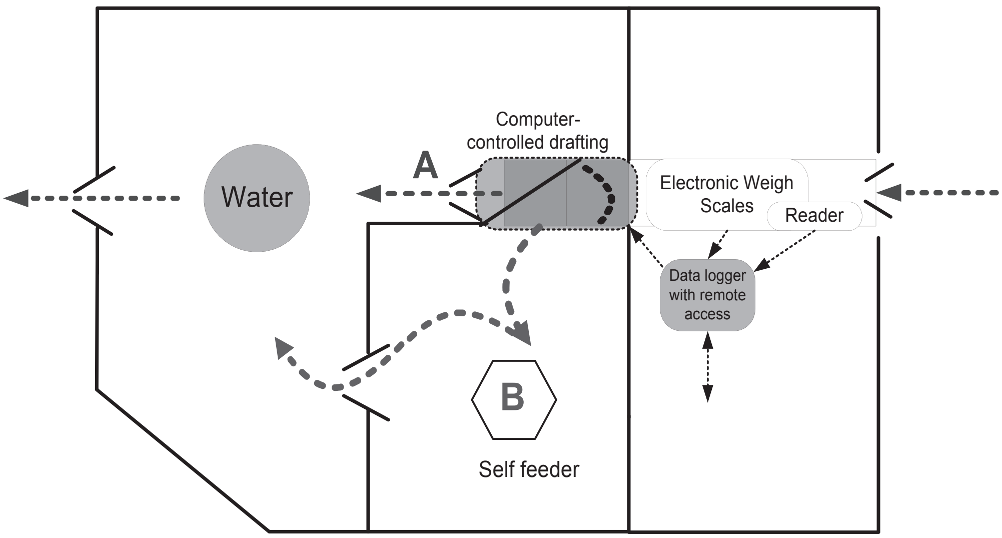

Fig. 1. Components of a precision nutrition system. Animals enter through spear gates on right-hand side and are identified by electronic tags as they walk over the weighing platform. From the weighing platform, sheep are either drafted into the area containing the self-feeder (B) or allowed to pass through to water (A). Spear gates maintain a uni-directional flow with access to feed controlled by computer-directed drafting.

The prototype precision nutrition systems have only been tested using small numbers of sheep (10 to 30) and the capacity of each unit has not yet been established. However, on a theoretical basis, a single unit could handle relatively large numbers sheep. The walk-through weighing function has been tested with a group of 600 sheep without any indication of crowding. In terms of access to the self feeder, only a portion of the flock will require supplementary feeding and programming of the indicator on a 7- or 14-day cycle means that access to the self-feeder for an individual animal could be set at any interval from daily to once per fortnight. For example, 25% of a flock of 1000 ewes may require feeding. If access to the feeder is set at once per week, the trough space at the feeder only needs to accommodate 30 to 40 sheep if they all visit the feeder at the same time. These numbers of sheep can be accommodated by a relatively small (1–2 tonne) self-feeder. The system is designed so that sheep have free access to water but not to feed. Once they pass through the spear gates to water they cannot re-enter the feeding area unless drafted into it. Further research is required to determine the capacity of precision feeding units and the interaction between different designs, types of feed and grazing conditions.

Which animals should be feed?

We have accurate information on the weight, condition score and growth rate required to ensure efficient reproductive performance and minimise lamb and weaner mortality. There are also established relationships between weights and condition scores for different classes of sheep. At least one manual calibration is desirable to obtain the starting weight and condition score for each animal. After the initial calibration, it is relatively easy to determine which animals are falling below critical target points and which need additional feed. We used GrazPlan equations (Freer et al., 1997) to determine maternal body weight change, relationships between weight, weight change and condition score, and the amount of additional feed required to meet target growth rates. These parameters can be monitored and set on a weekly or fortnightly basis.

What feed should be offered and how much do animals consume?

We do not yet have good information on what to feed and animal intake. In the early stages of developing the system, we used lupin grain as a safe and effective supplement that does not require gradual introduction. Research is required to determine the most cost-effective feedstuffs, how to introduce sheep to each feedstuff to minimise the risk of acidosis, animal variation in intake and performance, the role of salt and other additives to control amount eaten, frequency of feeding and the interaction of supplements with paddock forage. These studies will commence as additional equipment becomes available and as the operating systems become more robust. One of the key features of this approach to precision nutrition is the in-built monitoring system in the form of walk-through weighing. This means that the feeding regime can be changed in a timely way to respond to actual animal performance and does not rely on predictions based on estimates of feed on offer or pasture quality.

Economic assessment of targeted nutrition for ewes and weaners

We have developed spreadsheet models to estimate the value of each additional lamb and the costs of feeding varying segments of the flock. The results of the analysis are similar to those of Young (2005), who estimated that the value of an extra lamb (increased whole-farm $ per extra lamb) was between $12 and $49, depending on flock type and prices received. The value of extra lambs is lowest in specialist wool flocks when low meat prices exist, of intermediate value in flocks producing wool and Merino prime lambs and most valuable in specialist meat flocks when high meat prices exist.

In addition to the value of lambs determined by meat value, there are further benefits of improved nutrition on subsequent fecundity and ewe fleece quality and quantity (Oldham and Thompson, 2004) and also long-term progeny impacts as shown by the AWI *Lifetime Wool Project*: higher clean fleece weights and finer wool (Ferguson et al., 2004), slower growth (Paganoni et al., 2004b), less muscle and more fat at the same body weight (Paganoni et al., 2004a), lower immune competence (Cronje, 2003) and lower adult reproductive performance (Walker et al., 2003/4; Robinson et al., 2002). There is also evidence that fine wool ewes producing high fleece weight ewes tend to have lower fat reserves and higher energy requirements (Adams et al., 2006).

There are further impacts on subsequent fecundity and ewe fleece quality and quantity (Oldham and Thompson, 2005). Long-term progeny impacts of poor maternal nutrition revealed by the *Lifetime Wool Project* and other work include lower clean fleece weights of coarse wool sheep (Ferguson et al., 2004b), slower growth (Paganoni et al., 2004b), less muscle and more fat at the same body weight (Paganoni et al., 2004a), lower immune competence (Cronje, 2003) and lower adult reproductive performance (Walker et al., 2003, 2004; Robinson et al., 2002). These adverse effects on the progeny may be induced at levels of nutrition that may not necessarily reduce the birth weight of single lambs (Ferguson et al., 2004a). In addition, high-fleece-weight ewes tend to have lower fat reserves and higher energy requirements that cannot be met from intakes on poor quality pastures, which makes them more susceptible to under-nutrition, particularly when exacerbated by the higher demands of twin foetuses (Adams et al., 2006).

If it is assumed that it is appropriate to target feeding at 25% of ewes, the cost of 80 days' feed (assuming 0.3 kg/d feed at $350/t) will be $2100. It can be expected that this level of feeding will decrease lamb mortality from 25% to 12%; assuming a value for each additional lamb of $25, the additional lambs will be worth $4493. However, if 20% of the at-risk weaners are also fed (0.3 kg/d for 60 days), cost will be increased to $3309. Targeted feeding of the weaners is expected to reduce mortality from 15% to 6%. If the additional weaners from feeding ewes and weaners are valued at $40 each, the overall benefit will be $9566. The gross margin for targeted feeding in this example is thus more than $6,000 and appears to justify the cost of the infrastructure required ($10,000 to $15,000 per unit). The alternative cost of feeding the whole ewe flock and all of the weaners is more than $14,000 and is clearly not justified by the value of additional progeny.

Conclusions

The wide ranges of weight and body condition scores of pregnant ewes and weaners means that it is not biologically or economically sensible to apply a single standard of nutrition to the whole flock. Even segregation of ewes according to the number of foetuses observed with ultrasound scanning results in groups of animals with wide ranges of body condition scores and differential nutritional needs. The e-sheep technologies of computer directed drafting and walk-through weighing offer a way to manage individual animals according to their nutritional requirements and productive potentials. The ability to accurately target the minority of animals that require supplementary feeding can cut the overall cost of feed by 70–80% and is also likely to be more effective in reaching the target group with the appropriate level of supplementation. The capital cost of the weighing and drafting equipment as well as the perceived complexity of the e-sheep technology are expected to result in a slow initial uptake of precision nutrition. It is also important that further research on various feeds and management systems are completed before the new systems are presented to the sheep industry for widespread adoption. With increasing concern over animal welfare and the importance of reproductive efficiency in profitable sheep production, the new approach described in this paper is expected to become an essential component of sheep management within 3 years.

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