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Sheep Updates 2003 - Meat

Lucy Anderton
Department of Agriculture Western Australia

Rob Davidson
University of WA, Crawley

Keith Croker
Department of Agriculture Western Australia

Robin Jacob
School of Veterinary and Biomedical Sciences, Murdoch University

Rachel Kirby
Outback Solutions

See next page for additional authors

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Authors
Lucy Anderton, Rob Davidson, Keith Croker, Robin Jacob, Rachel Kirby, Steve Meerwald, John Milton, and David Pethick

Economic analysis of using terminal sires in a self replacing Merino flock

Lucy Anderton, Department of Agriculture Western Australia, Katanning

KEY MESSAGES

Prime lambs are profitable.

The time of lambing and the proportion of the ewe flock mated to terminal sires have the greatest impact on the profitability of the enterprise.

The most profitable system for the Great Southern and Eastern Wheatbelt is lambing all ewes to terminal sires in March to April and selling lambs for a premium in July.

Costs of replacing breeding ewes have a significant impact on the enterprise. A shortage of merino ewes for mating would decrease profitability.

The number of lambs born, weaned and sold are key profit drivers so good lambing percentages help maximise profits.

INTRODUCTION

It is becoming common practice for commercial wool producers to use terminal sires for prime lamb production, believing this will increase returns.

This paper discusses the key decisions farmers make when using terminal sires and how this affects profit. A comparison is made between the profitability of running a purebred self-replacing merino ewe flock versus a self-replacing merino flock with part of the flock mated to terminal sires for prime lamb production. Factors considered include lambing percentage, flock structure, wool production and price sensitivity.

Terminal sires are so-called because their progeny are not continued in the self-replacing merino flock. They are used to produce fast growing cross-bred prime lambs, slaughtered at target weights. Cross breds tend to have larger mature weights than merinos and they grow faster and reach slaughter weight sooner than the merino (see Figure 1). If used for breeding purposes they would be high maintenance animals requiring more feed than the smaller framed, lower weight merino.

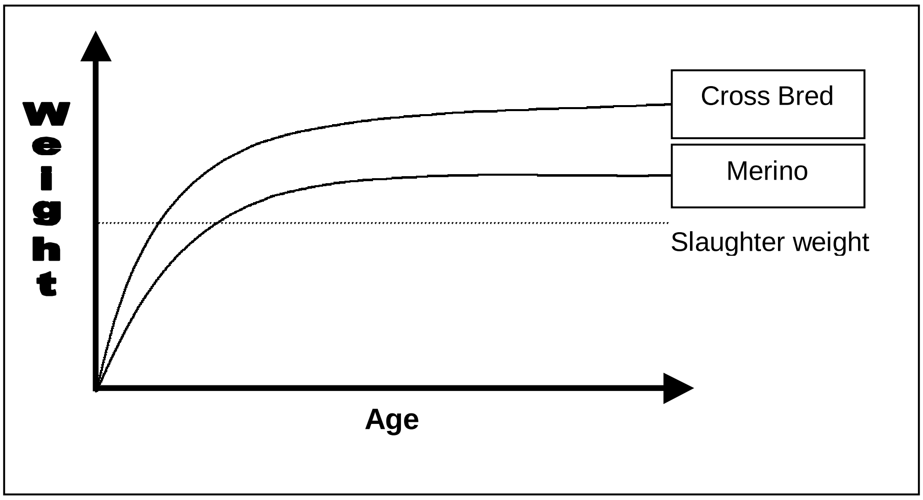

Figure 1. Age and weight of Merinos and cross breds (Source, J. Skerritt 2003, pers. com.).

The decline in the wool industry during the 1990s has seen more traditional wool producers shifting towards meat production as a way to maintain income from sheep production. Terminal sires in self-replacing merino flocks have become commonplace. The main breeds include the Suffolk, White-faced Suffolk, Dorsets and Texel.

The major issues for farmers are:

- How does use of terminal sires compare to alternatives such as 100 per cent wool production or 100 per cent prime lamb production?
- What proportion of the ewe flock should be mated to terminal sires?
- When is the best time for mating and therefore lambing?
- What is the economic cost of finishing lambs?
- How is flock structure affected?

THE ANALYSIS

The aim of this project was to analyse a specific enterprise within the farming system using gross margin (GM) analysis. GMs calculate an enterprise's gross income and then deduct its variable costs. If enterprises being compared have similar capital requirements and overheads then these costs are not included. GM's help identify the economic effect of changing one factor in an enterprise and doing sensitivity analysis on 'what if' scenarios. But a limitation with GM analysis can be costing the feeding requirements of various classes of sheep throughout the year. A first step prior to costing, is to analyse the metabolisable energy requirements of stock during the year and then match this with feed availability from pasture. At the times of the year when there is a feed shortfall, supplementary requirements are then calculated.

Sheep enterprises have complex issues and there are a large number of variables affecting outcomes. Key assumptions of this analysis are outlined in a following sub-section.

Sensitivity analyses using gross margins include:

- wool production versus prime lamb production;
- proportion of the ewe flock mated to terminal sires;
- the cost of replacements;
- the time of lambing, April/May, May/June and June/July;
- lambing percentages; and
- prices of lambs, feed supplements and finishing lambs.

Two regions of Western Australia were analysed; the Eastern Wheatbelt (Merredin) and the Great Southern (West Arthur and Kojonup). The base stocking rates used for these regions were 3 DSE/ha and 10 DSE/ha respectively, with some variation according to the system (BankWest Benchmarks 2001/2002).

KEY ASSUMPTIONS

Price of lambs

The average price for the last three years from the Midland and Katanning saleyards was used. Figures 2 and 3 show how the price in 2000 was much lower being as much as 50 per cent lower in July 2000 compared to July 2002. Although the price of lamb may not reduce in the near future it would be unrealistic to use the high prices of the last two years as indicative medium term averages. Therefore, including 2000 in the average gives a more realistic price for use in analysis and budgets.

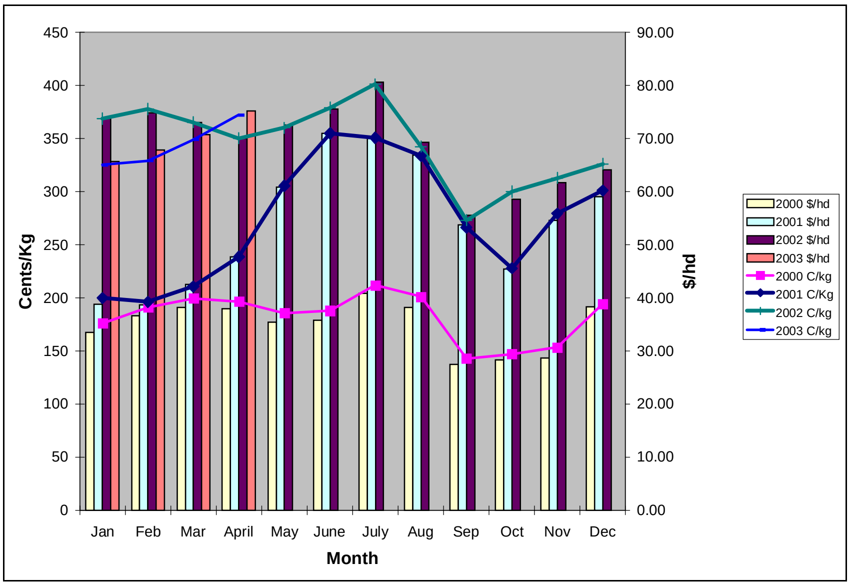

Figure 2. Price of Lambs (18-20 kg) at Katanning ($/hd and cents/kg for the last three years).

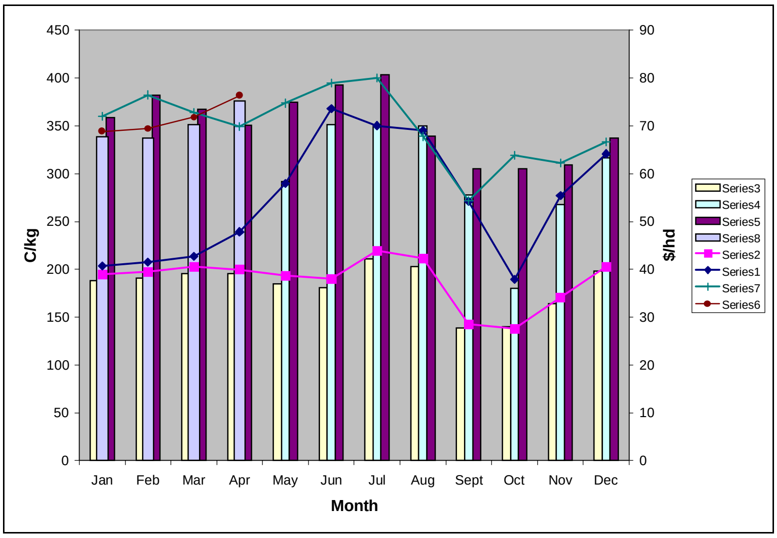

Figure 3. Price of lambs (18-20 kg) at Midland ($/hd and cents/kg for the last three years) (Source: G. Annan, Trade & Development).

Table 1. Prices of cross bred lambs

	Great Southern $/hd	Eastern Wheatbelt $/hd
July	64	64
August	58	59
September	45	48
October	44	42
November	48	49
December	54	57
January	53	55
February	55	56

Price of grain supplements

Supplementary grain feeding comprised lupins and oats. Grain prices in 2002/03 have been high compared to previous years. Prices of $240/t and $160/t have been used for lupins and oats respectively. The average price for lupins for the last 13 years is $214/t, but the price has been as low as $150/t in 1998/1999. There is a short supply of lupins due to the last two years of low production and the price is not likely to reduce much below the average in the short term. Sensitivity analysis of grain prices was undertaken.

Cost of replacements

Profitability of terminal sires is linked to cost of merino ewe replacements because mating over a certain proportion of the flock to terminal sires requires the purchasing of ewe replacements to maintain the merino flock. It was found that in the Great Southern purchases were required when mating 58 per cent or more of the flock to terminals and in the Eastern Wheatbelt this was 38 per cent. Lambing percentage also affected the required number of replacements.

Sensitivity analysis shows the effect of the cost of purchasing replacements on the profitability of the enterprise (see Table 9).

Figure 4 shows the price of sheep at the Katanning saleyards since August 1999. All classes have increased in value. It is unlikely for prices of ewes and ewe hoggets to decrease in the short-term. If more farmers use terminal sires in their self-replacing merino flocks then purchasing replacements could prove expensive as less merinos would be produced. If this is the case a lack of supply will help maintain strong prices (see Figure 5).

Replacement ewes purchased were assumed to be ewe hoggets because purchase of very old ewes for joining to terminal sires does not address as effectively the problem of failure of the self-replacing merino flock.

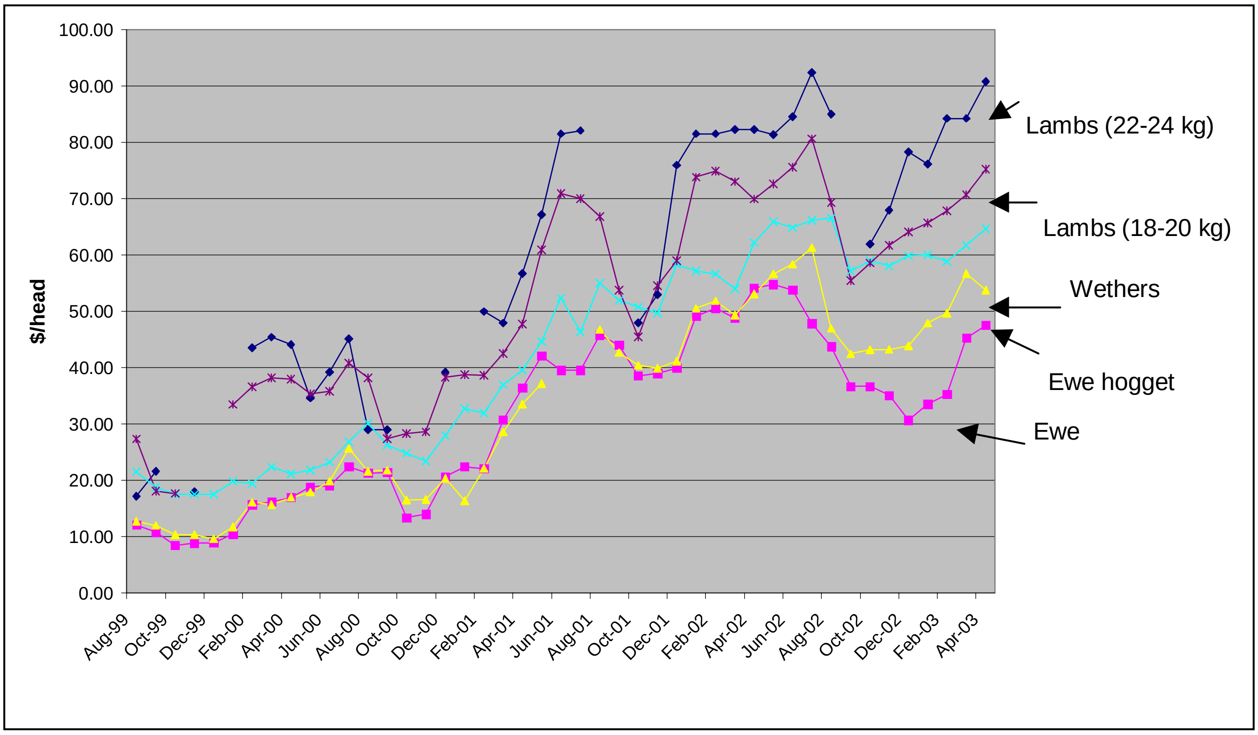

Figure 4. **Price of sheep ($/hd) at Katanning sale yard from August 1999 to April 2003.**

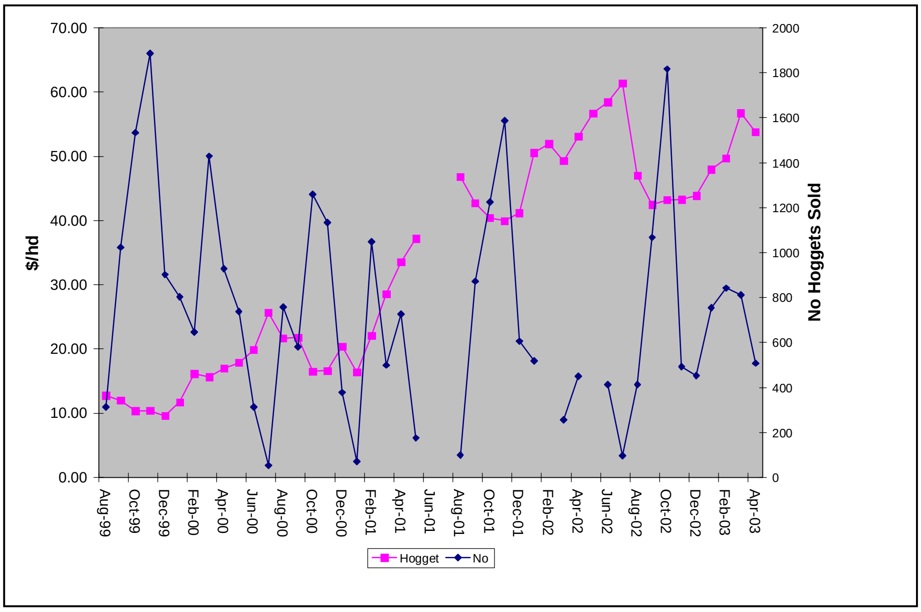

Figure 5. Number of hoggets sold and hogget price ($/hd from August 1999 to April 2003).

Lambing percentages

Lambing percentages for the Great Southern and the Eastern Wheatbelt were 81 per cent and 71 per cent respectively in the Bank West Benchmarks 2001/2002. This will vary with each producer and sensitivity analysis shows the effects of different lambing percentages on the profitability of the enterprise. Using terminal sires at lower lambing percentages is almost uneconomic because of the increased need to purchase replacements.

Time of lambing and lamb growth rates

Time of lambing has a significant impact on the profitability of the sheep enterprise. Two driving factors are the cost of supplementary feeding and the price premium for out-of-season lambs.

Three different times of lambing were analysed with the lambs sold according to their time of lambing. In the Eastern Wheatbelt it is assumed later lambs are finished on lupin stubble or are lot-fed. In the Great Southern, fodder crops, lucerne, lot feeding and cereal stubbles with supplementary feed are used. The following table summarises the assumptions made:

Table 2. Time of lambing and selling lambs

Lambing	Lambs sold	Finishing lambs
April/May	July, August, September	Pasture
May/June	September, October, November	Pasture
June/July	December, January	Lot feeding, Lupin stubble, Fodder crop, Lucerne, Cereal stubble

Information in Figure 6 was used to calculate the supplementary feed required for ewes during lambing and lactation, as well throughout the year. The ewe requirement plotted on the graph shows the required megajoules of metabolisable energy needed by the ewe each day. The line, ‘pasture + supplements’ is the amount of energy provided to the ewe from the pasture and supplementary feed.

There is a huge variation in feeds provided by producers to their sheep. The amounts calculated in this analysis were based on FarmNote recommendations and producer information. A sensitivity analysis was included (Table 8). Rations were increased for ewes lambing in March/April. Figures 6 and 7 illustrate that lambing from May through to July results in a better matching of ewe feed demands with availability of pasture. Lambing at this time of year requires less supplementary feeding than early lambing. Figure 6 clearly shows the added requirement for supplements in February, March and April.

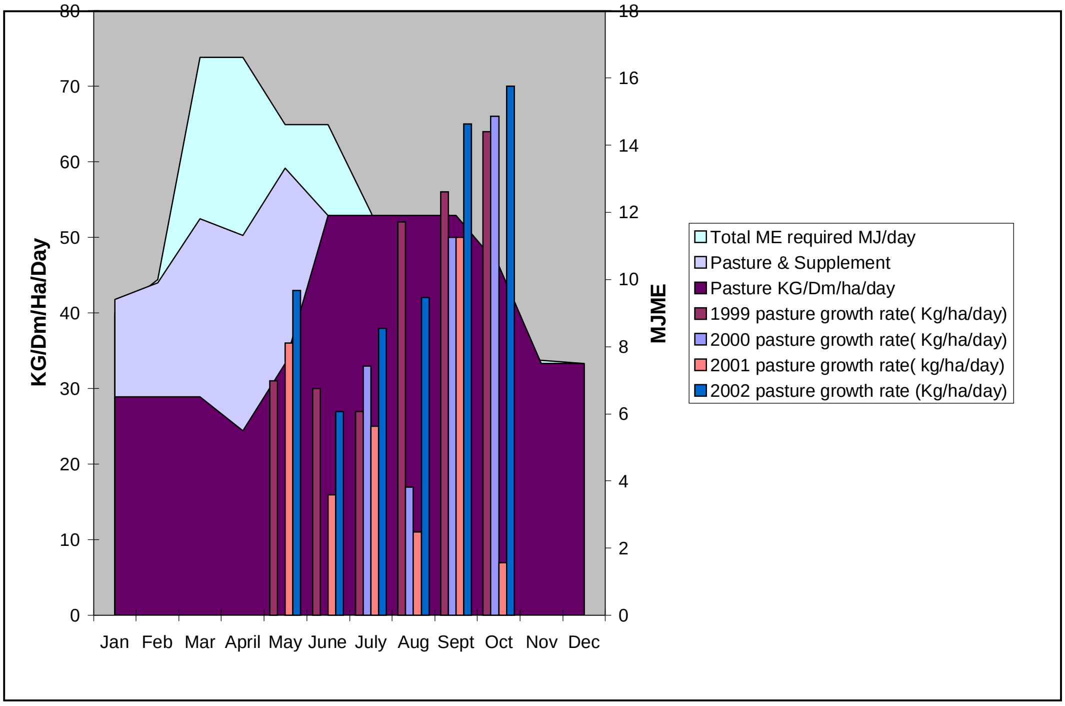

Figure 6. Ewe requirements for energy, lambing in March/April and pasture growth rates for the Arthur River shire (kg/Dm/ha/day) from 1999 to 2002.

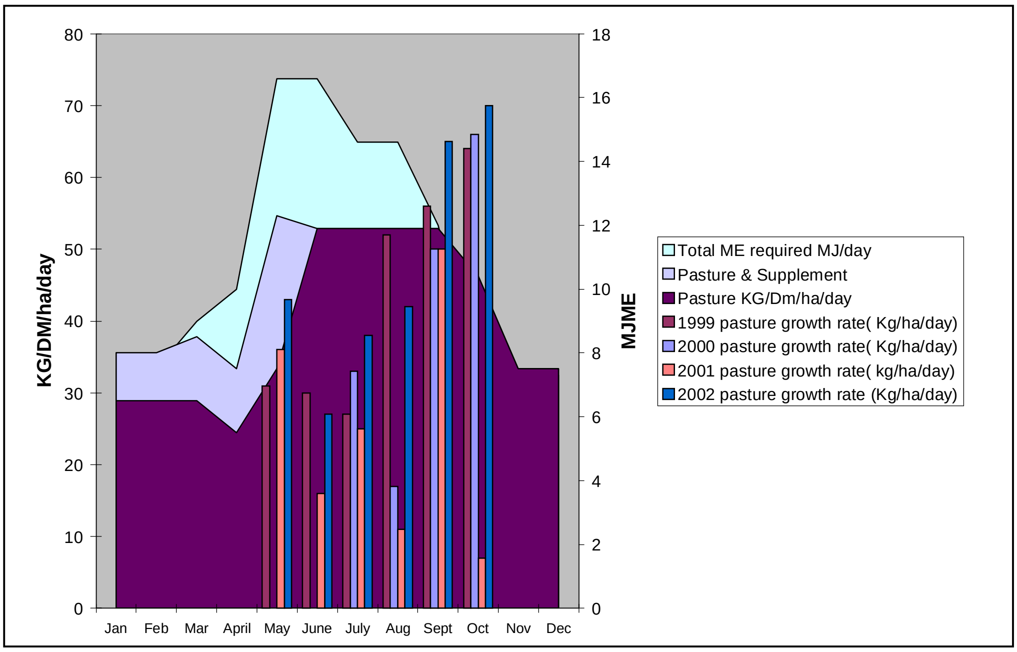

Figure 7. Ewe requirements for energy, June/July lambing and pasture growth rates (kg/DM/ha/day) at Arthur River (1999–2002).

Supplementary feed

The following rations were used for supplementary feed for ewes:

Table 3. Rations for ewes (g/hd/day)

	Oats g/hd/day	**Lupins g/hd/day**	**Oats g/hd/day High**	**Lupins g/hd/day High**
Pre pregnancy	150		150	
Pregnancy	200	100	200	100
Lambing	250	200	250	300
Lactation	250	200	450	300
Mating ewes		750/one week only		
Rams (before mating)		200 x 8 weeks		

The two columns on the right outline the ration used for sensitivity analysis (see Table 8).

Lamb growth rates and finishing lambs

Table 4. Assumptions for finishing lambs

Lupin stubble	**(8 weaners/ha)**	**@ 30 cents/hd/week**	
Date	**Liveweight**	**Feeding system**	**Expected daily weight gain* (g/hd/day)**
15 October weaning	30 kg	Pasture senescing	20
15 November	30.62 kg	Lupin stubble	160
1 January	38 kg	Lupins and stubble 0.15 kg/hd/day	160
17 January	40 kg		
Lot feeding			
0.24 cents/kg x 5.5 conversion ratio x 10 kg required growth Labour 16 hours/ week x 5 weeks			300
Forage crop (15 weaners/ha)			
$1.80/hd			160-250

* (Source: Marion Seymour, 2000)

Other considerations

Other assumptions include:

- Lambing percentage of maiden ewes is held constant at 65 per cent.
- Ewe hoggets are culled at a minimum of 10 per cent when purchasing replacements is required.
- The wool price is $5/kg greasy net ‘sweep the board’. This is held constant except for some sensitivity analysis in the Merino only GM. The cross bred wool was sold for $1/kg.
- In the Eastern Wheatbelt farms crop > 65 per cent of their farm (Bank West Benchmarks 2001/2002). Therefore it is assumed no super is applied to pasture.
- As the number of ewes mated to terminal sires increases the stocking rate decreases by 1 DSE/ha to allow for the extra prime lambs to finish. At 100 per cent prime lamb production more ewes can be run due to not having ewe hoggets and therefore more lambs are turned off.
- The liveweight of the ewes was estimated to range from 49 kg to 58 kg during the year in the Great Southern and in the Eastern Wheat belt from 50 kg to 60 kg. Ewes were at their heaviest going into the summer to allow for some decline of condition.

- All wether hoggets are sold as shippers for $45/hd, the average price over the last three years.
- A labour component was included for prime lamb production to account for the weighing of animals. The cost was three half days at $20/hour for five hours.

RESULTS

Time of lambing and the proportion of ewes mated to terminal sires are the key drivers to the profitability of a self replacing merino flock using terminal sires. Cost of replacements and lambing percentages are the next key drivers and then other influences such as prices received for products and costs of inputs such as grain.

Great Southern

Figure 8 shows the most profitable farming system was producing 100 per cent prime lambs. The least profitable is the common scenario of a self replacing ewe flock, using only using a small proportion of ewes, 18 per cent in this case. This latter scenario was less profitable because of the extra feeding requirements and costs associated with the enterprise; there are more ewe hoggets to maintain and less income.

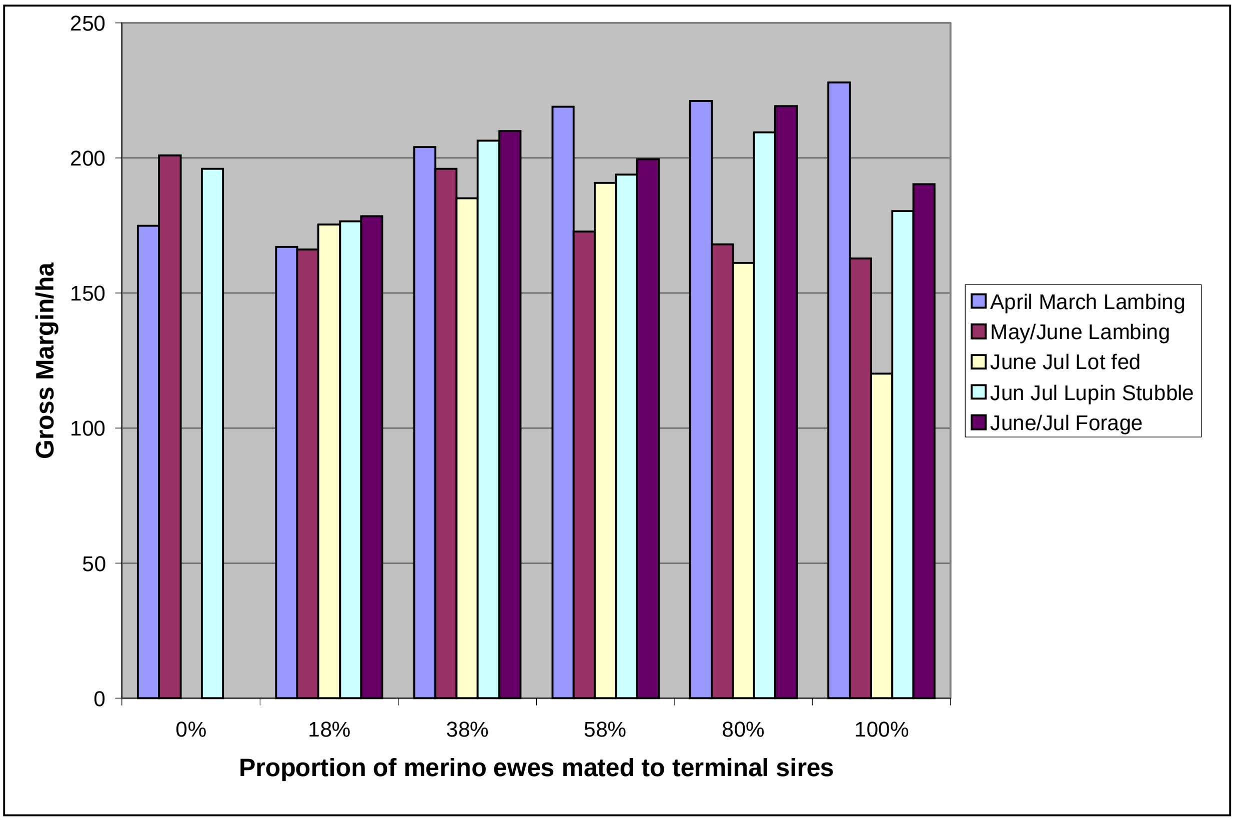

Figure 8. Great Southern gross margins.

Table 5. Assumptions for gross margins in Figure 8.

Assumptions	
Replacement cost of ewe hoggets	$60
Lamb prices	Refer to Table 1
Lambing %	80%
Lupins Oats	$240 $160

The wool only flock compared well to the terminal sire production and was more profitable than the 18 per cent ewe flock. The Merinos were less profitable when lambing in March/April as there was no premium for supplying more supplements to the ewes unlike in the cross bred system. Hence the 18 per cent group has a lower GM when lambing in March/April.

Sensitivity analysis

Table 6. Gross margins ($/ha) when lambing percentage is 70%.

Time of lambing	18%	38%	58%	80%	100%
April/March	$147	$170	$181	$181	$181
May/June	$147	$176	$153	$150	$142
June/July lot fed	$148	$171	$176	$138	$104
June/July lupin stubble	$156	$187	$175	$189	$158

When the lambing is 70 per cent profitability of the enterprise is reduced and more replacements in all the groups need to be purchased, and there are fewer sheep to sell. Lambing percentage is a key driver of profit.

Table 7. Gross margins ($/ha) when the price of lupins is $300/tonne and oats are $220/tonne

Time of lambing	18%	38%	58%	80%	100%
April/March	$149	$167	$191	$194	$196
May/June	$153	$183	$161	$157	$152
June/July lot fed	$156	$175	$182	$146	$112
June/July lupin stubble	$166	$196	$184	$201	$172

The increase in the price of grain does not have as much impact on the GMs compared to the lower lambing percentage. Increasing the supplementary ration to the ewes is demonstrated in the following table.

Table 8. Gross margin ($/ha) for a high ration of supplement (other assumptions as in Table 5)

Time of lambing	18%	38%	58%	80%	100%
April/March	$130	$177	$195	$204	$218

See Table 3 for the ration provided. The GM/ha reduces by $10/ha.

Table 9. Gross margin ($/ha) when ewe replacements are $30/hd

Time of lambing	18%	38%	58%	80%	100%
April/March	$168	$198	$226	$220	$267
May/June	$166	$193	$189	$196	$203
June/July lot fed	$176	$185	$191	$161	$161
June/July lupin stubble	$177	$203	$194	$238	$221
June/July forage	$178	$207	$200	$219	$231

The average price of ewe hoggets for the last three years is $30/head which is similar to ewes. A prime lamb producer relies on purchasing replacements after mating more than 34 per cent of his ewes to terminal sires. This allows ewe hoggets to be culled at 10 per cent. If the costs of replacements go higher than current prices then this will have a negative effect on the profitability of the enterprise. At $120/hd they become less profitable than the 18 per cent group.

Eastern wheatbelt

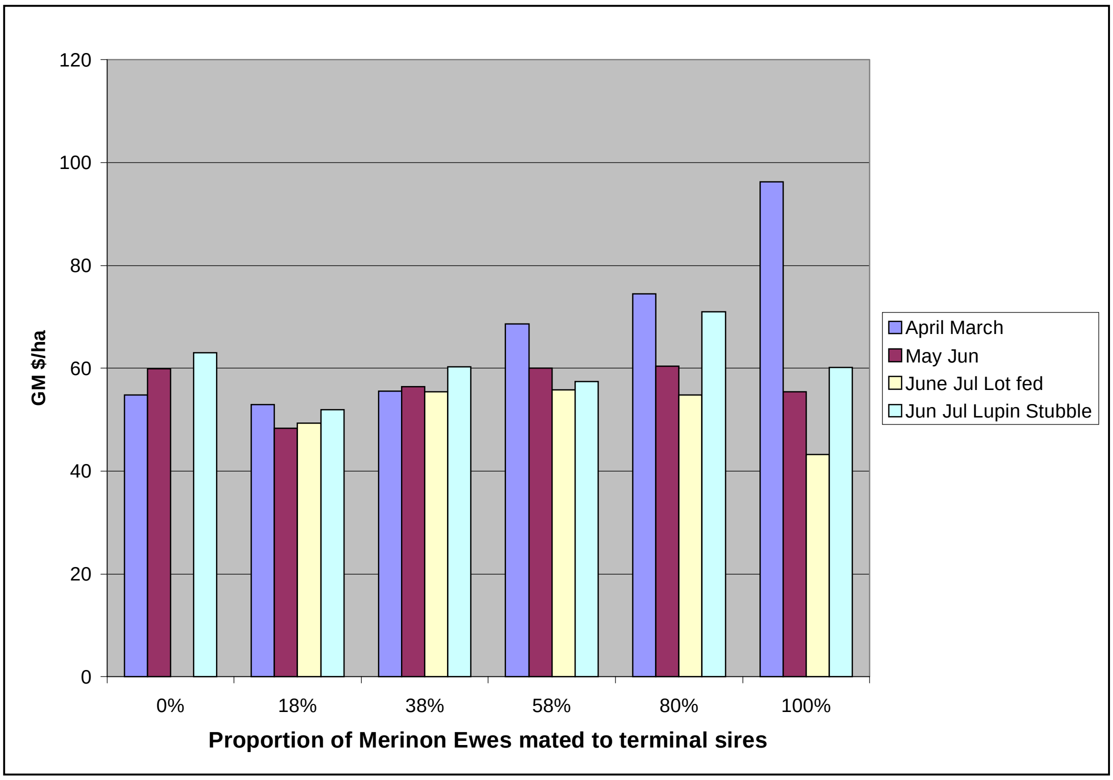

Figure 9. Eastern wheatbelt gross margins.

Table 10. Assumptions for gross margins in Figure 9

Assumptions	
Replacement cost of ewe hoggets	$60
Lamb prices	Refer to Table 1
Lambing %	70%
Lupins Oats	$240 $160

The most profitable system is lambing in March/April producing 100 per cent prime lambs. As mentioned above this is due to the premium paid for the out-of-season lambs and, if compared to wool only production, the late lambing is more profitable as it utilises pasture and is not reliant on supplements.

Sensitivity analysis

Table 11. Gross margins $/ha with lambing at 60 per cent

Time of lambing	18%	38%	58%	80%	100%
April/March	$41	$50	$57	$64	$64
May/June	$43	$50	$50	$53	$47
June/July lot fed	$43	$50	$50	$48	$37
June/July lupin stubble	$45	$54	$51	$62	$51

Table 11 demonstrates the effect of a low lambing percentage on the GM. Increased replacements have to be bought in and fewer lambs are sold.

The other issues already discussed for the Great Southern have a similar impact on the Eastern Wheatbelt GMs.

Wool price sensitivity analysis

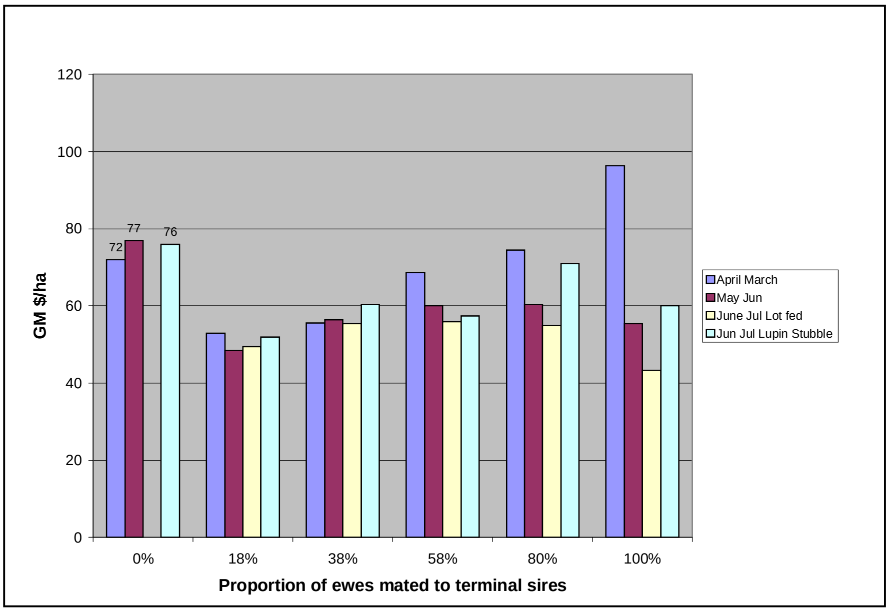

Figure 10. Effect of wool price has on GM.

Table 12. Assumptions for GMs in Figure 10

Assumptions	
Replacement cost of ewe hoggets	$60
Lamb prices	Refer to Table 1
Lambing %	70%
Lupins Oats	$240 $160
Wool price (net greasy sweep the board @65%)	$6

Figure 10 demonstrates how an increase in the price of wool affects GM's by making wool production profitability almost match the profitability of using terminal sires in a self replacing merino flock.

CONCLUSION

Sheep are a complex enterprise to analyse with a large number of variables affecting profit. Nutrition of sheep is one of the key production issues that drive profits. The number of lambs born, weaned and finished are key profit drivers.

Of the various sheep enterprises analysed, the most profitable was the 100 per cent prime lamb production, lambing in March/April. This enterprise permits more ewes to be carried through the year, due to not having ewe hoggets and therefore producing more lambs. There are however a few risks associated with the system. It assumes lambs will be sold in July, August and September receiving a premium for the product. But late breaks to the season could prolong feeding, increasing costs and reducing growth rates. It relies on the availability of purchasing ewe hoggets. Yet if more farmers use terminal sires then there will be a reduction in merino ewes and hoggets available to purchase which will put upward pressure on prices.

The critical profit drivers for the production of prime lambs using merino ewes in a self-replacing flock are:

- Time of lambing. Decide what product you are aiming for and then plan the time of lambing to utilise pasture as much as possible. Yet be aware of premiums paid for out-of-season lambs, as increases in these premiums could justify a change in lambing time.
- Lambing percentage. Do not consider using terminal sires unless lambing percentage is above 70 per cent. Purchasing ewe replacements reduces profit.

- Cost of replacements. Be aware of the break-even price of replacements. If they cost too much, then a traditional self replacing merino flock may be more profitable.
- Time is a cost. Weighing cross breds takes time.

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Paper reviewed by: Ross Kingwell

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Sheep Updates 2003

Is the mating of ewe weaners an option for increasing the numbers of lambs in WA?

Rob Davidson[1] and **Keith Croker**[2]

[1]University of WA, Crawley
[2]Department of Agriculture, South Perth

KEY MESSAGES

Providing ewe weaners are at least 9 to 10 months of age, weigh at least 38 kg, are on a rising plane of nutrition and in good health when rams are joined with them, then reasonable lambing performances can be expected.

INTRODUCTION

The rapid development of sections of Western Australia's agricultural zone during the 1960s significantly increased the need to boost the State's sheep population. Investigations then showed that mating ewes 12 months earlier than was the usual practice, was a way to increase sheep numbers. However, this strategy was not widely used by farmers.

Currently in Western Australia, there is once again the need to increase sheep numbers to re-build the wool production potential and to provide more prime lambs to meet the increased demand from both the domestic and international markets. Hence, mating of ewe weaners may provide an option for some farmers to increase their sheep numbers, but is it cost effective?

REVIEW

Initial research in the late 1960s and early 1970s examined the cost to ewes of bearing and raising lambs early in their life to see if it affected their long term productivity in terms of future fertility, wool production and mature body size. Most of the experiments then involved Border Leicester x Merino or Merino ewes.

Ewes mated at 7 to 8 months of age recorded 19 to 32 per cent lambing whilst producing between 0 to 7 per cent less greasy wool [1] [2]. Ewes mated slightly later (i.e. 10 to 12 months of age) recorded up to 71 per cent lambing and up to 9 per cent decrease in wool production [2] [3]. However, in all these trials the ewe weaners that lambed produced similar lambing percentages and kilograms of greasy wool over the next four seasons when compared with their contemporaries mated for the first time between 19 to 21 months of age.

More recently, results from the Maternal Central Progeny Test program conducted in New South Wales, Victoria and South Australia indicate that cross bred ewe weaners mated at 7 to 8 months of age have recorded lambing percentages of 20 to 100 per cent. The better performing breeds have been Border Leicester, East Friesian and Finn first cross ewes [4]. The Beacon Prime Lamb Group illustrated the potential of both the Finn and Booroola Leicester first cross ewes where by at 12 months of age the ewes had marked over 80 per cent lambs and inside two years had marked approximately 230 per cent lambs [5]. Investigations in Victoria with prime lamb producers have also shown the breeding from ewe weaners has the potential to increase the profitability of the enterprise [6] [7].

This year more evidence has been obtained that shows that under some situations there is a potential to join terminal sires with Merino ewe weaners. On a farm at Highbury (25 km South of Narrogin), 400 of the visually larger weaners were selected from a flock of about 1300 following shearing in February. The 9 to 10 month old weaners with an average liveweight of 40.4 kg and 1.8 body condition were teased for 14 days with testosterone prime wethers before White Suffolk rams (at 3.75 per cent) were joined with them for six weeks from early in March.

The weaners were pregnancy scanned at the end of May to determine the number of fetuses present. 83 5 per cent of the ewes were pregnant with the potential lambing percentage being 88.9 per cent . The ultimate marking percentage obtained from this flock will indicate the success of the joining.

Table 1. The number of ewe weaners per pregnancy classification and associated liveweights and body condition scores at pregnancy scanning (29 May 2003)

Pregnancy status	Number	Weight (kg)	Body condition
Dry	64 (16.4%)	39.4	1.8
Single	304 (78.2%)	41.5	1.8
Twin	21 (5.4%)	41.9	1.9

Another example of a successful early mating was on a commercial property at Normans Lake where 50 per cent of 8 to 9 month old Merino weaners weighing more than 35 kg and mated to Poll Dorset rams were pregnant (Cameron White, personal communication).

CONCLUSIONS

It appears that Merino ewes may take longer to reach puberty than other breeds. Therefore, although liveweight of the weaner is important, their age is probably of more significance. Considering all the published literature and our current results, we conclude that Merino ewe weaners should be 9 to 10 months of age and weigh more than 38 kg when joined with entire rams.

A successful strategy for mating ewe weaners will probably include an early weaning of their lambs so that the ewes can then be prepared for joining at the usual time as 2-tooth ewes. The weaning at an early age will necessitate the use of management options (such as feed lots, perennial pastures, standing fodder crops or the use of creep feeding) to deal with the young lambs.

We cannot conclude from the limited study at Highbury whether the teasing of the ewe weaners before mating was responsible for the very high fertility measured at the pregnancy scanning.

Finally, sire selection, especially if using terminal sires, is vital to minimise birthing problems and to allow unsupervised lambing and it is of upmost importance to maintain good nutrition of the pregnant ewe weaners/hoggets - for their own growth, milk production and mothering abilities.

KEY WORDS

ewes, weaners, lambs, age, weight

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Dehydration of lambs at the time of slaughter

Robin Jacob, School of Veterinary and Biomedical Sciences, Murdoch University

KEY MESSAGES

The Sheep Cooperative Research Centre (CRC) and Meat and Livestock Australia (MLA) are funding research to find ways to prevent dehydration in lambs prior to slaughter.

INTRODUCTION

If lambs become dehydrated during the farm curfew, transport and lairage periods, then carcass weight and condition score may be lower, and the meat darker in colour than expected [1, 2].

AIMS

There are three components to this dehydration work:

- Development of a method to measure dehydration in lambs (experiment 1).
- Characterisation of the seasonal incidence of dehydration in commercial consignments of lambs at the time of slaughter (experiment 2).
- Evaluation of strategies that can prevent dehydration during the farm curfew, transport and lairage periods (experiment 3).

Experiment 1 has been completed and experiments 2 and 3 are in progress.

METHODS

In experiment 1, lambs were fasted for 48 hours and subjected to one of the following four treatments prior to slaughter:

1. Access to water and normal ambient air temperature (max 25°C, min 15°C).
2. Access to water and raised ambient air temperature (max 38°C, min 25°C).
3. No access to water and normal ambient temperature (max 25°C, min 15°C); and
4. No access to water and raised ambient air temperature (max 38°C, min 25°C).

This experiment was replicated 4 times with n = 6.

RESULTS

It was found in experiment 1 that the level of dehydration induced by water deprivation depended on ambient air temperature. Water deprivation caused a significant reduction in muscle weight, muscle dry matter percentage, muscle luminescence (more dark in colour) cook loss and drip loss, but only when ambient air temperature was high. Dehydration in lambs under commercial conditions may therefore have a seasonal incidence

Water deprivation caused significant changes in serum electrolyte concentration and urine concentrations that were also dependent on ambient air temperature (Figure 1).

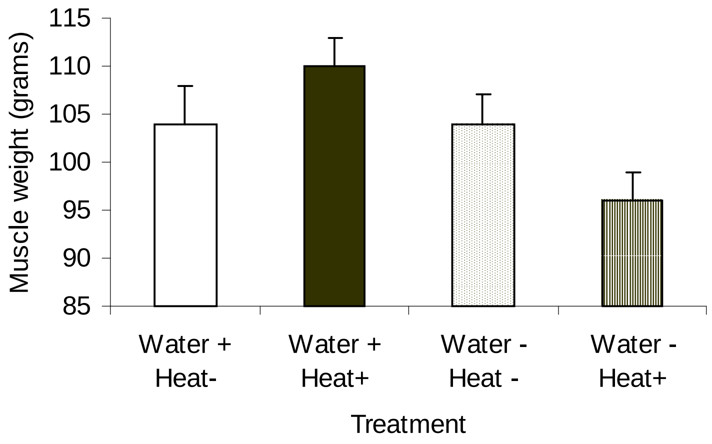

Figure 1. The effect of treatment on the weight of the m. semimembranosus (values are means ± sem).

CONCLUSIONS

The extent to which water deprivation caused dehydration in lambs depended on the ambient air temperature. A number of urine and serum parameters can be used to quantify the dehydration status of lambs at the time of slaughter and to predict the subsequent hydration status of meat derived from the lambs. Improvements in the hydration status of lambs at slaughter are likely to increase the weight of meat produced from each lamb.

KEY WORDS

lambs, dehydration, meat

ACKNOWLEDGMENTS

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Paper reviewed by; James Skerritt, Department of Agriculture, Narrogin

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Sheep Updates 2003

Feeding prime lambs for slaughter

Rachel Kirby, Outback Solutions

KEY MESSAGES

Producers must match the nutrients in feed to the lamb's requirements in order to optimise overall performance. Production targets must be set and lamb growth performance monitored to ensure adequate nutrition is provided to achieve the desired outcomes. Feed conversion efficiency, ration cost and the genetic growth potential of the lamb will determine the profitability of feeding prime lambs in a confined area.

INTRODUCTION

Today's consumer demands a consistent supply of large, lean lambs that provide a pleasant eating experience. Supplying larger carcases means that lambs are retained on farm for longer and producers often utilise finishing systems that are independent of pasture availability. This paper will discuss some of the factors to consider when developing an appropriate feeding strategy for feeding the weaned prime lamb for slaughter.

REVIEW

Efficient and profitable lamb finishing is achieved by supplying inexpensive on-farm feed resources along with supplementary grain (if needed) to meet their nutrient requirements and hence allow the lamb to grow to its genetic potential. There are four key steps to achieving that goal: assess what the feed base is providing, understand the nutrients required by the lamb, determine whether the supply of any nutrient is limiting production and to provide those nutrients to complement the feed base.

Assess feed base and understand the nutrient requirements of lambs

There are many different feedstuffs suitable for lamb production and these should be assessed for how well they match the requirements of the lambs being fed. The crude protein (CP %) and metabolisable energy (MJ ME/kg DM) of feedstuffs can vary markedly due to season and crop nutrition so it is advisable to regularly analyse feed to accurately assess the nutrient content (Table 1).

Table 1. Metabolisable energy and crude protein values for feedstuffs on an as fed basis [1]

Feed	ME (MJ/kg DM)	CP (%)
Cereal stubble	6.0- 7.5	4.0- 6.5
Lupin stubble	5.5- 9.5	6.0-10.0
Cereal grain	10.4-13.3	7.5-15.0
Lupin seed	13.1-14.1	27.0-42.0
Cereal hay	8.0-10.2	4.0-12.5
Pasture hay	8.0-11.2	8.0-23.0

The lamb requires energy, protein, vitamins and minerals. Energy is necessary to maintain body temperature, drive essential body processes, fuel physical activity and promote growth. To meet both the 'maintenance' and 'production' energy requirements of a weaned prime lamb, a high intake of a diet that contains 10.5-12.0 MJ ME/kg DM is necessary. Younger, growing animals have a higher protein requirement than more mature animals hence a finishing diet for weaned prime lambs should contain between 14.0-16.0 per cent crude protein. Whilst essential minerals and vitamins generally occur in sufficient quantities in green feed, some supplements may be necessary when the feed 'hays off'. Production targets (i.e. desired carcase weight and time of marketing) will influence the nutrient requirements and feeding strategies used.

Is the supply of nutrients limiting production?

In general, paddock feed is the cheapest feed available so the use of this resource should be maximised. If the supply of nutrients from the paddock and the demand of nutrients by the lamb don't match, then a supplement can be fed to provide the missing nutrients (complementary feeding). This rationale can be applied to paddock feed at different times of the year. For example:

- Mature pasture - As the paddock feed matures or is damaged by weather, the CP% and ME decline and minerals are leached. Supplementing weaned prime lambs grazing mature annual pastures with a legume grain such as lupins is appropriate as the lupins contain high levels of rumen degradable protein and energy. Cereal grains may also be an appropriate supplement for some pastures, but may not contain adequate protein to complement a mature grass pasture.
- Stubbles - The main nutritive value in lupin and cereal stubbles is from the spilt grain. Only moderate lamb growth rates can be achieved over the first three weeks of grazing before the stubble requires a legume based supplement [1]. Legume seeds are a good source of protein and energy but are low in minerals such as calcium, sodium and sulfur. Cereal grains are a good source of energy but are lower in protein than legumes and are also deficient in calcium and sodium. Mineral deficiencies can be corrected by feeding lime, salt and gypsum or a balanced mineral mix.
- Break-of-season - Although green pasture contains adequate protein and energy slow growth and low dry matter can limit the intake of nutrients by lambs. It may be necessary to complement with cereal grain to achieve high growth rates if feed on offer is less than 1800 kg DM/ha [1].

Regular weighing and condition scoring of lambs to monitor performance is an important tool that is used to assess the nutrient value of paddock feed. Lambs should be moved to a new paddock if they fail to maintain the desired growth rate or if inadequate ground cover exposes the paddock to erosion. The lamb expends energy to harvest feed from the paddock and in some situations the quality or quantity of paddock feed may not be adequate to compensate for energy used for grazing. If there is not sufficient paddock feed to finish lambs it will be more efficient to confine them.

Confinement feeding systems

The choice of feeding system will be influenced by production targets. Supplementation of dry summer paddock feed may be sufficient if the aim is to grow lambs at a moderate growth rate over a period of time, e.g. 100-150 g/day, but if the aim is to maximise growth rate to finish lambs, e.g. > 250 g/day, it may be necessary to feed a complete ration in a confinement feeding system.

The three most common feeding systems are total mixed ration, complete pelleted diets or loose mixed diets. Total mixed rations give the producer control over ration formulation and cheap byproduct ingredients can be included. Total mixed rations are an efficient way to offer a balanced ration but require specialised mixing equipment so are not well suited to small operations. Commercial pelleted diets are a convenient way to supply a balanced diet and are suitable for use in self-feeders. An *ad libitum* choice of grain mix and hay is the most common system of confined feeding (CRC survey, unpublished data). It is simple and inexpensive but wastage is higher than with a pelleted diet. Loose grain mix systems are less efficient, require a slow introductory period and can lead to variable growth because there is no control over the proportions of hay and grain consumed.

The profitability of confined feeding is directly related to the amount of feed that it takes to produce liveweight gain, i.e. feed conversion efficiency. There is a cost associated with bringing nutrients to a central area, rather than allowing the lambs to graze and harvest the nutrients from the paddock so feed conversion efficiency becomes more important during confinement feeding. Feed conversion efficiency is maximised by feeding a balanced ration that matches nutrient supply and nutrient requirements for growth. A total balanced ration can be formulated by using the same principles applied to determine supplementary feeding strategies.

Finishing systems that exist today utilise a range of on-farm feed resources and there is an increased emphasis on the use of grain, either for supplementation of dry standing feed or feeding in confinement areas. In the future, grain feeding is likely to become even more predominant as producers strive to meet target market specifications for lucrative export markets.

KEY WORDS

confinement feeding, feedlotting, grain, nutrition

Paper reviewed by: Rob Davidson, Faculty of Natural and Agricultural Sciences, UWA

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Live sheep export R&D

Steve Meerwald, Wellard Rural Exports

KEY MESSAGES

A recently completed report compiled by the Department of Agriculture, states that some 3.35 million sheep were exported from Western Australia to the Middle East and South East Asia during 2002. The total death rate of sheep exported from Fremantle for 2002 was 0.88%. This is down from the 2000 and 2001 levels of 1.23 per cent and 0.96 per cent respectively. The main cause of death for sheep exported from Fremantle is inanition, i.e. failure to eat [2].

The introduction of heat stress risk management to all shipments of live sheep and cattle to the Middle East will minimise mortality and stress to sheep being shipped during the northern hemisphere's summer. Exporters will use software named 'HotStuff' (developed through the Joint R&D Program) that incorporates climate, ship and animal heat stress threshold data to allow the calculation of voyage risk during the planning phase of a shipment.

Concurrently, research has been undertaken on sheep vessels following similar work on cattle ships, to determine the critical elements of efficiently ventilating sheep and goats on long haul voyages to the Middle East. The greatest heat stress risk to sheep occurs on open decks with limited mechanical ventilation where the ship is stationary while at the port of discharge. The results from this project have assisted the development of the heat stress risk management model, 'HotStuff'.

Also very much related to both these projects, is continuing work at Murdoch University in climate chambers where both sheep and cattle have undergone simulated voyage environmental conditions experienced while travelling to the Middle East during the northern hemisphere summer. This work is focussing on the potential use of electrolytes to minimise the detrimental effects of heat stress and the determination of heat stress thresholds in sheep and cattle. The physiological results to date indicate that sheep cope relatively better with heat stress than *Bos taurus* cattle and intervention with electrolytes is not likely to have significant benefits to the animal.

AIMS

Sheep research being funded by the joint LiveCorp/MLA livestock export R&D program is targeted at reducing mortalities and morbidity at the assembly feedlot and on ship. The principal risk factors for sheep during export are failure to eat, the farm group of animals, age, season of the year, fatness and heat stress. Failure to eat and salmonellosis account for about 75 per cent of all deaths on ship [2]. Work has recently been completed at Portland, Victoria to manage the risk of inanition and salmonellosis. This is likely to continue with more emphasis on the causal factors on farm, on transport and in the feedlot.

This paper will focus on the results of the development of the heat stress risk management model 'HotStuff'.

METHOD

The heat stress risk management project was lead by an engineering firm with extensive experience in road tunnel and underground mine ventilation. The same company previously undertook the ventilation investigative work on cattle and sheep vessels. The project team included a veterinary epidemiologist, a biometrician, a meteorologist, a software programmer and a computational fluid dynamic analyst.

The software links known animal physiology data, climate data and ship specifications. Data in the literature and that obtained from other funded research allowed the definition of a heat stress threshold and mortality limit for sheep and cattle of different breeds, condition score, hair length, acclimatisation, etc. This data is the least precise of all the inputs and efforts are continuing via climate room research and shipboard monitoring to be more accurate with the mortality limit for different classes of sheep and cattle. The climate data was sourced from international sources so that the voyage routes from Australia to overseas ports of destination could be divided into numerous grids. Climate data for areas of Australia created six distinct climatic zones. The key climate variables in the model are wet bulb temperature (as a comfort index) and air movements while in port; the later being critical for open ship decks.

Ship specifications have been obtained from all ship owners operating vessels to the Middle East. The important ship variable is pen air turnover, which is the deck air supply divided by the available pen space. Computational fluid dynamics were used to model the movement of thermals on open decks where it was not possible to calculate wet bulb temperature rises as on closed decks.

RESULTS

The risk estimate software 'HotStuff' is able to automate the calculation process involving table look-ups and repetitive calculations for many combinations of input variables.

CONCLUSION

For closed decks, it is recommend that planned voyages do not proceed if the risk of heat stress related mortality as assessed using 'HotStuff' is higher than predetermined levels. The current limit is a voyage shall not proceed if the risk of mortality exceeding 5 per cent exceeds a 2 per cent probability. It should be noted that this model is only dealing with heat stress and no other causes of mortality.

For open decks, is it recommended that new ships should be ventilated and assessed as for closed decks. Existing ships with mechanical pen air turnover on open decks of less than 150 m/hr should undertake engineering investigations to identify all reasonably practical measures for improving pen air turnover. Open decks not assessed as for closed decks shall be operated according to protocols designed to minimise still air risks. These operational guidelines include not proceeding into port (in extreme ambient conditions) if it seems plausible that the crosswind will fall below critical values (around 2 knots).

Although the model has economic impacts for some ship owners, the model has been well received by the regulatory bodies and industry with the understanding that the model will continue to evolve to a point where its level of confidence will be extremely high.

KEY WORDS

inanition, heat stress threshold, risk management, mortality limit

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Paper reviewed by: Steve Banney, Consultant to Meat and Livestock Australia

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Confinement feeding sheep in Western Australia

John Milton, The University of Western Australia

KEY MESSAGES

Confinement feeding of sheep is a management strategy that can allow sheep and cropping to co-exist effectively as the systems complement one another. With the nutritional management afforded by feeding sheep in confinement producers can implement strategies that will allow them to increase production of quality wool and sheepmeats. The synergies created by integrating sheep with cropping should provide a more profitable, versatile and robust farming system that is sustainable.

INTRODUCTION

With the low wool prices of the 1990s and the reasonable returns from grain many WA producers turned away from sheep to cropping. Consequently the WA sheep flock has declined to the lowest in about 50 years. In the last three years the low returns from grain, due to dry conditions, plus some recovery in the wool market combined with exceptional returns from sheepmeats has renewed producer interest in sheep, especially for production of prime lambs. Sheep that are fed in confinement over summer and through the break-of-season until the green feed gets away can be held in a body condition for optimum production of either wool or meat. From a cropping perspective, removing sheep from paddocks at this time avoids damage through either wind erosion or pugging. By feeding sheep in confinement, producers should be able to continue to crop a similar area of the farm while running a viable breeding flock and reduce financial risk by diversifying their sources of income.

REVIEW

'Lock-em up, feed-em and make money' has become an adage of farmers who strategically feed sheep in confinement to gain additional farm income without impacting on the cropping enterprise. Sheep, being selective grazers, spend a lot of time walking to select-out the desirable components from the feed on offer (FOO). The situation is exacerbated when the FOO is limited and contains only a small component of the material the sheep prefer to eat. Excessive walking adds to the sheep's maintenance requirement, so that less of the nutrients consumed are then available to produce meat, wool or milk. We often see this in sheep after a few weeks of continually grazing stubble paddocks in summer. Without supplements the sheep begin to lose body condition and this puts additional stress on them, especially if they are pregnant ewes or growing weaners. Sheep continuously trafficking over stubble paddocks in search of feed, break-up the top soil and leave it exposed to wind erosion, especially the light textured soils of WA. Top soil is the most valuable component of the soil profile and, if lost, represents a major loss of nutrients as well as the soil itself.

After the break-of-season rains, sheep that continuously graze paddocks 'chase the green pick' which can be detrimental to the sheep, the pasture and the soil. The sheep spend a lot of time walking while trying to select-out and harvest enough nutrients to meet their requirements and this walking, in turn, increases their maintenance requirements. The short plant material they consume contains a lot of water, is low in functional fibre and is often high in rumen degradable protein and, because it has a low concentration of plant sugars, may lead to an asynchronous fermentation in the rumen. Considered together these factors do not result in productive sheep, especially if they are pregnant, lactating or growing. The consequences can be even more severe if the sheep become infected with worms through continuously grazing short, green pick. Ewes under stress can build-up a worm burden and pass it onto their lambs by infecting the pastures and this will help to keep the parasite cycle going. The need for these sheep to be drenched to avoid further loss in productivity only detract from our efforts to reduce drench resistant worms. From a plant's perspective, the frequent removal of leaf material through continuous grazed seriously limits subsequent plant growth and ultimately the total amount of plant material produced over the growing season. In addition the continual trafficking by sheep over the wet soil at the break-of-season can lead to compaction and pugging and ultimately structural problems in the soil. To minimise many of these problems and help avoid digestive upsets, sheep should be gradually released from confinement when the green FOO is about 1,000 kg DM.

Management of sheep in confinement

Over the past five years an increasing number of prime lambs and a few older sheep have been lotfed production rations in confinement prior to slaughter. Although not the topic of this presentation, experience with lotfeeding sheep and the unseasonal dry conditions over the past three years has led many producers to feed other classes of sheep in confinement. They have had considerable success with feeding pregnant ewes, ewes with lambs-at-foot and weaners in confinement, but there have been some problems when feeding lambing ewes. Pregnant ewes or weaners are generally fed a limited ration to meet the demands of pregnancy or modest growth while ewes with lambs-at-foot are fed at a level to support good growth of the lambs. With restrictive feeding all sheep must be able to get their fair share of feed when offered as two or three feeds per week so it is essential that there be adequate feed space. Otherwise, ‘shy feeders’ will become a problem. Many different types of feeding systems have been used. The White family from the Nepowie Merino stud have developed a novel single-sided feeding system and they have been most generous to allow many producers to inspect their set-up and to copy the feeding system. If the sheep can have access to both sides of the feed area, the total length of feed space required can be halved. The length of feed space required per sheep depends on the size of the sheep, the length of their wool, the stage of pregnancy and the bulkiness of the feed. Quality water is essential for sheep being fed in confinement and the pen area for about 500 sheep may be two to five square metres per sheep fed.

An array of feedstuffs has been fed, varying from pelleted diets containing grains, some roughage and additives fed in conjunction with cereal hays and straws through to total mixed rations (TMRs). The on-farm TMRs generally contain hays, straws and/or silages along with cereal grains and appropriate mineral and vitamin additives. A number of producers who currently lotfeed prime lambs have purchased mixer wagons to make-up TMRs for their different classes of sheep. Many producers have their rations professionally formulated after analysis of the main ingredients and incorporate all necessary minerals and vitamins in the rations so the diets are nutritionally complete. This is an ethically responsible approach as sheep in confinement have no choice but to eat the ration provided and, apart from affecting performance, abuse of this could become a welfare issue. With the dry seasons of the past few years there has been a lot of grain seconds and screenings available on farms and these have been widely used in confinement rations. There is likely to be greater use of silages in confinement rations in the agricultural areas of WA since more producers are now using silage as a tool to help control herbicide resistant weeds. Chaff cart residues collected to help control herbicide resistant ryegrass are currently being used in TMR rations. However, it is essential that cocky chaff residues be free of ARGT and phomopsin toxins. Confinement feeding gives producers the potential to remove the summer/autumn/early winter feed gap as a constraint to implementing management practices, such as focused feeding, that can lead to increases in production of both quality wool and sheepmeats.

The site where sheep are to be fed in confinement needs to be carefully selected before establishing any facilities. The WA Department of Agriculture is currently providing advice on this and a proposal to quantify concerns about possible problems that may arise from sites where sheep are fed in confinement will soon be put to industry funding bodies. This will allow local authorities to make informed decisions on the siting of confinement lots in future rather than to rely on possible inappropriate data from other intensive industries. A factor that will need to be taken into account in these deliberations is the potential to return mulched excreta from the confinement area back onto cropping paddocks.

CONCLUSION

Confinement feeding of sheep is a management strategy that can allow sheep and cropping to co-exist effectively through complimentary components in both systems. The nutritional management afforded by confinement feeding allows producers to implement strategies to increase production of quality wool and sheepmeats. The synergies created by integrating sheep with cropping should provide a more profitable, versatile and robust farming system that is sustainable.

KEY WORDS

farming system, herbicide resistance, nutritional management, quality wool, sheepmeats

Paper reviewed by: Emeritus Professor David Lindsay, The University of Western Australia

Sheep Updates 2003

Sheepmeat eating quality - affects of animal age, finishing and processing

David Pethick, School of Veterinary and Biomedical Sciences, Murdoch University

KEY MESSAGES

This paper summarises some of the research and development being undertaken as part of the Meat and Livestock Australia's sheepmeat eating quality program.

A system for describing the consumer defined quality of sheep meat has been developed and this relates directly to failure rate.

With the exception of the topside there is a relatively small effect of cut in lamb such that most perform well under grill cooking given optimal processing. The topside, when consumed after roasting as an easy carve leg, also performs well.

Over a broad range of animal age, loin tenderness declines with increasing animal age in a predictable way but liking of flavour, juiciness and overall liking are less affected resulting in acceptable consumer scores even for older sheep (mutton). This is in part driven by the intramuscular fat levels found in older well finished sheep.

Grilled leg muscles of mutton and hogget tend to decline more sharply in consumer acceptance than the loin when compared to lamb.

The definition of lamb could be changed to include lambs with erupted teeth but not in wear with no associated decline in eating quality of the loin.

Finishing (or growing) sheep pre-slaughter is an important component of assuring eating quality as it affects intramuscular fat, muscling and glycogen levels in muscle.

The type of finishing system should be dictated by cost of production and seasonal constraints and not perceived affects on the flavour of sheepmeats.

Processing and product aging is an important determinant of sheepmeat quality.

REVIEW

This paper summarises some of the findings resulting from Meat and Livestock Australia's (MLA) research program that investigates the eating quality of sheepmeats. The research began with an Industry consultation process involving producers, processors, wholesalers, retailers, food service and scientists who developed a series of 'best bet' critical control points that might determine consumer acceptability of sheepmeats (Figure 1).

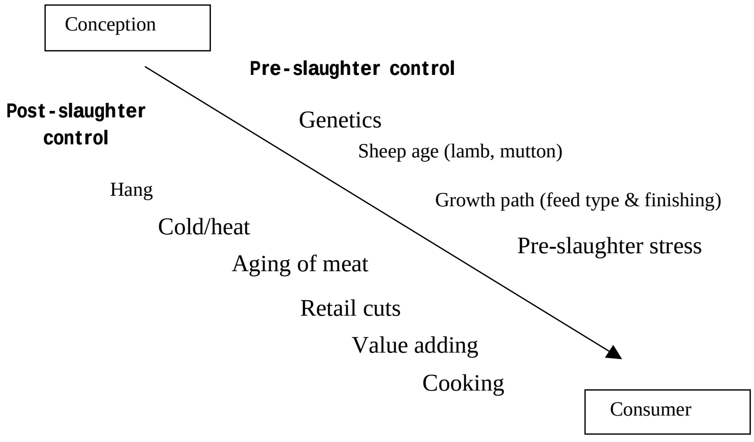


Figure 1. Critical control points for the consumer acceptance of sheepmeat.

After this a range of experiments were designed and undertaken with the overall aim of producing a model which could be used by supply chains to optimise and continuously improve product quality. The paper below focuses on the effects of animal age, finishing system and processing as it effects the eating quality of sheepmeats.

Establishment of sheepmeat eating quality measurement protocols

The ultimate way of measuring consumer perceptions of lamb and sheepmeat eating quality is consumers. Untrained, consumer taste panels are the closest we have to 'the real thing' in terms of assessing the quality of lamb and sheepmeat products. The measurement of eating quality in this program has been based on consumer taste panels very much along the line of MLA's Meat Standards Australia research. The word consumer means people selected from the community with the only requirement that they are between 20-50 years old and eat sheep meat at least once every two weeks. For any muscle/cut 10 consumers will have given their opinion of the eating quality attributes. The attributes scored by the consumers are:

Attribute	**Scale**
Tenderness	0-100 (very tough - very tender)
Liking of flavour	0-100 (dislike - like)
Juiciness	0-100 (very juicy - dry)
Overall liking	0-100 (dislike - like)

After this the consumer is then asked to give an 'overall rating' for the product consumed by ticking one box only, e.g.

- Unsatisfactory
- Good every day
- Better than every day
- Premium.

The consumer scores for tender; juicy etc were then related to the rating (good every day, etc.) and to our surprise most sheep meat fell into the good every day/better than every day categories - this included both lamb and mutton. Given this, one approach is to use the consumer score data to predict the risk of product failure. Thus the higher the consumer score the lower the risk of failure (Figure 2).

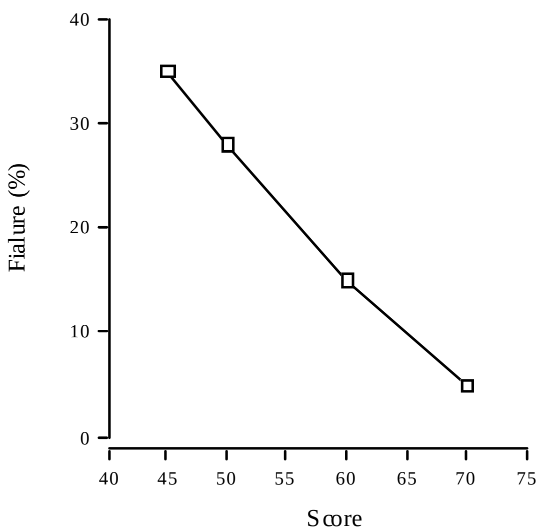


Figure 2. The relationship between consumer score and failure.

Effect of cut

Most of the previous work in sheepmeats has concentrated on understanding the eating quality of the loin since this muscle is both easy to use and prepare, plus it is high in value. However the message from Industry was to investigate other cuts in addition to the loin. The data in Table 1 summarises the average consumer score under a grill protocol for several muscle groups throughout the carcass in lambs, hogget and mutton under optimal processing conditions. There are clear differences due to animal age and muscle. A striking feature for lamb is that it performs well (failure rate about 10%) from the consumer perspective across the carcass with the notable exception of the topside.

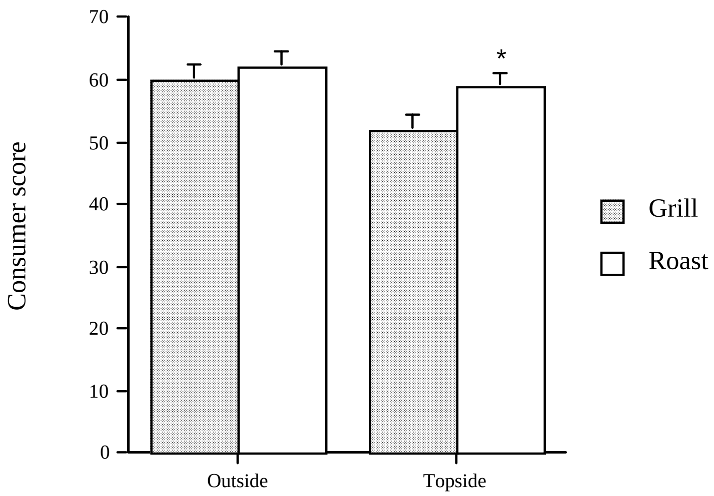
Table 1. Average consumer score (overall liking) for lamb, hogget and mutton muscle groups under a grill protocol and optimal processing. (Values are collated from a 4000 item data base - mean standard error 2.6. Only meat samples undergoing 'optimal processing' scenarios i.e. stimulated + 5 days aging; unstimulated + 10 days aging; Tenderstretch + 5 days ageing)

Muscle	Consumer score		
	Lamb	Hogget	Mutton
Loin	66	61	60
Rump	65	-	56
Outside	60	56	50
Topside	52	-	50
Chuck	68	-	56

Loin = *M. lonsissimus dorsi*, Rump = *M. gluteus medius*, Outside = *M. biceps femoris*, Topside = *M. semimembranosis*, Chuck = *M. serratus ventralis*.

The topside has an improved consumer score after roasting in the form of an easy carve led increasing from the low 50's to around 60 (Figure 3).

Figure 3. The relationship between cooking method and consumer score for grilled versus roasted outside



and topside muscle groups. (Values are the mean of 18 animals. All carcasses received 'optimal processing' = electrical stimulation + 5 days).

Cut x animal age

The other striking feature from the data in Table 1 is the relatively high rating given to the hogget and mutton loin which ranks only some five to six points lower than the average lamb value. Indeed in controlled experiments where similar animals have been compared as older carryover lamb and as hoggets there is little difference between the two. The same cannot be said for the 'leg' cuts in older sheep. Except for the topside, the mutton 'leg' muscle groups eat some 10-12 points lower indicating a significant ($P < 0.05$) cut x animal age effect. Indeed the real value of the current lamb definition is that it assures eating quality of muscles across the carcass.

Animal age - lamb to mutton

In one experiment we examined animal age more closely. Merino ewes spanning carry over lamb (nine months old) to older mutton (five years) were sourced from a commercial farm and placed on a nutritionally balanced feedlot pellet for four weeks on farm. For the loin consumer scores did not decline until after 20 months of animal age (hogget). After this the loin scores significantly ($P < 0.05$) declined in a quadratic manner by 15, eight, seven and eight points for tenderness, juiciness, liking of flavour and overall liking respectively as animal age progressed to five year old mutton (Figure 4).

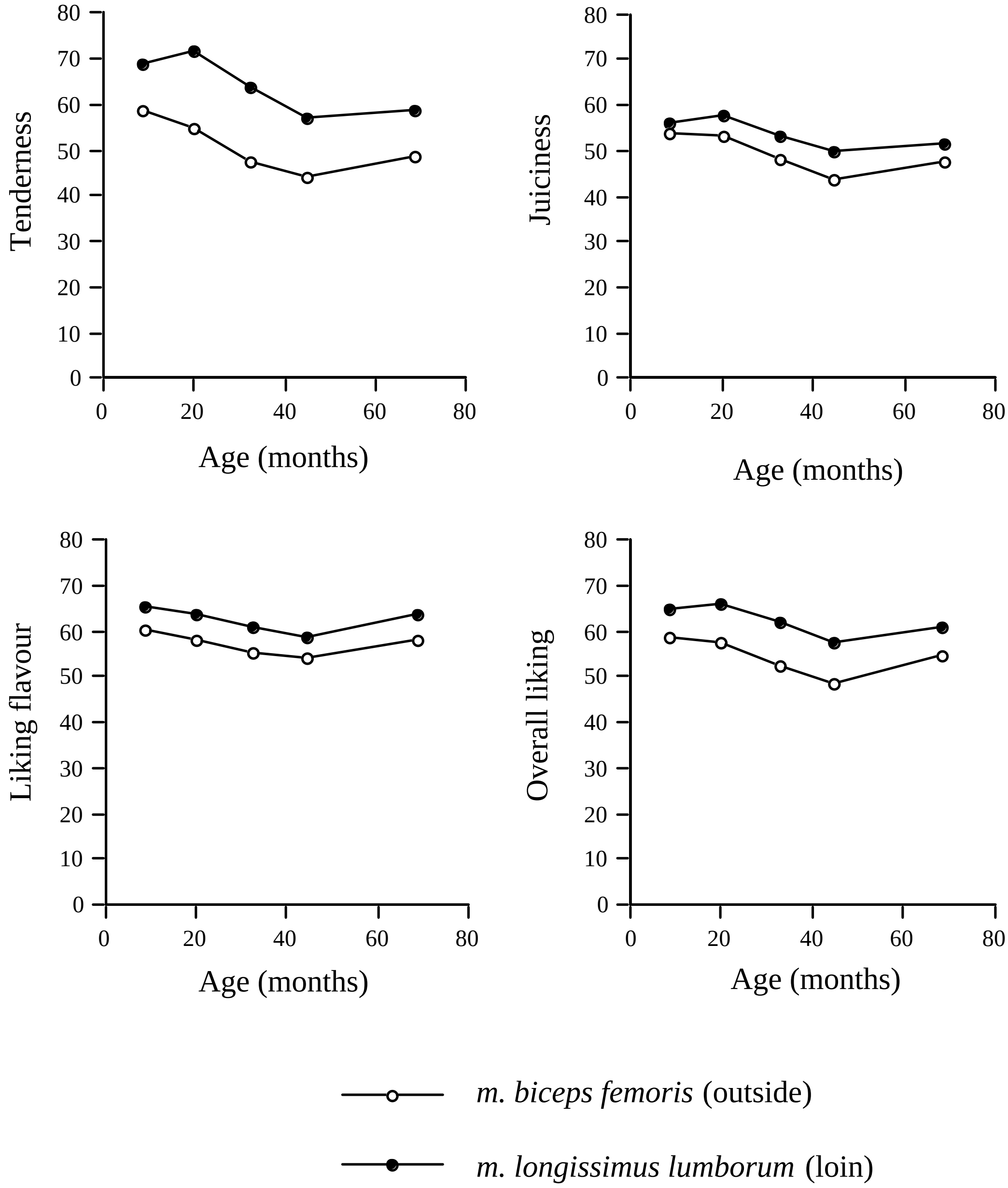


Figure 4. The relationship between animal age and consumer score for grilled loin and outside muscles. (Values are the mean of 18 animals and the average standard error of the mean was 2.1. All carcasses received 'optimal processing' = electrical stimulation + 5 days aging.)

The large effect of animal age on tenderness was expected since it matches the known biological mechanisms which reduce tenderness in older animals (due to changes in the properties of connective tissue). The remaining scores for juiciness, liking of flavour and overall liking declined to a smaller extend and this suggests that any negative aspect of sheep meat flavour associated with animal age must have been less than for tenderness in determining the final consumer rating of the meat. The mechanism behind the relatively smaller decline in the overall liking of mutton might in part reside in the increased levels of intramuscular fat found in the older ewes which peaked at about 9%. In support of this there was the positive correlation between intramuscular fat, animal age and juiciness, liking of flavour and overall liking ($r^2 = 0.08\text{-}0.11$, $P < 0.008$) but not tenderness.

Teeth eruption

An experiment involving three very different commercial flocks (different breed mix, environment, pasture) has been conducted to evaluate the changes in the consumer score of meat derived from sheep over the teeth eruption period when young sheep change from lamb to hogget. The sheep were selected into three dentition classifications: milk teeth (i.e. normal lamb), partially erupted but new teeth close to the gum and fully erupted teeth but not in wear. This period of teeth eruption represented about six weeks in total. All carcasses were electrically stimulated and the product aged for eight days.

The consumer score for the loin derived from sheep over the teeth eruption phase did not vary (in fact there was a small but significant increase). This is not surprising given the above data and the narrow time frame of just six weeks between the milk and fully erupted dentition classes. Importantly fears relating to stress placed on the animals due to the teeth eruption would seem unfounded at least with respect to eating quality. The New Zealand definition of lamb takes advantage of this since the first two teeth can be erupted but not in wear; however there is an important extra constraint that lamb must not be greater than 12 months old.

Finishing system

Our work has shown that finishing system has little effect on eating quality providing sheep are gaining weight before slaughter and that they are finished to a fat score of two. Thus consumers could detect no difference between finishing on an actively growing clover/rye grass sword versus balanced grain (barely, wheat, lupin) based diets. Thus the finishing system should be set by cost of production or seasonal constraints and not bias regarding effects on flavour.

The need to finish sheep pre-slaughter is based on three different premises at least from an eating quality point of view.

(i) Guarantee intramuscular fat levels

Intramuscular fat is an important sensory component of meats affecting flavour and juiciness. The level of intramuscular in the loin of prime lambs finished to a fat score of 2/3 sits at around four to five per cent. This is relatively constant and is even unaffected if terminal sires selected for heavy muscling are used. Work in other species suggests that if the level of intramuscular fat falls below two per cent then the consumer will perceive the meat as dry and less flavoursome. Given this it would appear that prime lambs have adequate levels of intramuscular fat. The factors which affect this level in lambs are thought to be driven by carcass fatness and so long term nutrition is clearly important. However even a short period (two weeks) of severe under nutrition pre-slaughter can dramatically reduce the level of intramuscular fat in lambs.

(ii) To optimise the amount of muscle fibres

Muscle tissue is comprised of relatively soft muscle fibres which are surrounded by a matrix of stronger (tougher) connective tissue fibres which increase in toughness as animals age. Poorly nourished animals which are loosing weight will mobilise muscle fibres to nourish the rest of the body but the connective tissue fibres remain largely unchanged. Thus poorly finished mutton with a low condition score will likely be tougher since they will have relatively more connective tissue and less softer muscle fibres particularly in the 'leg' muscles. Combining this with lower than expected levels of intramuscular fat will reduce the potential eating quality score of the animal.

(iii) To optimise the level of muscle glycogen at slaughter

Glycogen within muscle in the living animal represents a store of sugar which is used particularly during exercise. After slaughter the glycogen is converted to lactic acid and assuming adequate levels of glycogen are available the pH of the meat will finally be reduced to around 5.5. Low pH meat has many associations with high quality including:

- a bright cherry red colour rather than dark;
- more consistent cooking characteristics;
- improved flavour;
- better keeping quality.

Thus it is imperative that there are adequate levels of muscle glycogen in sheep at the point of slaughter. The control of muscle glycogen level is best thought of in terms of a leaky bucket (Figure 5).

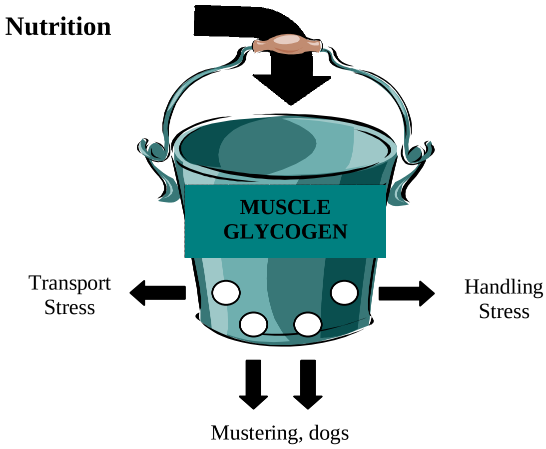


Figure 5. The muscle glycogen bucket.

The muscle glycogen bucket is filled up by good nutrition which means animals gaining weight at ≥ 50 gm/day. Unfortunately the bucket is leaky since stress can cause the loss of glycogen from muscle. Thus optimising glycogen at slaughter is a combination of good pre-slaughter nutrition and reducing stress in the immediate pre-slaughter period. This includes careful mustering and handling in the yards, high standard road transport and good lairage conditions. Our studies suggest the most important commercial factors affecting low glycogen levels pre-slaughter are: (i) pre-slaughter nutrition; and (ii) the increased susceptibility of merino lambs to lower levels of muscle glycogen. We are unclear on the causes for the 'Merino' effect but it is likely related to temperament. However good nutrition and careful handing can readily overcome the merino effect.

Processing

Modern processing requires high throughput and strong chilling of carcases in order to maximise both profitability and carcase hygiene. Indeed this rationale can also apply to the retail sector. Given the desire for strong chilling and minimal product aging it would appear that sheepmeat could be tough due to a combination of cold shortening and minimal time for proteolytic based tenderisation.

One approach to strong chilling and cold shortening is electrical stimulation which was developed by New Zealand many years ago to improve the quality of frozen lamb being shipped to the Northern Hemisphere.

The data for the effects of aging and electrical stimulation across the sheepmeat eating quality data based has been summarised into a processing model shown in Figure 6. There are significant effects of electrical stimulation and meat aging ($P < 0.02$) on consumer scores. Clearly the domestic market has two options for maximising the eating quality of the product offered and these are to electrically stimulate and age the product for three to five days before sale.

One clear positive is that extended product aging assures good eating quality product and shows that cold shortening was not an irreversible process at least under the extremes of chilling tested in this program.

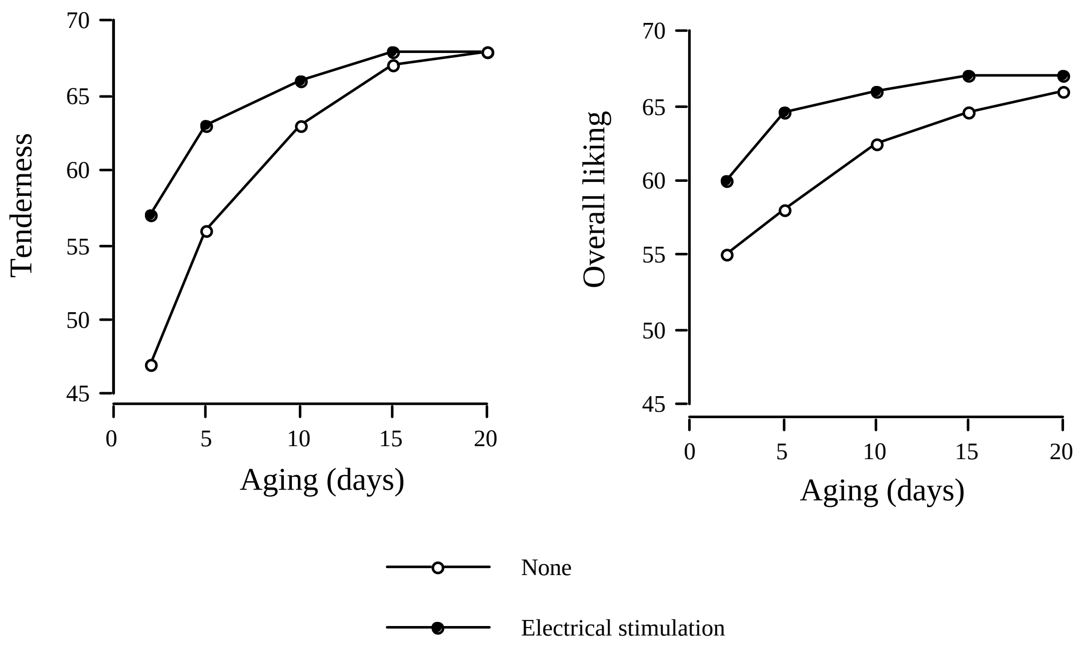


Figure 6. The effect of electrical stimulation and days of meat-ageing on the consumer score of the lamb loin.

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Paper reviewed by: James Skerritt, Department of Agriculture Western Australia

REFERENCES

Thus far the work has been reported as a series of final reports which are available from Meat and Livestock Australia, Walker St, Sydney, NSW.

The experiments will also be published as a special series in the Australian Journal of Experimental Agriculture which is due for publication in early 2004.