Sheep CRC Conference Proceedings

Document ID:	SheepCRC_22_17
Title:	Improving sheep feedlot management
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Key words:	sheep; feedlot; nutrition; management

This paper was presented at the Sheep CRC Conference 'Wool Meets Meat' held in Orange, NSW in 2006. The paper should be cited as:

Bowen, M.K.; Ryan, M.P.; Jordan, D.J.; Beretta, V.; Kirby, R.M.; Stockman, C.; McIntyre, B.L.; Rowe, J.B. (2006) *Improving sheep feedlot management* in 'Wool Meets Meat' (Editors P. Cronje, D. Maxwell) Sheep CRC pp 134-141.

Improving sheep feedlot management

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Abstract

This paper summarises six studies undertaken by the Sheep CRC to elucidate certain aspects of confinement feeding of sheep. A review of confinement feeding highlighted the variability of growth rate and feed conversion of sheep and revealed that little is known about the use of sorghum for feeding sheep. The review indicated that the main factors responsible for variation of growth rate and feed conversion were adaptation to grain and feeding system, including the preparation and presentation of feed. The importance of social and physiological adaptation to grain feeding was confirmed. Factors identified as responsible for safe induction and uniform growth rates included prior exposure to grain as lambs, gradual introduction of grain and, when concentrate was provided ad libitum from the first day, the use of either virginiamycin, a pelleted feed, a total mixed ration or a step-wise increase of high-starch grain components. Separate feeding of hay and grain resulted in performance comparable with that of a pelleted diet and that of a total mixed ration. Sorghum-based concentrate diets resulted in growth rates and carcase weights similar to that for winter cereal grains or pellets. Steam flaking or expanding of sorghum had no significant effect on growth rates or carcase weights. These results can be used to determine the profitability of various feedlotting options.

Introduction

Systems for intensive feeding are not as well defined for sheep as they are for beef cattle. As the importance of confinement feeding of sheep is increasing, clear guidelines and well-defined production parameters are needed to assist producers to achieve predictable growth rates and feed conversion rates. The Sheep CRC conducted a review of feeding practices and their implications for growth and feed conversion (Sheep CRC, 2004), which complements reports such as that of Davis (1977). An important finding of the CRC review was the variability in the results of experiments that appeared to involve similar dietary treatments, feeding systems and animals. The review concluded that background conditions , including past nutritional history, should be clearly defined in future experiments to understand variability in adaptation to grain diets and that liveweight gain should be related to carcase weight change to reduce variation associated with gut fill. Growth rate and feed conversion of sheep in grain finishing systems are affected by many factors including genotype, diet composition, feed intake, feed conversion efficiency, past nutritional history, past exposure to grain, social interaction, age, sex, liveweight and disease. As the quantitative impact of many of these variables is not well understood (Kirby and Beretta, 2004), the Sheep CRC undertook research to provide better information on three aspects of confinement feeding identified by the review as priorities: management systems to ensure safe adaptation to grain feeding, understanding the benefits and costs of various feeding systems and information on the use of sorghum in sheep feedlot diets. This paper summarises the results of six experiments conducted by Sheep CRC researchers to investigate the impact of these variables on growth, feed conversion and carcase quality of lambs and cast-for-age sheep.

Adaptation to grain feeding

Learning to eat feedlot diets

Prior experience of a feedstuff expedites the acceptance of that feedstuff later in life, especially if the initial exposure was experienced in the presence of experienced social partners (Green et al., 1984; Lynch and Bell, 1987). McDonald et al. (1988) confirmed the benefits of prior exposure of lambs or hoggets to feedstuffs in terms of increased feed intake during the first five days of trough feeding and a reduction in the number of sheep that did not approach the trough during this period. They suggested that exposure of young sheep to grain feeding early in life should be part of best-practice management in preparing animals for supplementary feeding or grain finishing later in life.

Managing acidosis

The change from roughage to a high grain diet requires a major adaptation of rumen and hind-gut bacteria as well as of enzyme production in the small intestine. Gradual introduction of grain facilitates the development of a stable bacterial population that is able to utilise the new substrate and metabolise lactic acid Virginiamycin can assist adaptation to grain because it reduces lactic acid production while the bacterial population adjusts to the new substrate. Although safe methods for introducing grain-based diets are well-known, acidosis is common under commercial conditions. The amount and quality of roughage and the type of grain and its preparation can influence the outcome of adaptation programs. Several experiments were conducted to examine adaptation programs.

Experiment 1 was conducted on a commercial property in south-east Queensland to investigate the effects of various methods of grain introduction typical of opportunity feedlots. Sheep were exposed to grain in the paddock for 14 days by trail feeding, after which they were admitted to a feedlot and given ad libitum access to hay (low-quality sorghum stubble (ME, 7.4 MJ/kg DM; CP, 5.8%) and various grain-based diets. Six hundred cast-for-age Merino wethers (initial liveweight 34.3 kg and condition score 1.07) were allocated to one of two replicates of three grain diets: (i) commercial lamb feedlot pellets based on sorghum grain, (ii) whole sorghum with added urea, ammonium sulphate and limestone, (iii) whole barley with added urea, ammonium sulphate and limestone. Sheep fed the whole grain diets lost weight during the first seven days in the feedlot and had a higher ($P < 0.05$) cull rate from the experiment (based on weight loss and declining condition score) than sheep fed the pelleted diet (Table 1). The commercial feedlot pellet contained a mixture of grain, roughage and minerals and may be better than whole grain in the absence of careful introduction to grain. It appears that under the prevailing drought conditions, there was insufficient pasture roughage consumption prior to feedlot entry and all animals were not adequately exposed to grain during the paddock introduction.

During Experiment 2, introduction to grain was more carefully managed than for Experiment 1,. In Experiment 2, cast-for-age merino ewes (n = 301; initial carcase weight = 16.4 kg; fat score = 1.0) were allocated to six diets, each with three replicates. Three of these diets examined the effect of the introductory regimen: (i) sorghum-based diet, (ii) sorghum-based diet + virginiamycin (20 mg/kg grain), (iii) whole cottonseed, which was gradually replaced by a sorghum-based diet. Sheep allocated to treatments (i) and (ii) received increasing amounts of grain (50 g/d) for the first 14 d. For treatment (iii), the composition of the ration was altered over the first 14 days so that the sorghum component of the ration increased at 50 g/d while whole cottonseed was included at 150 g/d for the

Table 1. Daily weight change (kg/d) for the first seven days in the feedlot and mean logit of sheep remaining in treatment groups at 14 and 42 days (probability of sheep remaining in brackets) for cast-for age Merino wethers in Experiment 1.

		Treatment			
		Pellets	Sorghum	Barley	Average SED
Daily weight change †	First 7 d	0.52^{b}	–0.39^{a}	–0.44^{a}	0.067
Mean logit (probability in brackets) of sheep remaining in treatment groups ‡	Day 14	2.37^{b} (0.91)	1.32^{a} (0.79)	0.89^{a} (0.71)	0.280
	Day 42	2.09^{c} (0.89)	0.53^{b} (0.63)	0.03^{a} 0.51)	0.247

Means within rows with different superscripts differ significantly ($P < 0.05$).
† Daily weight change determined from linear regression.
‡ Significant differences determined on mean logit of sheep remaining in treatment groups, which were derived from generalised linear mixed models.

first eight days and was then reduced by 25 g/d over the following six days. From day 14, all groups were fed sorghum ad libitum. All sheep had free access to wheat hay (ME, 8.9 MJ/kg DM; CP, 10.9%), which was provided separately to the grain. In this experiment, no sheep had to be culled for poor performance during the introductory period. There were no significant differences ($P > 0.05$) between the three treatments in rumen fluid pH on days 18 (pH 6.24) and 51 (pH 6.21). There were no significant differences ($P > 0.05$) between treatments in growth rate (mean = 117 g/d) or carcase weight (mean = 19.5 kg).

In Experiment 3, we studied more aggressive introductory feeding regimens when concentrate and roughage were fed separately. Three hundred and sixty Poll Dorset × Merino ewe and wether lambs (initial liveweight 35 kg) were allocated to six diets with three replicates and fed for 12 weeks (84 days), including a two-week introductory period. After the introductory period, all sheep received the same concentrate diet (finishing diet) ad libitum (55% barley, 10% oats and 35% lupins). The introductory treatments were: (i) commercial feedlot pellets, including 50% high-roughage pellets and 50% finishing pellets, (ii) a total mixed ration (TMR) consisting of 70% concentrate of the same composition as the finishing diet and 30% ground oaten hay, (iii) concentrate of the same composition as the finishing diet + virginiamycin, and (iv), (v) and (vi) different starting levels of lupins (60%, 60% and 40%, respectively) and oats (30%, 20% and 50%, respectively), which were changed to the finishing diet in two steps over a period of 14 days. Oaten hay was provided ad libitum for all treatment diets during and after the introductory period. In all treatment groups, lambs adapted successfully to the grain-feeding regime and there were no mortalities. There were differences between treatments in growth rate over the 12-week feeding period: virginiamycin resulted in higher growth rates ($P < 0.05$; 172 g/d vs. 155 g/d) than two of the introductory treatment regimens with step-wise increases of the high-starch grain (treatments v and vi). Inclusion of virginiamycin also resulted in a higher ($P < 0.05$) percentage of lambs that reached target slaughter weights (87%) than those fed the TMR (70%) or two of the introductory regimens with step-wise increases of high-starch grain (treatments v and vi; 67%).

Experiment 4a examined methods of feeding and introduction to grain. In this experiment, 195 Merino and 195 Poll Dorset × Merino wether lambs were allocated to one of three feeding groups: (i) pelleted diet including roughage, (ii) milled, loose mix ration (TMR) with the same composition as the pelleted diet, (iii) grain and roughage fed separately. There were high percentages of non-feeding sheep (i.e., those not eating concentrate on a particular day) during the first five days of feeding, especially for sheep consuming the TMR. Results for Merino lambs are given in Fig. 1.

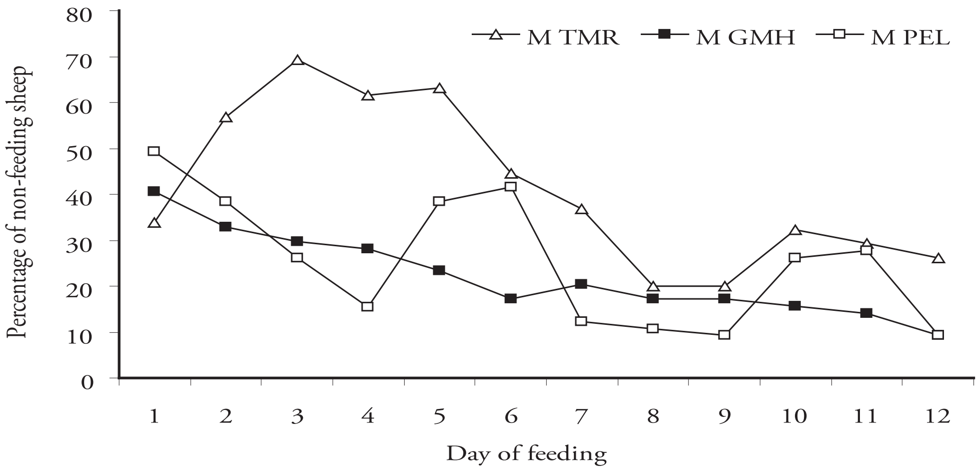

Fig. 1. Percentage of non-feeding Merino (M) wether lambs consuming a pellet (PEL), separate grain and hay (GMH) or a total mixed ration (TMR) in Experiment 5a.

The series of experiments reported above illustrates the importance of feeding good quality roughage prior to and during the introduction of grain, even if roughage is incorporated with the grain into a pellet. Gradual introduction of grain is reliable or, when a long introductory period is impractical, lambs can be safely introduced to ad libitum grain from the first day of feeding using either added virginiamycin, commercial feed pellets, a TMR or step-wise introduction of high-starch grain.

Importance of feeding systems

Three main feeding systems are used in sheep feedlots: pelleted diets, usually fed using self-feeders; TMR, usually fed using open troughs; whole grain, either fed using open troughs or self-feeders with long roughage provided separately. Each system has different requirements for infrastructure and different costs for labour and equipment. The simplest and cheapest system, feeding grain and hay separately, allows the sheep to select their own diet and can potentially lead to consumption of more roughage than is the case with pellets or TMR, resulting in lower growth rates and less efficient feed conversion. The use of pellets prevents diet selection and facilitates the use of self feeders, but increases costs. TMR requires grinding and mixing equipment as well as regular feeding (daily or every second day).

An experiment was conducted with 195 Merino wether lambs (42 kg) and 195 Poll Dorset × Merino wether lambs (40 kg) to examine the performance of lambs in three feeding systems: (i) complete pellet diet (provided via a self-feeder), (ii) TMR fed daily in troughs, (iii) grain and roughage components provided separately in self feeders and hay racks, respectively (Experiment 4b). Crossbred lambs grew significantly ($P < 0.05$) faster than Merino lambs (172 g/d vs. 124 g/d, respectively). The average growth rate of lambs fed hay and grain separately (148 g/d across both breeds) was not significantly different to that of lambs consuming either pellets (158 g/d) or the TMR (138 g/d). However, the growth rate of lambs fed pellets was greater ($P < 0.05$) than that of lambs fed the TMR. Furthermore, feeding hay and grain separately resulted in a carcase weight similar to that of lambs fed the pelleted diet and a better carcase weight than that of lambs consuming the TMR.

Eye muscle areas of lambs followed a similar trend to that of carcase weight. This study showed that the simple system of feeding grain and hay separately resulted in growth and carcase characteristics similar to those of the more expensive pelleted diet. Producers formulating whole-grain diets should be aware of differences in nutrient content between grains and ensure that appropriate protein and minerals are included to balance diets.

Sorghum grain in feedlot diets

Sorghum grain is cheaper than other cereal grains in parts of Australia, but is not widely used because its nutritive value for sheep is not well understood (Beretta and Kirby, 2004). This is possibly because steam flaking or reconstitution of sorghum are required for feeding to cattle. While steam flaking or reconstitution equipment may be justified for large cattle feedlots, the cost would be prohibitive for smaller sheep feeding operations. In addition to sorghum, cottonseed is normally readily available in tropical and sub-tropical areas. Sheep feeding systems that use these ingredients are encountered less than would be expected on the basis of the nutritional composition and price of these ingredients. Four experiments were conducted to investigate the use of sorghum grain in sheep diets and processing of sorghum.

The methods of introductory feeding were as described for Experiment 2. Four of the six treatment diets examined sorghum in feedlot diets for cast-for-age ewes: (i) commercial feedlot pellet containing 44.6% sorghum on an as-fed basis (ME, 12.3 MJ/kg DM; CP, 17.5%), (ii) sorghum + urea and ammonium sulphate (S+U; ME, 13.3 MJ/kg DM; CP 13.8%), (iii) sorghum + whole cottonseed at 28.6% of concentrate DM (S+WCS; ME, 13.5 MJ/kg DM; CP, 14.4%), (iv) sorghum + cottonseed meal at 13.9% of concentrate DM (S+CSM; ME, 13.2 MJ/kg DM; CP, 14.8%). Diets (ii) to (iv) contained 1.4% limestone, 2.1% salt and 2.0% molasses (DM basis) and all were fed with ad libitum wheaten hay as described previously. Ewes fed whole sorghum with whole cottonseed had similar ($P < 0.05$) carcase weights and fat scores to those fed pellets (Table 2). There were no significant differences between diets for final liveweight after 68 days on feed. Higher levels of faecal starch were recorded for sheep fed whole-grain sorghum diets compared to those fed pellets.

The results of Experiment 1 indicate that, over a feeding period of 42 days, sorghum plus non-protein nitrogen (urea and ammonium sulphate) produced growth rates for cast-for-age Merino wethers (150 g/d) that were almost identical to those for a diet based on whole barley plus non-protein nitrogen (150 g/d; $P > 0.05$). Although growth rates tended to be greater for wethers consuming a commercial pelleted diet (170 g/d), differences were not significant ($P > 0.05$).

Table 2. Experiment 2: final liveweight, carcase weight and fat score (scale 1–5) for cast-for-age Merino ewes after 68 days on feed; faecal starch content was measured after 50 days on feed.

	Treatment			
	Pellets	S+U	S+WCS	S+CSM
Final liveweight (kg)	50.2	48.4	49.4	49.2
Carcase weight (kg)	20.8^{a}	19.4^{b}	19.9^{ab}	19.6^{b}
Fat score	2.4^{a}	1.8^{b}	2.1^{ab}	2.0^{b}
Faecal starch (g/kg DM)	72^{b}	274^{a}	239^{a}	310^{a}

Means within rows with different superscripts differ significantly ($P < 0.05$).

Experiment 5 was conducted to obtain more information about the performance of lambs fed sorghum-based diets. A total of 339 Poll Dorset × Merino wether lambs (initial carcase weight 15.0 kg, fat score 1.7) were allocated to one of three replicates of six treatment diets:

- WS: whole sorghum, no urea or ammonium sulphate added (CP 12.2%),
- WS+U: whole sorghum + urea and ammonium sulphate (CP 16.6%),
- CS+U: cracked sorghum + urea and ammonium sulphate (CP 17.1%),
- ES+U: expanded sorghum + urea and ammonium sulphate (CP 18.0%),
- WS+WCS: whole sorghum + whole cottonseed at 28.6% DM (CP 15.4%),
- WS+CSM: whole sorghum + cottonseed meal at 14.4% (CP 17.4%).

All concentrate diets contained 1.4% limestone, 2.1% salt and 2.0% molasses (DM basis) and ME was estimated to be 13.5 MJ/kg DM. Concentrates were fed separately to wheaten hay (ME 6.0 MJ/kg DM, CP 7.44%). Although cracking or expanding sorghum grain did not result in significantly ($P > 0.05$) increased carcase weight compared to whole sorghum grain plus non-protein nitrogen (Table 3), expanding sorghum tended to increase liveweight gain, carcase weight and reduce days to reach 18 kg carcase weight. Furthermore, although there were no significant differences in carcase weights of lambs fed diets plus protein supplements, sorghum plus true protein sources (WCS or CSM) tended to increase liveweight gain and carcase weight compared to sorghum plus non-protein nitrogen. Sorghum plus cottonseed meal produced greater fat depth than the other treatments and reduced the number of days required to reach the target of 18 kg carcase weight, which was less than that of all other treatments except expanded sorghum plus non-protein-nitrogen. The significant reduction in faecal starch content with expanded sorghum indicates improved starch digestion but this did not result in significant differences in growth or carcase characteristics.

Table 3. Intake, growth and carcase characteristics of Poll Dorset × Merino lambs fed a range of sorghum-based diets for 76 days (Experiment 5).

	Treatment							
	WS	WS+U	CS+U	ES+U	WS + WCS	WS + CSM	Feedlot Mean	Mean SED
Concentrate intake (g/d; days 15–76)	800[a]	916[bc]	894[b]	985[c]	959[bc]	968[bc]	920	40.7
Liveweight (kg; day 76)	46.3	47.9	48.0	49.1	49.0	49.7	48.4	1.09
†Weight gain (g/d; days 0–76)	149	170	172	187	190	190	176	15.5
Carcase weight (kg; day 76)	20.0[a]	20.9[ab]	21.1[b]	21.7[b]	21.4[b]	21.8[b]	21.1	0.44
Fat depth at the GR site (mm; day 76)	11.8[a]	12.9[a]	14.2[b]	14.7[b]	14.3[b]	15.9[c]	14.0	0.48
‡Days to reach 18 kg carcase weight	55.8[a]	46.0[bc]	47.0[b]	39.9[cd]	44.6[bc]	36.7[d]	45.0	3.198
Faecal starch content (g/kg DM; day 59)	192[a]	184[a]	193[a]	79[b]	217[a]	182[a]	175	33.3

Means within rows with different superscripts differ significantly ($P < 0.05$); † Determined from linear regression
‡ Determined from linear regressions fitted to estimated carcase weights at days 0, 41 and 56 and actual carcase weight at day 76.

The effect of steam-flaking of sorghum was examined in Experiment 6. A total of 60 cast-for-age Merino wethers (initial liveweight 32.2 kg) were housed in individual pens and offered a whole sorghum diet plus oaten chaff or steam-flaked sorghum plus oaten chaff for 92 days. Growth and carcase characteristics of wethers fed steam-flaked sorghum did not differ ($P > 0.05$) from that of those fed whole sorghum (final liveweight = 45.0 vs. 44.5 kg, respectively; carcase weight 17.5 kg vs. 17.6 kg, respectively) despite higher levels of faecal starch in sheep fed whole sorghum.

Conclusions

Adaptation to feedlot diets

Pre-weaning exposure to concentrates improves the rate of acceptance of feed in the feedlot and should be considered as routine pre-weaning treatment. Carefully controlled step-wise introduction of grain will ensure good early intakes and weight gain in the feedlot. Lambs can be safely introduced to ad libitum concentrate diets from the first day of feeding using added virginiamycin, commercial feedlot pellets, a total mixed ration or a step-wise increase of high-starch grains.

Feeding systems

Feeding systems that supply hay and grain separately resulted in lamb performance comparable to that of a complete pelleted diet or a total mixed diet. The reduced costs of labour and infrastructure make feeding of whole grain and long hay attractive because this system does not reduce feedlot performance. The nutrient content of grain and hay can vary considerably and mineral and additional protein supplements may be required.

Sorghum for sheep feeding

Sorghum-based diets resulted in growth and carcase characteristics in lambs and older sheep similar to those of sheep fed barley or commercial feed pellets. This finding is significant for sheep producers because sorghum is often cheaper than winter cereal grains such as wheat or barley, or pellets. Cracked sorghum did not improve lamb growth rates compared to that of whole sorghum. Although heat treatment of sorghum by steam flaking or expanding reduced faecal starch (increased starch digestion), it did not have a significant effect on growth rates or carcase characteristics relative to that of whole grain. Given the high cost of steam flaking and expanding, this finding has important implications for the use of sorghum in sheep feeding systems.

General conclusion – factors that affect profit

In all experiments, there was a large variation between individual sheep in their growth rate during grain feeding. The relatively large numbers of animals that grow slowly, have poor feed conversion and fail to meet target carcase weight are a hidden cost associated with sheep feedlotting. At present, the only method of identifying and removing slow-growing animals is by regular weighing. For most producers, this is not a cost-effective option at present. However, those preparing to feed sheep should consider adding a large 'safety margin' to account for this variability. Strategies to reduce variability include using best-practice preparation and introductory management. However, this is an area requiring further research, as genetic variation is a possible contributing factor. The profitability of a feedlotting enterprise will be determined by the performance of sheep, the cost of feed, infrastructure and labour, and the market value of mutton and lamb. The Sheep CRC Feedlot Calculator (www.sheepcrc.org.au) is a useful tool for determining the financial implications of feeding operations.

Acknowledgements

These experiments were mainly funded by the Australian Sheep Industry Cooperative Research Centre. The in-kind contributions from all associated CRC co-operators are gratefully acknowledged.

Assistance from John Elias in providing a copy of report by C. Davis is gratefully acknowledged. Information summarised in this article is used with permission of the following CRC researchers: Experiment 1: D.J. Jordan, P.M. Pepper, G. Newell, A. Mills, J.B. Rowe; Experiment 2: M.K. Bowen, P.M. Pepper, E. Patterson, I. McConnel, D.J. Jordan; Experiment 3: M. Ryan, McIntyre; Experiment 4a: C. Stockman, A. Barnes; Experiment 4b: R.M. Kirby, M. Ryan, K. Buttler; B. McIntyre; Experiment 5: M.K. Bowen, P.M. Pepper, J. Winkleman, I. McConnel; Experiment 6: V. Beretta, A. Simeone, J.M. Thompson, D.B. Savage, J.B. Rowe.

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