WOOL DESK REPORT – FEBRUARY 2009

TIMES OF LAMBING IN AUSTRALIAN FLOCKS – 2005 to 2007

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Summary

Producers throughout Australia were surveyed in 2005, 2006 and 2007 to identify the times when they lambed their ewes. This study was undertaken by the Department of Agriculture and Food, Western Australia for Australian Wool Innovation Limited and the Australian Sheep Industry Cooperative Research Centre.

The start of lambing followed similar patterns in the years surveyed. However, lambing of Merino ewes began last in Tasmania and earliest in South Australia and Western Australia.

Data for Merino first cross ewes were collected in 2007 when Tasmania had the latest lambings and Queensland the earliest lambings.

Combined results for the three years showed large differences in time of lambing across various statistical divisions in some states. For example, in Queensland the start of lambing in the Darling Downs and South West was quite different to the Central West and North West.

The largest variation was between statistical divisions in New South Wales and Victoria with much smaller differences between the divisions in the other states.

A significant result was the observation that lambing begins in June or earlier in many flocks in Australia. This practice is contrary to extension campaigns encouraging producers to lamb their ewes later when pastures are better able to meet the feed requirements of ewes in many parts of Australia.

This suggests that producers should be consulted to determine the significant factors involved in deciding to change the time of lambing.

Introduction

The time of lambing can impact upon the production of ewe flocks. On most farms, selecting the time for joining of rams with ewes and the subsequent lambing five months later involves compromises between numerous factors including:

- major aims of the sheep enterprise, including the date of turn-off of prime lambs
- grazing pressure on the farm
- breeding season of the ewes
- seasonal patterns of rainfall, temperature and pasture growth
- ability to supply extra feed, if required, either as grain or special purpose crops
- interactions between lambing and other farm activities.

Research over a number of years and in different locations and environments shows that the efficiency of ewe flock production can be increased by grazing ewes on growing, green pasture for the last third of pregnancy and during lactation (Croker 1988; Marshall 1970).

In many parts of Australia this means that ewes are mated in late summer and lamb in late winter or early spring, well after the break of the season. Under this management program, there should be plenty of pasture to satisfy the nutritional requirements of ewes in late pregnancy and early lactation. This optimises the chances of lambs surviving after birth. They will have an adequate weight at birth and the ewes should have a good supply of colostrum, and then milk, to sustain the lambs. Subsequently, the availability of plenty of good quality feed should ensure fast growth of the lambs before the pastures senesce.

High lambing percentages can result when ewes with good weight and body condition are mated in late summer. This is discussed for Merinos in Morley (1948), Watson (1953) and Dun et al. (1960).

Lambing in late winter or early spring has been advocated for years in many areas in Australia. Advisers argued that nutritional requirements were better matched and the reproductive efficiency of ewes was increased.

This study set out to determine the level of adoption by Australian producers of the practice of matching the time of lambing to the production of pastures.

Methodology

Surveys of sheep producers in Australia were commissioned by Department of Agriculture and Food, Western Australia on lambing times in 2005, 2006 and 2007. The study was part of an Australian Sheep Industry Cooperative Research Centre project with support from Australian Wool Innovation Limited.

During March 2005 a national phone survey of 1700 producers across Australia was carried out by Market Equity Pty Ltd (Curtis and Croker 2005). Taverner Market Research undertook similar surveys in June 2006 (1120 producers) and March 2007 (1810 producers).

In 2005 the number of producers to be surveyed in selected statistical divisions was determined by the relative proportions of producers in each division, as recorded in the Australian Bureau of Statistics agricultural census conducted in June 2001 (Australian Bureau of Statistics 2001).

In 2006 and 2007, the number of producers to be surveyed in each statistical division was determined by the relative proportions of wool producers in each area according to the Australian Wool Innovation Limited shareholder database. The surveyed statistical divisions (Appendix 1) have 85 per cent of the Australian sheep population. Numbers of producers surveyed in each state in each year and flock sizes are shown in Table 1.

In some cases, responses were incomplete and could not be used; hence, the number of producers in Table 1 differs from the number contacted for the surveys.

Interviewers only surveyed producers with 500 or more sheep on their property. This minimum number was chosen to ensure the flock demographics were representative of commercial sheep producers.

A set of standard questions was used to determine when lambing started. In 2006 the producers were asked to give the main reasons why they mated their ewes in the month they chose. The producers could give more than one reason and all reasons were coded. In the 2007 survey producers were asked for the months when lambing started for their Merino first cross ewes as well as their Merino ewes.

Year	State	Number of producers	Sheep shorn (million)	Wool production (thousand bales)	Merino ewes (million)	Merino first cross ewes (million)
2005	NSW	566	1.55	48	1.02	
	QLD	63	0.29	8	0.19	
	SA	249	0.47	17	0.31	
	TAS	39	0.18	5	0.09	
	VIC	289	0.86	24	0.46	
	WA	331	1.16	38	0.80	
	Total	1537	4.51	140	2.87	
2006	NSW	398	0.97	31	0.74	
	QLD	43	0.18	5	0.11	
	SA	171	0.36	13	0.29	
	TAS	26	0.13	3	0.08	
	VIC	236	0.67	19	0.45	
	WA	210	0.76	24	0.56	
	Total	1084	3.07	96	2.23	
2007	NSW	598	1.31	40	0.83	0.16
	QLD	65	0.28	8	0.17	0.01
	SA	267	0.51	19	0.36	0.05
	TAS	41	0.16	4	0.07	0.01
	VIC	353	0.99	28	0.58	0.12
	WA	358	1.24	38	0.88	0.05
	Total	1682	4.49	136	2.98	0.40

Table 1 Summary of data on lambing time in Australia 2005–2007

Statistical methods

A linear mixed model was fitted to an arcsin transformation of the percentage of Merino ewes which started lambing $\left(\frac{\sqrt{6Lambing}}{100}\right)$ in each month for each statistical division and

each year. The percentage of Merino ewes that lambed was set to zero for the months in each statistical division which were not nominated by any surveyed producer. Percentages were weighted according to the total number of ewes recorded in a statistical division for each year.

Effects due to state, statistical division, year and month were included in the model as random effects in order to estimate the proportion of variance attributable to each factor combination.

A regression model was used to test whether the percentage of Merino ewes lambing changed significantly between months, between states and between statistical divisions within months. Variance between years within each month and between statistical divisions was used to estimate residual variance. Similar models were fitted to an arcsin transformation of the percentages of farms where lambing started in each month for each statistical division and each year.

A linear mixed model was fitted to the arcsin transformation of the percentage of Merino ewes and Merino first cross ewes lambed in each statistical division and each month in 2007. Effects due to state, statistical division, genotype and month were included in the model as random effects in order to estimate the proportion of variance attributable to each factor combination.

A regression model was used to test whether the percentage of ewes to start lambing was significantly affected by the main effects of state, statistical division within state, month and genotype and interactions between state, genotype and month. Other effects of statistical divisions were used to estimate residual error.

Results

The variance in the arcsin transformation of the percentage of Merino ewes which started lambing in different months can be subdivided into the proportion due to 1) an overall variance between months (43 per cent); 2) a variance between states within months (37 per cent); and 3) a variance between statistical divisions within states and months (19 per cent). The remaining variance between years is negligible (1 per cent). Other variance components were zero.

Similarly, the variance in the arcsin transformation of the percentage of farms which started lambing in different months can be subdivided into the proportion due to 1) an overall variance between months (41 per cent); 2) a variance between states within months (41 per cent); and 3) a variance between statistical divisions within states and months (16 per cent). The remaining variance due to differences between years was negligible (2 per cent).

For the data collected in 2007 it is possible to subdivide the variance further. The variance in the arcsin transformation of the percentage of ewes which started lambing in different months can be subdivided into the proportion due to 1) an overall variance between months (43 per cent); 2) a variance between states within months (21 per cent); 3) a variance between statistical divisions within states and months (27 per cent); 4) a variance between genotypes (Merino ewes versus Merino first cross ewes) within months (4 per cent); and 5) a variance between states within months and genotypes (4 per cent). Other variances were negligible.

In most states there was a large spread in the times when the Merino ewes started lambing (Figure 1). There was a significant difference between the overall proportion of Merino ewes that lambed in each month (P<0.001), a significant difference between the proportion that lambed in each state for each month (P<0.001), and a significant difference between the proportion that lambed in each month across statistical divisions for each state (P<0.001) (Figures 2 to 7).

Table 2 shows the months of the year by which 10, 50 and 90 per cent of ewes had started lambing for each statistical division, based on predictions from the regression model. For instance, in the Northern statistical division in New South Wales, 10 per cent of ewes had started lambing by the end of July, 50 per cent had started lambing by the end of September, and 90 per cent had started lambing by the end of October. Eighty per cent of ewes started lambing within this four-month period of July to the end of October.

In Tasmania, it is clear that 80 per cent of ewes lambed over three months in both of the statistical divisions and over four months in nearly all of the statistical divisions in Western Australia. Lambing was spread over more than five months in Queensland. In the Central West and North West statistical divisions in Queensland there was a bimodal distribution for the start of lambing with peaks in April and August, and March and August, respectively.



Figure 1 Percentage of ewes that started lambing each month in the six states, with standard error bars

	Ewes started lambing (%)				Farms started lambing (%)			
Statistical division	10	50	90	Range ¹	10	50	90	Range ¹
New South Wales								
130 – Northern	Jul	Sep	Oct	4	Jul	Sep	Oct	4
135 – North Western	Apr	Aug	Sep	6	Mar	Jul	Sep	7
140 - Central West	Mar	Jun	Sep	7	Mar	Jun	Sep	7
145 – South Eastern	May	Aug	Sep	5	Apr	Aug	Sep	6
150 – Murrumbidgee	Mar	May	Aug	6	Mar	May	Aug	6
155 – Murray	Apr	May	Aug	5	Mar	May	Aug	6
160 – Far West	Apr	Jun	Oct	7	Apr	Jun	Oct	7
Queensland								
320 – Darling Downs	Jul	Sep	Nov	5	May	Sep	Oct	6
325 – South West	May	Aug	Oct	6	Jun	Aug	Oct	5
335 – Central West	Feb	May	Sep	8	Feb	May	Oct	9
355 – North West	Mar	Jun	Sep	7	Jan	May	Aug	8
South Australia								
410 – Outer Adelaide	Apr	May	Jul	4	Apr	May	Jul	4
415 – Yorke, Lower North	Apr	May	Jul	4	Mar	May	Aug	6
420 – Murray Lands	Mar	Apr	Jun	4	Mar	Apr	Jun	4
425 – South East	Apr	May	Jul	4	Apr	May	Jul	4
430 – Eyre	Mar	May	Jul	5	Mar	May	Jul	5
435 – Northern	Apr	Jun	Aug	5	Apr	Jun	Aug	5
Tasmania								
610 – Southern	Aug	Sep	Oct	3	Aug	Sep	Oct	3
615 – Northern	Jul	Aug	Sep	3	Jul	Sep	Sep	3
Victoria								
210 – Barwon	May	Aug	Sep	5	Apr	Jul	Sep	6
215 – Western District	May	Aug	Sep	5	Apr	Jul	Sep	6
220 – Central Highlands	Apr	Jul	Sep	6	Apr	Jul	Sep	6
225 – Wimmera	Apr	May	Aug	5	Apr	May	Aug	5
230 – Mallee	Apr	May	Jul	4	Apr	Apr	Aug	5
235 – Loddon	Apr	May	Aug	5	Apr	Apr	Aug	5
240 – Goulburn	Apr	May	Aug	5	Apr	May	Aug	5
245 – Ovens–Murray	Apr	Jul	Sep	6	Apr	May	Aug	5
250 – East Gippsland	May	Jul	Sep	5	May	Jun	Sep	5
Western Australia								
510 – South West	May	Jun	Jul	3	Мау	Jun	Jul	3
515 – Lower Gt Southern	Apr	Jun	Jul	4	Mar	Jun	Jul	5
520 – Upper Gt Southern	Apr	Jun	Jul	4	Apr	May	Jul	4
525 – Midlands	Apr	May	Jul	4	Apr	May	Jul	4
530 – South Eastern	Mar	May	Jun	4	Mar	May	Jun	4
535 – Central	Apr	May	Jul	4	Apr	May	Jul	4

Table 2 Lambing times in Australia 2005–2007 (for ewes and for farms) by state, statistical division, month and range of months

¹ The number of months over which 10 to 90 per cent of the ewes started lambing.

Note: These are the percentage of the ewes and farms that had started lambing by the month listed.



Figure 2 Percentage of ewes that started lambing each month in the statistical divisions surveyed in New South Wales



Figure 3 Percentage of ewes that started lambing each month in the statistical divisions surveyed in Queensland



Figure 4 Percentage of ewes that started lambing each month in the statistical divisions surveyed in South Australia



Figure 5 Percentage of ewes that started lambing each month in the statistical divisions surveyed in Tasmania



Figure 6 Percentage of ewes that started lambing each month in the statistical divisions surveyed in Victoria



Figure 7 Percentage of ewes that started lambing each month in the statistical divisions surveyed in Western Australia



Figure 8 Percentage of farms that started lambing each month in the six states, with standard error bars

There was also a spread in the times when lambing started on the farms (Figure 8). There was a significant difference between 1) the overall percentage of farms that started to lamb in each month (P<0.001); 2) between the percentage that started to lamb in each state for each month (P<0.001); and 3) between the percentage that started to lamb in each month between the statistical divisions for each state (P<0.01).

Table 2 shows the months of the year by which 10, 50 and 90 per cent of farms for each statistical division had started lambing based on predictions from the regression model. Results were very similar to those for when ewes started lambing except that the length of the period over which 80 per cent of farms started lambing was one to two months longer in some statistical divisions because farms with very large numbers of ewes started lambing in the middle of the period.

In 2007 the month by genotype interaction of the percentage of ewes that started lambing was close to significance (Figure 9; P=0.079). There was a peak in lambing for Merino first cross ewes in April that was not obvious for Merino ewes and a larger percentage of Merino ewes started lambing after August. In 2007, 80 per cent of the Merino ewes started lambing between April and September whereas 80 per cent Merino first cross ewes started lambing between April and August.



Figure 9 Percentage of Merino ewes and Merino first cross ewes that started lambing each month in 2007, with standard error bars

Table 3 records the reasons given by two per cent or more of producers for their choice of lambing times. Other reasons with less than two per cent of responses were not reported in Table 3.

Reasons	No. of producers	Per cent of producers
To match usual feed availability with feed requirements	599	53.5
To benefit from generally good weather, e.g. more lambs survive	353	31.5
To integrate management programs, e.g. other enterprises such as cropping or cattle	167	14.9
To optimise lambing/weaning rates	115	10.3
To coincide/fit in with shearing	96	8.6
To maximise lamb growth	92	8.2
To get the best possible sale price	86	7.7
To produce weaners big enough to get through their first summer	50	4.5
To better match seasonal conditions	48	4.3
To meet market demand/to suit market/age of lambs is right for market	46	4.1
Convenience/fits in with management of the farm/sheep system	33	2.9

Table 3 Producers' reasons for choice of lambing times in 2006

Notes: Response total = 1831; Number of producers who provided reasons = 1120; Less than 2 per cent of producers gave additional reasons which were not recorded. Producers could give multiple reasons and so the percentages do not total 100.

Discussion

In this study less than one per cent of the variance in the percentage of Merino ewes that started lambing in each month was accounted for by year effects. However, there were differences between states and between statistical divisions within states.

In Queensland and New South Wales there was a spread of when lambing started: the highest proportion of farms (around 25 per cent) started lambing in August. In Victoria the peak starts for lambing were in May and August. In Tasmania lambing was relatively concentrated with a later start than other states—more than 50 per cent of the farms started lambing in September. In South Australia, early lambing was favoured with more than 25 per cent of the farms starting in April. In Western Australia the start of lambing was more confined with the peak of around 25 per cent in June.

This spread in the start of lambing across the states is surprising. There have been many campaigns to convince producers that the concurrence of late pregnancy and lactation with peak pasture production (that is, late winter/spring in most states) is more efficient. The growth of pastures is more seasonal in Tasmania and this is the state with the latest lambing which obviously is when the availability of pastures and climatic conditions are more conducive to optimum performances of ewes and lambs.

Apart from Tasmania and New South Wales, the data for the Merino first cross ewes also show that most of the lambing started in the first half of the year, which is similar to the Merino ewes (Figure 9). In Tasmania crossbred ewes started lambing in August, a month earlier than was recorded for the combined figures. In New South Wales the spread was similar, but peak lambing was earlier for the crossbred ewes.

The spread of the lambing in South Australia was similar for the Merino ewes and Merino first cross ewes. Other states had similar patterns of lambing for Merino ewes and Merino first cross ewes, but the peaks for the crossbred ewes were earlier. Merino first cross ewes probably were lambed earlier to ensure that the lambs could be marketed before pastures senesced and the growth of lambs fell to a level that would prevent them from reaching a marketable weight.

The top reason given by producers for choice of lambing time (Table 2) was 'to match usual feed availability with feed requirements'. However, this is not reflected in the observations. In Victoria, South Australia and Western Australia on many farms lambing started well before the peak in pasture production. In Queensland and New South Wales, the potential growth of pastures over summer may influence the times when ewes are lambed.

It appears that the second and third reasons (Table 2) for preferred time of lambing—'to benefit from generally good weather, e.g. more lambs survive' and 'to integrate management programs, e.g. other enterprises such as cropping or cattle'—may be more important than the availability of feed in determining when flocks are lambed.

All other reasons were given by 10 per cent or less of the producers. This suggests that a range of factors influence producers when deciding on lambing times.

Although the surveys did not canvas whether the drought conditions influenced choice of lambing time, it appears that the drought did not induce major changes over the period surveyed.

Tasmania

In most states there is some variation in lambing time within statistical divisions. Tasmania is the exception. In both statistical divisions, lambing of most flocks was late in the year. A higher proportion of producers started lambing in September in the Southern division.

Queensland

Start of lambing was spread widely in Queensland. The average for the three years peaked in August/September. The main times of lambing varied between the statistical divisions but most were similar to the times reported by Kleemann (1999). The exception was the North West division where the peak in March was well below the level Kleemann observed. Our data show that about 25 per cent of the producers joined the ewes in spring which is substantially lower than the 72 per cent reported by Kleemann.

New South Wales

In New South Wales the start of lambing was spread out in the divisions of Central West, Far West, North Western and Murrumbidgee. In Murray the lambing peak was in April. The Northern and South Eastern divisions were the only ones with late lambings with peaks in late winter/spring, that is, August/September.

Our result for the South Eastern division contrasts with earlier observations by Caple et al. (1989) who reported that 61 per cent of producers with Merino ewes in south-eastern New South Wales lambed in autumn. This indicates that some producers in the South Eastern division over the last 20 years have moved lambing time so that the demands of ewes are better matched to the availability of pastures.

The observation from the Northern division is surprising. Perhaps some producers in this division have a late lambing when conditions are more conducive to higher rates of survival of lambs. Another reason could be the availability of green feed to ensure the growth of lambs over the summer period.

Victoria

The overall figures for Victoria show peaks of lambing in April/May and August. In over half of the statistical divisions (Goulburn, Loddon, Mallee, Ovens–Murray and Wimmera) the peak lambing was in April/May whereas in the other divisions (Barwon, Central Highlands, East Gippsland and Western District) the peak was in August/September.

The results from surveys done 20 years ago showed that the majority of producers lambed in autumn in Victoria. Campbell et al. (1986) reported that 70 per cent of Victorian wool growers lambed their ewes in autumn although they reported a trend towards a later joining in the high rainfall areas. Caple et al. (1989) reported that 79 per cent of producers mated their ewes for an autumn or winter lambing while Vizard (1990) found that 90 per cent of the 423 producers surveyed in central Victoria mated their Merino ewes to lamb in the autumn.

Based on the observations reported by Campbell et al. and Vizard it appears that in some areas in Victoria there has been a change from an autumn to a late winter/spring lambing. The change hasn't been uniform and there are obviously factors other than the availability of feed that underlie the choice of an early lambing.

The four divisions in Victoria where the peak in lambing was late in the season are closer to the coast with longer growing seasons for pastures. This would provide good quality feed and continued growth of lambs later in the year which would enhance their survival over summer.

The shorter growing season inland could make it more difficult for late born lambs to reach a weight adequate for the summer period. Pastures in winter dominant rainfall areas usually decrease in quantity and quality over summer (Biddiscombe et al. 1980). Producers in these areas are probably cautious and chose early lambing. If lambs can reach suitable weights while green pastures are available, they are more likely to get through the following summer/autumn period.

South Australia

The data from South Australia show some variation in lambing times between statistical divisions. However, in all divisions except the Northern division, the peak time for lambing is late autumn. In the Northern division there were peaks in April and June.

Kleemann et al. (1989) reported that 86 per cent of the flocks surveyed in the cereal– livestock and high rainfall areas in South Australia were joined from October to December, that is, for an early lamb drop. Trengove (1990) found that 81 per cent of sheep flocks in south-eastern South Australia lambed during February to May.

In a more recent survey Krause et al. (1996) reported that 38 per cent of the sheep breeders in the cereal/sheep and high rainfall zones lambed at least half of their ewes late in 1996 with forward estimates of at least 60 and 41 per cent, respectively, lambing their ewes late by 2001.

Taylor (2001) subsequently reported that about 60 per cent of the South Australian woolgrowers surveyed had flocks that started lambing late.

The results obtained from our 2005–2007 surveys are in marked contrast to the reports of Krause et al. and Taylor and indicate that most producers in South Australia have flocks in which lambing starts in autumn. The differences in the observations may be associated with the selection of producers surveyed. As outlined earlier, in the surveys reported here the sample size in each statistical division was determined by the relative proportion of producers in each area. Australian Bureau of Statistics census data was used for the 2005 survey and the Australian Wool Innovation Limited shareholder register for 2006 and 2007. The statistical divisions we surveyed have 85 per cent of the Australian sheep population. The producers surveyed were selected at random from those available to give a balanced sample.

Western Australia

In Western Australia most of the producers in the surveys reported lambing started in May and June, with some variation between statistical divisions. The Lower Great Southern was the exception with a peak start in June/July.

Very few flocks lambed at the peak of the pasture growth which was in September in most areas in Western Australia.

The results reported here are similar to earlier surveys on relatively small numbers of randomly selected producers in the Western Australian agricultural area. McFarland (1998) reported an almost identical spread in the start of lambing in 1993 in the Upper Great Southern.

In a benchmarking survey done in 1996, Shaw and McFarland (1998) reported small variations in the times when lambing started in some of the statistical divisions compared to our observations, but overall the results were similar. The exception was a marked concentration of lambing in the 'Northern area' where 75 per cent of the producers started lambing in April/May. This area of Shaw and McFarland included the Central and Midlands statistical divisions where we found more flocks started lambing in May/June.

There does not appear to have been a significant change in the times of lambing in Western Australia over the last 10 to 13 years.

Conclusions

Although numerous programs over the last 40 years have tried to convince Australian producers to lamb their ewes later in the pasture growing season, this study confirms that most flocks start lambing in the autumn. However, there are exceptions which make it clear that producers consider several factors when deciding the best time to start lambing.

No single strategy is applicable to all producers. The availability of fast growing pastures is not the only factor considered. Advisers and agencies should continue to promote the best management options for ewe flocks so that producers can determine the optimum combination for their situation.

References

- Australian Bureau of Statistics (2001). *Agricultural Commodities: Small area data Australia, 2000–01*. Cat. no. 7125.0, Australian Bureau of Statistics, Canberra.
- Biddiscombe, EF, Arnold, GW, Galbraith, KA & Briegel, DJ (1980). 'Dynamics of plant and animal production of a subterranean clover pasture grazed by sheep. 1. Field measurements for model calibration'. *Agricultural Systems,* **6**, 3–22.
- Campbell, IP, Clarke, JD, & Love, KJ (1986). *Managing sheep reproduction–knowledge and practices of Victorian sheep producers (1974–1982)*, Research Report No. 12, Department of Agriculture and Rural Affairs, Melbourne.
- Caple, IW, Vizard, AL, Allworth, MB & Morley, FHW (1989). 'Solutions to suboptimal performance in livestock in the field'. *Recent Advances in Animal Nutrition*, **10**, 92–101.
- Croker, KP (1988). *Time of lambing in Western Australia*. Research Report. 1/88. Western Australian Department of Agriculture, South Perth.

- Curtis, K & Croker, K (2005). *Wool Desk Report September 2005*, Issue No. 6. Department of Agriculture and Food, Western Australia, South Perth.
- Dun, RB, Ahmed, W & Morrant, AJ (1960). 'Annual reproductive rhythm in Merino sheep related to the choice of a mating time at Trangie, central western New South Wales', *Australian Journal of Agricultural Research*, **11**, 805–26.
- Kleemann, DO (1999). *Improving sheep and wool producing systems in western Queensland: A review*. p 14. Queensland Department of Primary Industries, Brisbane.
- Kleemann, DO, Walker, SK & Singh, AW (1989). 'Time of joining of South Australian Merino flocks', *Wool Technology and Sheep Breeding*, **37**, 87–8.
- Krause, M, Slee, J & Kleemann, D (1996). 'Evaluation of later lambing extension project'. Report prepared by Agricultural Risk Management Pty Ltd, Adelaide.
- Marshall, T (1970). 'Choosing your lambing time', *Journal of Agriculture Western Australia*, **11**, 217–20.
- McFarland, IJ (1998). *Needs analysis*, Miscellaneous Publication 26/98, Agriculture Western Australia, South Perth.
- Morley, FHW (1948). 'Some seasonal factors affecting fertility among Merino ewes in the Trangie District, New South Wales', *Australian Veterinary Journal*, **24**, 106–11.
- Shaw, S & McFarland, I (1998). *Wool Program Benchmarking Survey 1997*, Miscellaneous Publication 25/98, Agriculture Western Australia, South Perth.
- Taylor, G (2001). Supplement to: The results of a survey of SA woolgrowers to evaluate the BETTER BREEDING project. Taylored Marketing, Elizabeth.
- Trengove, CL (1990). 'Opportunities for improvement in sheep and beef cattle production in the south east of South Australia', *Proceedings of the Australian Society of Animal Production*, **18**, 404–7.
- Vizard, A (1990). 'Sheep overview', in *Improving profitability of wool production from pasture*, pp. 103–8. Department of Agriculture and Rural Affairs, Ballarat.
- Watson, RH (1953). 'Studies on the seasonal variation in the level of fertility in Merino ewes.
 1. Observations on mating, pregnancy and lambing at intervals of four months', *Australian Journal of Agricultural Research*, **4**, 349–59.

Appendix 1

State	Statistical division			
Otale	Name	ID number		
New South Wales	Northern	130		
	North Western	135		
	Central West	140		
	South Eastern	145		
	Murrumbidgee	150		
	Murray	155		
	Far West	160		
Victoria	Barwon	210		
	Western District	215		
	Central Highlands	220		
	Wimmera	225		
	Mallee	230		
	Loddon	235		
	Goulburn	240		
	Ovens-Murray	245		
	East Gippsland	250		
Queensland	Darling Downs	320		
	South West	325		
	Central West	335		
	North West	355		
South Australia	Outer Adelaide	410		
	Yorke and Lower North	415		
	Murray Lands	420		
	South East	425		
	Eyre	430		
	Northern	435		
Western Australia	South West	510		
	Lower Great Southern	515		
	Upper Great Southern	520		
	Midlands	525		
	South Eastern	530		
	Central	535		
Tasmania	Southern	610		
	Northern	615		

Statistical divisions sampled in the surveys in each state