

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

# Accelerated and out-of-season lamb production in New Zealand



A thesis submitted in partial fulfilment of the  
requirements for the degree of  
Doctor of Philosophy

at Massey University, Palmerston North,  
New Zealand

Gina deNicolo

2007



---

# Abstract

---

deNicolo, G. (2007) Accelerated and out-of-season lamb production in New Zealand, PhD Thesis, Massey University, Palmerston North, New Zealand.

## **Abstract**

The objective of this study was to evaluate ewe and lamb performance in an accelerated lamb production system, and to compare the performance and lamb output between a conventional and an accelerated lamb production system. In the “Conventional” system, ewes were bred in March to lamb in August. The “Accelerated” system was based on the “STAR” system (Lewis et al., 1996), in which there were five breeding periods within each year. In the current experiment these were 14<sup>th</sup> January, 28<sup>th</sup> March, 9<sup>th</sup> June, 21<sup>st</sup> August and 2<sup>nd</sup> November. Progesterone was used to synchronise the breeding periods and during the non-breeding season, eCG was used to induce reproductive activity. Lambing began on each of these dates and weaning was 73 days later, coinciding with the next breeding period. The experiment ran over a three-year period beginning with breeding in March 2003 and was complete with the weaning of lambs from the January 2006-bred ewes. This resulted in 15 lambing and breeding periods over the three years in the Accelerated system and three lambing and breeding periods in the Conventional system.

Average pregnancy rates were lower in the Accelerated system than in the Conventional system. Lamb growth rates were similar between the two systems, although lamb live weights at weaning were lower in the Accelerated system due to the age of the lambs at weaning (average = 69 vs 96 days). More lambs were born and weaned, resulting in more kilograms of lamb weaned in the Accelerated system relative to the Conventional system over the experimental period (26,200 vs 24,300 kg).

Labour input was 35% higher in the Accelerated system, or 13% higher per lamb weaned. Average annual ewe energy requirements were 6% higher in the Accelerated system. Ewe energy requirements per kilogram of lamb weaned was lower (6%) in the Accelerated system due to more breeding and lambing periods per ewe per year.

---

Laparoscopic observation of ewes' ovaries at each breeding period revealed that most ewes had active ovaries and were therefore capable of successfully producing a viable foetus. In a subsequent experiment, blood samples were collected for analysis of progesterone concentrations from ewes bred during the spring and autumn breeding periods. Observations of data indicated that a small number of ewes conceived and lost their conceptus, or had abnormal corpora lutea. Results suggested that pregnancies were failing due to a lack of an appropriate signal from the embryo to the dam/uterus.

Exposing Romney ewes to an artificial lighting regimen was unsuccessful for inducing reproductive activity during spring. In another experiment, melatonin implants administered to Romney ewes in spring and used in conjunction with eCG and progesterone, resulted in 61% more lambs born per ewe treated, compared to eCG and progesterone alone. This result indicated that melatonin implants, used with eCG and progesterone may be a suitable method for improving reproductive performance in sheep bred out of season in New Zealand.

Delaying weaning of lambs and breeding lactating ewes can be used to obtain heavier lamb weaning weights in the Accelerated system. Spring-bred ewes had lambs weaned at either 69 days post partum or 90 days post partum. Reproductive performance was similar between the two groups of ewes, and lamb live weights in the later weaned group were heavier when lambs were 90 and 120 days of age.

This research has shown that accelerated or out-of-season lamb production is an option for some New Zealand sheep farmers. However, the mechanisms associated with reproductive seasonality and methods of successfully circumventing this seasonality require further attention in order to achieve optimum reproductive performance.

---

# Acknowledgements

---

Firstly, I wish to thank the funding institutions who made it possible for this research. Meat and Wool New Zealand provided a considerable amount of funds for the major experiment in which the ewes were maintained for three years. Contributions from Massey University, the C. Alma Baker Trust and the Riverside Farm Research Fund are also greatly appreciated. Personal funding from AgMARDT provided me with a scholarship and enabled me to do this PhD, for which I am grateful. I would also like to thank the Vernon Wiley Trust who contributed funds for me to attend an international conference in Turkey and visiting various research facilities and scientists in Europe.

Thanks to Margaret Nash and the other ladies in the Livestock Improvement Corporation laboratory in Hamilton for their assistance in processing the many hundreds of serum progesterone samples. Special thanks to Dr Chris Morris who originally sparked my interest in animal research.

I wish to extend my appreciation and gratitude to my supervisors, Professor Steve Morris, Dr Paul Kenyon and Dr Patrick Morel, for all their assistance in conducting this research, and their guidance with writing and statistics. Thanks for seeing through all the grumpy days and for not biting back (most times). Special thanks to Professor Tim Parkinson for his assistance in writing, his openness to ideas and his humour. Thanks also to all the research technicians and to the friends and colleagues who assisted on trial work.

Finally, I wish to thank my family and friends who often copped the brunt of my stress and frustration. Thanks heaps to mum and dad for their continuing support and their belief in my ability to succeed here, and to Morgan for you regular calls to check on me. Thanks to my friends who often kept me sane (ha! or at least they tried). Thank you so much everyone.

---

---

# Table of contents

---

Chapter 1	Introduction .....	1
Chapter 2	Literature review .....	7
2.1	Introduction .....	7
2.2	Sheep production in New Zealand .....	8
2.3	Accelerated lamb production systems .....	13
2.4	Limitations to accelerated lamb production systems .....	17
2.5	Overcoming seasonality .....	22
2.6	Summary .....	29
2.7	Scope and purpose of research .....	30
Chapter 3	Comparison of an accelerated and a conventional lamb production system .....	35
3.1	Introduction .....	37
3.2	Material and methods .....	38
3.3	Results .....	43
3.4	Discussion .....	50
3.5	Conclusion .....	51
Chapter 4	Ewe energy requirements, and labour input - a system comparison .....	55
4.1	Introduction .....	55
4.2	Methods .....	56
4.3	Main findings .....	57
4.4	Conclusion .....	64
Chapter 5	Ewe reproduction and lamb performance at five different breeding periods within a year .....	73
5.1	Introduction .....	75
5.2	Material and methods .....	76
5.3	Results .....	79
5.4	Discussion .....	84
5.5	Conclusion .....	88
Chapter 6	Induced seasonal reproductive performance in two breeds of sheep .....	93
6.1	Introduction .....	95
6.2	Material and methods .....	96
6.3	Results .....	100



---

6.4	Discussion.....	107
6.5	Conclusion.....	110
Chapter 7	Serum progesterone concentrations during early pregnancy in spring- and autumn-bred ewes.....	115
7.1	Introduction .....	117
7.2	Materials and methods.....	118
7.3	Results.....	120
7.4	Discussion.....	125
7.5	Conclusion.....	128
Chapter 8	Out-of-season breeding of sheep using artificially induced long days .....	131
8.1	Introduction .....	133
8.2	Materials and methods.....	134
8.3	Results.....	138
8.4	Discussion.....	143
8.5	Conclusion.....	145
Chapter 9	Melatonin-improved reproductive performance in sheep bred out of season.....	149
9.1	Introduction .....	151
9.2	Materials and methods.....	152
9.3	Results.....	156
9.4	Discussion.....	161
9.5	Conclusion.....	164
Chapter 10	Effect of weaning pre- or post-mating on performance of spring-mated ewes and their lambs in New Zealand.....	167
10.1	Introduction .....	169
10.2	Materials and methods.....	170
10.3	Results.....	172
10.4	Discussion.....	175
10.5	Conclusion.....	177
Chapter 11	General discussion .....	181
11.1	Introduction .....	181
11.2	Summary of experimental chapters and conclusions drawn.....	182
11.3	Limitations and weaknesses identified .....	186
11.4	Recommendations for further research.....	189
11.5	Overall summary and conclusions .....	194
11.6	Concluding remarks .....	196
	Bibliography .....	199

---

## List of Tables

---

Table 2.1	Number of lambs born per ewe per year in accelerated lamb production systems, country in which study was conducted and breed of sheep.....	14
Table 3.1	Ewe live weights (kg) on the first day of the breeding period and at approximately two weeks prior to the first predicted day of lambing for East Friesian composite and Romney ewes in the accelerated and conventional lamb production systems.....	43
Table 3.2	Pregnancy rates for East Friesian composite and Romney ewes in the accelerated and conventional lamb production systems.....	44
Table 3.3	Litter size at birth and weaning for East Friesian composite and Romney ewes in the accelerated and conventional lamb production systems.....	45
Table 3.4	Birth weights (kg), weaning weights (kg) and average daily liveweight gains for East Friesian Composite and Romney lambs in the accelerated and conventional lamb production systems.....	47
Table 3.5	Number of lambs born and weaned per ewe lamb per year for East Friesian composite and Romney ewes in the accelerated and conventional lamb production system.....	48
Table 3.6	Number of East Friesian Composite and Romney ewes bred and lamb ed, number of EF and Romney lambs born and weaned, and kilograms of lambs sold for each year for the conventional and accelerated lamb production systems.....	49
Table 4.1	Values used for calculation of annual energy requirements for one 60 kg ewe grazing rolling hill country in the Conventional and the Accelerated lamb production systems.....	58

---

Table 4.2	Annual energy requirements for a 60 kg ewe grazing rolling hill country in the Conventional and Accelerated lamb production system, and different scenarios for improvement of the Accelerated system. ....	60
Table 4.3	Time requirements in hours for tasks involved in running a conventional lamb production system and an accelerated lamb production system run on 20 hectares.....	61
Table 5.1	Pregnancy rates for five different breeding periods over three years for East Friesian composite and Romney ewes..	79
Table 5.2	Number of lambs born and weaned per ewe lambled for five different breeding periods over three years for East Friesian composite and Romney ewes. ....	81
Table 5.3	Effect of lamb breed, year and lambing period on lamb birth weights and mortality from birth to weaning. ....	82
Table 5.4	Weaning weight (kg) and daily weight gain between birth and weaning for five different lambing periods over three years for East Friesian composite and Romney ewes.....	83
Table 6.1	Number of mixed-aged East Friesian Composite and Romney type ewes, and the ewe:ram ratio * used for each breeding period.....	97
Table 7.1	Numbers of ewes and proportions that did not display oestrus, displayed oestrus but were non-pregnant and were pregnant for March and August breeding periods.....	120
Table 8.1	The effect of ewe treatment on proportion of ewes displaying oestrus, proportion of ewes with corpora lutea present, average number of corpora lutea, pregnancy rate, conception rate, foetuses per ewe treated and litter size.. ....	140
Table 8.2	The effect of ewe treatment on the proportion of ewes that were non-responsive, displayed silent oestrus or pseudo-oestrus, and the proportion of non-pregnant and pregnant ewes. ....	141

---

Table 9.1	Effect of ewe treatment (melatonin + progesterone; melatonin + progesterone + eCG; progesterone + eCG) on oestrus rate (number of ewes marked by the ram per ewe exposed to the ram), proportion of ewes with corpora lutea present and average number of CLs.....	157
Table 9.2	The effect of ewe treatment (Melatonin + progesterone; Melatonin + progesterone + eCG; progesterone + eCG) on the proportion of ewes displaying no oestrus, silent oestrus, pseudo oestrus, non-pregnant and pregnant.....	159
Table 9.3	Effect of ewe treatment (melatonin + progesterone; melatonin + progesterone + eCG; progesterone + eCG) on conception rate, litter size and fertility.....	161
Table 10.1	The effect of Early and Late weaning and rearing rank on the live weights at P0, P21 and P47 of lambs present at the start of the synchronised breeding period..	173
Table 10.2	The effect of Early and Late weaning and rearing rank on the average number of follicles and corpora lutea present at laparoscopy nine days after the start of synchronised mating, and number of ewes with or without corpora lutea present.....	174
Table 10.3	Effect of ewe treatment and litter size on the lamb crown-rump length and girth measurements, and live weight at L0, L35 and L73.....	175
Table 11.1	Proposed experimental groups and treatments for further experimentation into the effects of melatonin implants or artificial light on reproductive performance in sheep bred during the non-breeding season.....	188

---

---

## List of Figures

---

Figure 2.1	Numbers (millions) of sheep in New Zealand from 1960 to 2005.....	9
Figure 2.2	Total weight (thousand tonnes, bone-in) of New Zealand annual lamb production and export for the seasons from 1981 to 2005.....	9
Figure 2.3	Lamb carcass weights with trend line and lambing percentages with trend line from 1981 to 2005.....	10
Figure 2.4	Lamb deaths from starvation/exposure classified according to birth weight; multiple-born and, single-born lambs. ....	11
Figure 2.5	Number of lambs sent for processing each month in New Zealand for the 2004/05 season and average monthly lamb schedule from February 2004 to January 2005. ....	12
Figure 2.6	Average monthly rainfall and temperature in 2004 for New Zealand's main area in relation to time of lambing. ....	16
Figure 2.7	Seasonal pattern of pasture growth for different regions in New Zealand...	17
Figure 6.1	Conception rates and pregnancy rates in a) East Friesian Composite and b) Romney type mixed aged ewes bred at different seasons within one year...	101
Figure 6.2	The proportion of a) East Friesian Composite and b) Romney type mixed aged ewes with successful or unsuccessful pregnancies at different seasons within one year.....	103
Figure 6.3	Average number of corpora lutea in all ewes exposed to the ram for a) East Friesian Composite and b) Romney type mixed aged ewes at different seasons within one year.....	104
Figure 6.4	Average number of corpora lutea in non pregnant and pregnant a) East Friesian Composite and b) Romney type mixed aged ewes for different seasons within one year.....	106

---

Figure 7.1 Progesterone concentrations (ng/ml) for individual ewes that did not display oestrus after progesterone + eCG treatment in spring (August) with normal or abnormal corpora lutea.....	122
Figure 7.2 Mean progesterone concentrations (ng/ml) for March- and August-bred mixed aged ewes from Day 8 to 39 days post-oestrus.....	124
Figure 7.3 Mean progesterone concentrations (ng/ml) for March- and August-bred pregnant and non-pregnant mixed aged ewes from Day 8 to 18 post-oestrus..	123
Figure 8.1 Average plasma melatonin concentrations at 1900, 2300, 0300 and 0700 hr for eight ewes in exposed to artificial light and treated with progesterone or progesterone + eCG and ewes not exposed to light and treated with progesterone + eCG..	139
Figure 9.1 The proportion of ewes within each treatment group with plasma melatonin concentrations less than 20 pg/ml, between 20 and 100 pg/mL and over 100 pg/ml. .	158
Figure 11.1 Possible explanations for reduced reproductive performance in ewes bred out of season. ....	189
Figure 11.2 Possible reasons for reduced seasonal reproductive performance in ewes as a result of seasonal affects on the ram. ....	193

---

# List of abbreviations and definitions

---

## **Sheep breeds**

EF	East Friesian Composite (½ East Friesian, ¼ Texel, ¼ Polled Dorset)
Rom	Romney

## **Hormones (endogenous and artificial)**

FSH	Follicle stimulating hormone
LH	Luteinizing hormone
GnRH	Gonadotrophin releasing hormone
eCG/PMSG	Equine chorionic gonadotrophin/Pregnant mares' serum gonadotrophin
CIDR	Controlled internal drug releasing devices
MAP	medroxyprogesterone
FGA	fluorogestone acetate

## **Reproductive jargon**

Oestrus rate	Proportion of ewes displaying oestrus per ewe exposed to the ram
Pregnancy rate	Proportion of ewes pregnant per ewe exposed to the ram
Conception rate	Proportion of ewes pregnant per ewe mated
Fecundity	Number of lambs (or foetuses) per ewe pregnant
Fertility	Number of lambs (or foetuses) per ewe exposed to the ram
PPI	Post partum anoestrus interval (the period of time between parturition and resumption of ovarian activity)