The Effects of Pre-Lamb Shearing on Feed Intake, Metabolism and Productivity of Sheep

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Animal Science at Massey University

NAJAFGHOLI DABIRI

1994
Title of thesis: "The effects of Pre-Lamb Shearing on Feed Intake, Metabolism and Productivity of Sheep"

(1) (a) I give permission for my thesis to be made available to readers in Massey University Library under conditions determined by the Librarian.

(b) I do not wish my thesis to be made available to readers without my written consent for ... months.

(2) (a) I agree that my thesis, or a copy, may be sent to another institution under conditions determined by the Librarian.

(b) I do not wish my thesis, or a copy, to be sent to another institution without my written consent for ... months.

(3) (a) I agree that my thesis may be copied for Library use.

(b) I do not wish my thesis to be copied for Library use for ... months.

Signed: 

Date 21/4/94

The copyright of this thesis belongs to the author. Readers must sign their name in the space below to show that they recognise this. They are asked to add their permanent address.

NAME AND ADDRESS

DATE
In the Name of Allah,
the Compassionate, the Merciful,
Praise be to Allah, Lord of the Universe,
and Peace and Prayers be upon
His Final Prophet and Messenger.
<table>
<thead>
<tr>
<th>Page</th>
<th>Paragraph</th>
<th>Line</th>
<th>Correct</th>
<th>Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>3</td>
<td>7</td>
<td>regimens)</td>
<td>regimens</td>
</tr>
<tr>
<td>xvii</td>
<td>1</td>
<td>13</td>
<td>Controlled</td>
<td>Controleed</td>
</tr>
<tr>
<td>xviii</td>
<td>1</td>
<td>1</td>
<td>temperature</td>
<td>temprature</td>
</tr>
<tr>
<td>xviii</td>
<td>1</td>
<td>31</td>
<td>yellowness index</td>
<td>tristimulus value (yelloww)</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
<td>Weekes</td>
<td>Weeks</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>13</td>
<td>for</td>
<td>of</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>9</td>
<td>Mosse</td>
<td>Moose</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>10</td>
<td>%</td>
<td>%,1970;</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>1</td>
<td>During the</td>
<td>During</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>8</td>
<td>W/m²</td>
<td>W m⁻²</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>4</td>
<td>Averill</td>
<td>Avrill</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>5</td>
<td>lead</td>
<td>leads</td>
</tr>
<tr>
<td>24</td>
<td>1</td>
<td>4</td>
<td>losses from</td>
<td>losses</td>
</tr>
<tr>
<td>38</td>
<td>2</td>
<td>4</td>
<td>Hooper</td>
<td>Hopper</td>
</tr>
<tr>
<td>44</td>
<td>2</td>
<td>7</td>
<td>difference</td>
<td>differences</td>
</tr>
<tr>
<td>65</td>
<td>2</td>
<td>5</td>
<td>Hooper</td>
<td>Hopper</td>
</tr>
<tr>
<td>74</td>
<td>1</td>
<td>15</td>
<td>climatic</td>
<td>better climatic</td>
</tr>
<tr>
<td>99</td>
<td>2</td>
<td>4</td>
<td>difference</td>
<td>differences</td>
</tr>
<tr>
<td>120</td>
<td>3*</td>
<td>3,4</td>
<td>HPₘin/SA</td>
<td>HP/SAₘin</td>
</tr>
<tr>
<td>172</td>
<td>4*</td>
<td>2</td>
<td>Hurley</td>
<td>Huntey</td>
</tr>
</tbody>
</table>

ABSTRACT


The objective of this research programme was to investigate issues relating to the development of the pre-lamb shearing policy as a means of improving the productivity of, and financial returns to, New Zealand sheep farming systems. Four experiments were conducted with Border Leicester x Romney sheep to examine the potential advantages and disadvantages of pre-lamb shearing, and means of ameliorating the latter.

Experiment 1 compared the effect of pre-lamb and conventional (post-weaning) shearing by standard comb on the productivity of spring-lambing ewes (n= 250 per group) and their lambs under commercial conditions over 3 years. Ewes were shorn either about one month prior to lambing (during winter) or at weaning (during summer). Pre-lamb shearing was associated with a significant (P<0.05) increase in ewe fleeceweight and weaning weight in one year but not in the other (the first year being used to adjust ewes to the new shearing regimens. Shearing treatment did not affect lamb production (birthweight, weaning weight or growth rate).

In Experiment 2, a more detailed study was made of the effects of pre-lamb shearing, again by standard comb, in both spring (August)- and autumn (May)-lambing ewes (n = 30 per shearing x lambing policy group). Ewes in each policy were shorn on pregnancy day 118 (P118) or left unshorn until weaning. Pre-lamb shearing was associated with increased organic matter (OMI, 1739±58 vs 1526±59 g/d, P<0.05) and dry matter (DMI) intakes only at P141-144 (i.e. 2-3 weeks after shearing). Ewe liveweights and body condition scores, and lamb weights from birth to weaning, were unaffected by shearing treatment but back fat depths were significantly (P<0.05) lower in pre-lamb shorn ewes (4.3±0.2 mm) than in unshorn ewes (5.1±0.2 mm) on P142. The only parameter to exhibit a significant lambing policy x shearing treatment interaction was midside clean wool growth over P118-L (lactation day) 13, pre-lamb shorn May-lambing ewes producing significantly (P<0.01) greater clean wool weights than unshorn ewes (0.927±0.042 vs 0.721 ±0.048 mg/cm²/day) whereas shearing was without effect in August-lambing ewes (shorn, 0.542±0.041 vs unshorn, 0.641 ±0.045 mg/cm²/day, P>0.05).

The third experiment examined the potential benefits of pre-lamb shearing by cover comb. Ewes were shorn by cover comb or standard comb on P114 or left
unshorn until weaning \((n=100/\text{group})\). Despite similar post-shearing ewe survival rates and herbage intakes between ewes shorn pre-lamb by cover comb and unshorn ewes, standard comb-shorn ewes had greater losses \((14 \text{ vs } 3 \%, P<0.05)\), OMI over P123-126 \((1781±115 \text{ vs } 1566±115 \text{ g/d, } P<0.10)\) and biting rates \((99.2±1.8 \text{ vs } 93.7±1.8 \text{ bites/min, } P<0.05)\) than cover comb-shorn ewes. Over the 20 days after shearing, only the standard comb-shorn group lost liveweight. Both pre-lamb shorn groups had greater \((P<0.05)\) clean wool growth rates and superior \((P<0.05)\) wool quality (yield and brightness) than unshorn ewes while lamb production and survival were similar between shearing treatments. Rectal temperature \((\text{RT})\) was significantly \((P<0.05)\) lower in ewes shorn by the standard comb \((38.9±0.08 \degree C)\) and cover comb \((39.0±0.08 \degree C)\) than in the unshorn group \((39.3±0.08 \degree C)\) on day 3 post-shearing \((\text{S3})\), but by S5 only the ewes shorn by the standard comb had lower RT. Generally, blood metabolite and hormone concentrations were different over the same time interval as RT, with circulating glucose and non-esterified fatty acid \((\text{NEFA})\) concentrations being elevated to the greatest extent in ewes shorn by standard comb.

Experiment 4 determined the effect of shearing by standard comb or cover comb on heat production and metabolism of non-pregnant, non-lactating sheep \((8 \text{ pairs})\) in calorimetry chambers over 10 days post-shearing. Plasma NEFA concentrations and heat production \((\text{HP})\) were significantly greater in sheep shorn by standard comb than in those shorn by cover comb \((\text{a maximum difference in HP of } 5.4 \text{ MJ/24h in wet, windy and cold conditions})\) while the reverse was true for body insulation and liveweight gain. This superior cold resistance in the cover comb-shorn group reflected their greater residual stubble depth \((5.1±0.2 \text{ vs } 3.1±0.2 \text{ mm})\).

The above results indicate that the effects of shearing treatment and lambing policy were additive in most respects, suggesting that the advantages and disadvantage of pre-lamb shearing spring-lambing ewes are also likely to apply to autumn- lambing ewes. The greater survival rate, rectal temperature and liveweight gain, but lower feed intake and heat production, of ewes shorn pre-lamb by cover comb than ewes shorn by standard comb, which reflected their greater residual stubble depth, clearly indicated that use of the cover comb should be strongly supported as a means of ameliorating the effects of pre-lamb shearing on cold stress and feed intake. A financial analysis of these results in a simulated sheep production system showed that pre-lamb shearing by cover comb could be expected to increase returns to the sheep farmer by approximately \$1.26 per ewe compared with conventional post-weaning shearing. These increased returns were a consequence of both improved productivity and reduced overdraft charges for seasonal finance.
ACKNOWLEDGEMENTS

First of all praise be to Allah (God), The Lord of the Universe for giving me this opportunity to complete this difficult period and guiding my supervisors for their excellent supervision. Peace and Prayers also be upon the Final Prophet and all messengers and their Companions who were the righteous servants of God and consequently human beings.

This study programme was supervised by Professor Stuart McCutcheon, Dr Stephen Morris and Professor George Wickham of the Department of Animal Science, and Professor Warren Parker of the Department of Agricultural & Horticultural Systems Management, Massey University. I am particularly grateful for their enthusiastic support and expert supervision. I will never forget the patience of my chief supervisors (Professor Stuart McCutcheon and Dr Stephen Morris) for their constructive editing of draft scripts and assistance with the design and execution of my trials. I would like to acknowledge Professor Colin Holmes of the Animal Science Department as another (informal) supervisor and to express my grateful thanks for his friendly help in the field of climatic physiology and Experiment 4.

The excellent technical support for all field trials from Mr Dean Burnham and Mr Tim Harcombe in handling, collecting samples and recording data from sheep over a long period through difficult weather conditions, and also the help of Professor Max Wallentine of Utah University, USA (who was visiting the Animal Science Department over 3-4 months), are appreciated. Mr Kerry Kilmister and Mrs Lynley Free prepared and assisted with the management of livestock used for experiments in grazing conditions. Mr Barry Parlane provided friendly service with the running of the indoor experiment at the Animal Physiology Unit. The assistance of all of them is appreciated.
I would like to express my thanks to: staff of the Wool Laboratory for providing facilities for wool measurement; staff of the Nutrition Laboratory (particularly Mrs Kathy Morton and Mrs Barbara Purchas) for helping with the tedious task of digesting hundreds of faecal samples for chromium analysis; Miss Rosemary Watson for measuring chromium by atomic absorption spectrophotometry; and Mr David Hamilton for analysis of extrusa samples collected by oesophageal fistulated sheep for in vitro digestibility and fibre. Thanks are also due to Miss Margaret Scott, Miss Yvette Cottam and Ms Penny Back, staff of the Physiology Laboratory, for helping in collecting blood samples and analysing them for metabolites and hormones.

Thanks are extended to all staff of the Animal Science Department, particularly Dr Roger Purchas for measuring back fat depth of sheep and Dr Dorian Garrick for his statistical guidance.

The presence of all Iranian postgraduate students and their families in Palmerston North made my family and me feel at home. I wish a prosperous and happy future for all of them.

I would like to express my sincere thanks to the Ministry of Culture and Higher Education of Iran, for awarding me the scholarship to undertake this study.

I am particularly grateful to Mina, my wife, for her patience, considerable encouragement and loyal support during the last four years. Without her help this thesis would never have eventuated. Therefore this work is dedicated to her. The patience of my son Alireza and my daughters Maryam and Marzieh (Maedh), who suffered inadequate contact with their father for four years, is appreciated.
# Table of Contents

ABSTRACT...........................................................................................................i

ACKNOWLEDGEMENTS................................................................................. iii

LIST OF TABLES..............................................................................................xii

LIST OF FIGURES.............................................................................................xvi

LIST OF ABBREVIATIONS.............................................................................. xvii

CHAPTER ONE: INTRODUCTION........................................................................ 1

BACKGROUND................................................................................................. 1
  Second-Shear Policy ..................................................................................... 3
  Eight-Month Policy ..................................................................................... 3
  Pre-Lamb Shearing ..................................................................................... 4

ADVANTAGES OF PRE-LAMB SHEARING...................................................... 5
  Wool Quantity ............................................................................................ 5
  Wool Quality .............................................................................................. 6
  Yield ........................................................................................................... 7
  Strength ..................................................................................................... 7
  Colour ....................................................................................................... 8
  Lamb Production and Survival ................................................................... 8
  Farm Management Parameters ............................................................... 10

DISADVANTAGES OF PRE-LAMB SHEARING........................................... 11
  Feed Intake Responses of Shorn Sheep .................................................... 11
  Grazing behaviour .................................................................................... 14
  Ewe Survival ............................................................................................. 14
Ewe Liveweight and Condition Score ................................................................. 17

PRE-LAMB SHEARING AND OUT OF-SEASON LAMMING ............................... 18

COVER COMB SHEARING ................................................................................... 19

PURPOSE AND SCOPE OF THE INVESTIGATION .............................................. 21

CHAPTER TWO: EFFECTS OF PRE-LAMB AND CONVENTIONAL
FULL-WOOL SHEARING ON THE PRODUCTIVITY
OF, AND FINANCIAL RETURNS FROM, EWES ............................................ 22

ABSTRACT ........................................................................................................ 22

INTRODUCTION ................................................................................................. 23

MATERIALS AND METHODS ........................................................................... 25
  Experimental Design and Animals ................................................................. 25
  General Management ..................................................................................... 25
  Animal Measurements .................................................................................. 26
  Statistical Analysis ....................................................................................... 27

RESULTS .......................................................................................................... 27
  Ewe Lamming Performance .......................................................................... 27
  Ewe Liveweight and Fleeceweight ................................................................. 27
  Lamb Weight and Growth ............................................................................. 29

DISCUSSION .................................................................................................... 30
  Ewe Lamming Performance ......................................................................... 30
  Ewe Liveweight and Fleeceweight ................................................................. 30
  Lamb Production ........................................................................................... 32
  Financial and Management Considerations .................................................. 32

CONCLUSIONS ................................................................................................. 34
CHAPTER THREE: EFFECTS OF PRE-LAMB SHEARING ON FEED INTAKE AND ASSOCIATED PRODUCTIVITY OF MAY- AND AUGUST-LAMBING EWES

ABSTRACT

INTRODUCTION

MATERIALS AND METHODS
Experimental Design and Animals
Pasture Conditions and Grazing Management
Pasture Measurements
Animal Measurements
Measurement of Herbage intake
Statistical Analysis

RESULTS
Pasture Conditions
Animal Performance
Herbage intake
Ewe liveweights
Back fat depth and condition score
Wool growth and fibre diameter
Lamb live weight

DISCUSSION
Pasture Conditions
Pasture Type
Lambing Policy ........................................................................................................ 67
Ewe feed intake, liveweight, back fat depth and condition score ................................ 67
Wool production ......................................................................................................... 70
Lamb production .......................................................................................................... 71

Shearing ....................................................................................................................... 72
Ewe feed intake, liveweight, back fat depth and condition score ................................ 72
Wool production .......................................................................................................... 73
Lamb production .......................................................................................................... 74

CONCLUSIONS .......................................................................................................... 75

CHAPTER FOUR: EFFECT OF SHEARING METHOD ON EWE AND LAMB PRODUCTIVITY AND THE METABOLIC ADAPTATION OF PREGNANT EWES TO FLEECE REMOVAL ............................................................... 76

ABSTRACT .................................................................................................................. 76

INTRODUCTION ........................................................................................................ 77

MATERIALS AND METHODS ................................................................................. 78
Experimental Design and Animals ............................................................................. 78
Grazing Conditions and Pasture Measurements ....................................................... 79

Animal Measurements ............................................................................................. 81
Herbage intake ............................................................................................................ 81
Liveweight and condition score ............................................................................... 82
Wool production ........................................................................................................ 82
Blood metabolite and hormone concentrations ..................................................... 83
Rectal temperature .................................................................................................... 84
Lamb performance ..................................................................................................... 85
CHAPTER FIVE: EFFECTS OF SHEARING BY COVER COMB OR STANDARD COMB ON THE SHEEP'S RESISTANCE TO COLD, WINDY AND WET CONDITIONS .................................................. 116

ABSTRACT .................................................................................................................. 116

INTRODUCTION ........................................................................................................... 117

MATERIALS AND METHODS ......................................................................................... 118
Experimental Design and Animals ................................................................................ 118
Fleece Depth .................................................................................................................. 119
Oxygen Consumption .................................................................................................. 120
Heat Production, Body Insulation and Lower Critical Temperature ......................... 120
Plasma Metabolite Concentrations .............................................................................. 121
Rectal Temperature .................................................................................................... 121
Statistical Analysis ..................................................................................................... 121

RESULTS ..................................................................................................................... 123
Liveweight, Fleece Depth and Rectal Temperature ..................................................... 123
Heat Production, Body insulation and Lower Critical Temperature ......................... 123
Plasma Metabolite Concentrations .............................................................................. 125

DISCUSSION ............................................................................................................... 130

CONCLUSIONS .......................................................................................................... 132
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The critical environmental temperature of sheep</td>
</tr>
<tr>
<td>1.2</td>
<td>Changes in the mean metabolism of five breeds of sheep on exposure to low air temperatures, wind and rain</td>
</tr>
<tr>
<td>1.3</td>
<td>Summit metabolic rate of adult shorn sheep and environmental temperatures at which heat loss equals maximum heat production and below which thermoregulation would fail</td>
</tr>
<tr>
<td>2.1</td>
<td>Number of experimental ewes in each shearing treatment at set stocking for lambing and their lambing performance 1989-1991</td>
</tr>
<tr>
<td>2.2</td>
<td>Effect of shearing treatment on ewe liveweight prior to lambing and at weaning, and on annual fleece weight 1989-1991</td>
</tr>
<tr>
<td>2.3</td>
<td>Effect of shearing treatment on lamb birthweight, weaning weight, and lamb growth rates from birth to weaning 1989-1991</td>
</tr>
<tr>
<td>2.4</td>
<td>Net returns received for wool from pre-lamb shorn and conventionally shorn ewes 1988-1991</td>
</tr>
<tr>
<td>3.1</td>
<td>Dates of faecal sampling in capsule-treated May- and August-lambing ewes</td>
</tr>
<tr>
<td>3.2</td>
<td>Sward height, herbage mass, botanical composition and in vitro digestibility of herbage grazed by May- and August-lambing ewes at P112-P140</td>
</tr>
<tr>
<td>3.3</td>
<td>Sward height, herbage mass, botanical composition, and in vitro digestibility of herbage grazed by May- and August-lambing ewes at L0-L33</td>
</tr>
<tr>
<td>3.4</td>
<td>Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe herbage intake over three periods during pregnancy</td>
</tr>
</tbody>
</table>
3.5 Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe herbage DM intake at six times after shearing during pregnancy ..........52

3.6 Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe herbage OM intake at six times after shearing during pregnancy ..........54

3.7 Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe herbage intake over three periods during lactation ..............................................56

3.8 Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe liveweight at five times during pregnancy and lactation .................58

3.9 Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe back fat depth at P142 and on condition score at three periods during pregnancy and lactation ........................................59

3.10 Effect of policy, shearing treatment, litter size and pasture type on ewe midside clean wool growth over three periods during pregnancy and lactation ..........................................61

3.11 Effect of lambing policy, shearing treatment, litter size and pasture type on ewe midside fibre diameter at three times during pregnancy and lactation .................62

3.12 Effect of lambing policy, shearing treatment, litter size, sex and pasture type on lamb liveweight at four times from birth to weaning .........................64

4.1 Sward height, herbage mass, botanical composition, and in vitro digestibility of pasture grazed by ewes during pregnancy and lactation ..................87

4.2 Effect of shearing treatment, litter size, and ewe age on ewe losses during pregnancy (post-shearing). .................................................................89

4.3 Effect of shearing treatment, litter size, and age on ewe dry matter intake, organic matter intake, and biting rate during late pregnancy .........................91

4.4 Effect of shearing treatment, litter size, and age on ewe liveweight at five times during pregnancy and lactation ..................................................93

4.5 Effect of shearing treatment, litter size, and age on ewe condition score at
four times during pregnancy and lactation .................................................94

4.6 Effect of shearing treatment, litter size and age on ewe midside greasy wool
growth and clean wool growth during pregnancy and lactation...............96

4.7 Effect of shearing treatment on ewe wool yield, fibre diameter and colour,
and weight of residual wool after shearing .............................................97

4.8 Effect of shearing treatment, litter size, and age on ewe rectal temperature -
pre-shearing and on days 1, 3, 5 and 10 post-shearing ..............................98

4.9 Effect of shearing treatment, litter size, and age on ewe plasma glucose
concentration pre-shearing and on days 1, 3, 5, 10 and 20 post-shearing ..100

4.10 Effect of shearing treatment, litter size, and age on ewe plasma 3-hydroxy-
butyrate concentration pre-shearing and on days 1, 3, 5, 10 and 20 post-
shearing ......................................................................................................101

4.11 Effect of shearing treatment, litter size, and age on ewe plasma non-
esterified fatty acid concentration pre-shearing and on days 1, 3, 5, 10 and
20 post-shearing ..........................................................................................102

4.12 Effect of shearing treatment, litter size, and age on ewe plasma growth
hormone concentration pre-shearing and on days 1, 3, 5, 10 and 20 post-
shearing ......................................................................................................104

4.13 Effect of shearing treatment, litter size, and age on ewe plasma insulin
concentration pre-shearing and on days 1, 3, 5, 10 and 20 post-shearing ....105

4.14 Effect of shearing treatment, litter size, dam age and sex on the proportion
of lamb losses at birth and from birth to weaning ........................................107

4.15 Effect of shearing treatment, litter size, age and sex on lamb liveweight at
birth, docking and weaning ................................................................. 108

5.1 Sequence of events on each measurement day ......................................122
5.2 Effect of shearing treatment (standard vs cover comb) on fleece-free liveweight, rectal temperature and fleece depth of sheep exposed to cold conditions on day 2 prior to shearing and on days 0, 2, 6 and 10 post-shearing ................................................................. 124

5.3 Effect of shearing treatment (standard vs cover comb) on heat production of sheep exposed to cold conditions, either wind or wind+rain, on days 3 and 2 prior to shearing and on days 0, 2, 6 and 10 post-shearing .......................... 126

5.4 Effect of shearing treatment (standard vs cover comb) on body insulation of sheep exposed to cold conditions, either wind or wind+rain, on days 0, 2, 6 and 10 post-shearing .............................................................. 127

5.5 Effect of shearing treatment (standard vs cover comb) on lower critical temperature of sheep exposed to cold conditions, either wind or wind+rain, on days 0, 2, 6 and 10 post-shearing ................................................... 128

5.6 Effect of shearing treatment (standard vs cover comb) on plasma glucose and non-esterified fatty acid concentrations of sheep exposed to cold conditions (wind+rain) on day 2 prior to shearing and on days 0, 2, 6 and 10 post-shearing ................................................................. 129

6.1 Production and financial parameters for a partial budget comparison of pre-lamb shearing by cover comb and conventional shearing (shearing post-weaning) .......................................................... 147

6.2 Partial budget calculation showing the effects of changing from post-weaning to pre-lamb ewe shearing on a sheep farm .......................................................... 148
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Shearing policies in relation to wool growth in the majority of sheep breeds in New Zealand.</td>
</tr>
<tr>
<td>2.1</td>
<td>Average monthly pasture cover for Riverside farm from January 1989 to December 1991</td>
</tr>
<tr>
<td>4.1</td>
<td>Mean Sward height readings, measured by an EPM, over pregnancy and lactation</td>
</tr>
<tr>
<td>6.1</td>
<td>Clean price for wool sold in either September (assumed to be from pre-lamb shearing) or December (assumed to be from conventional shearing) by auction between 1989 and 1993.</td>
</tr>
<tr>
<td>6.2</td>
<td>Average monthly cashflow from July to June 1993 for a sheep and cattle farm wintering 1951 stock units and shearing 1000 mixed age ewes either prior to lambing or after weaning</td>
</tr>
</tbody>
</table>
# LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>air temperature(s)</td>
</tr>
<tr>
<td>b</td>
<td>bite(s)</td>
</tr>
<tr>
<td>BFD</td>
<td>back fat depth</td>
</tr>
<tr>
<td>BI</td>
<td>body insulation</td>
</tr>
<tr>
<td>BLXR</td>
<td>Border Leicester x Romney</td>
</tr>
<tr>
<td>BR</td>
<td>biting rate(s)</td>
</tr>
<tr>
<td>BW</td>
<td>body weight</td>
</tr>
<tr>
<td>CIDR</td>
<td>Controlled Internal Drug Releasing device</td>
</tr>
<tr>
<td>cm</td>
<td>centimetre(s)</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>chromic oxide</td>
</tr>
<tr>
<td>CRC</td>
<td>Controlled Release Capsule</td>
</tr>
<tr>
<td>CS</td>
<td>condition score</td>
</tr>
<tr>
<td>CV</td>
<td>coefficient of variation</td>
</tr>
<tr>
<td>CW</td>
<td>clean wool</td>
</tr>
<tr>
<td>d</td>
<td>day(s)</td>
</tr>
<tr>
<td>P</td>
<td>day of pregnancy (e.g. P118 = day 118 of pregnancy)</td>
</tr>
<tr>
<td>L</td>
<td>day of lactation (e.g. L13 = day 13 of lactation)</td>
</tr>
<tr>
<td>S</td>
<td>day from shearing (e.g. S-2 = 2 days prior to shearing)</td>
</tr>
<tr>
<td>°C</td>
<td>degree(s) Celsius</td>
</tr>
<tr>
<td>°S</td>
<td>degree latitude South</td>
</tr>
<tr>
<td>D</td>
<td>digestibility</td>
</tr>
<tr>
<td>DM</td>
<td>dry matter</td>
</tr>
<tr>
<td>DMD</td>
<td>dry matter digestibility</td>
</tr>
<tr>
<td>DMI</td>
<td>dry matter intake</td>
</tr>
<tr>
<td>DOMD</td>
<td>digestible organic matter in dry matter</td>
</tr>
<tr>
<td>EPM</td>
<td>Ellinbank Pasture Meter</td>
</tr>
<tr>
<td>FD</td>
<td>fibre diameter</td>
</tr>
<tr>
<td>FO</td>
<td>faecal output</td>
</tr>
<tr>
<td>g</td>
<td>gram(s)</td>
</tr>
<tr>
<td>GW</td>
<td>greasy wool</td>
</tr>
<tr>
<td>GH</td>
<td>growth hormone</td>
</tr>
<tr>
<td>ha</td>
<td>hectare(s)</td>
</tr>
<tr>
<td>h</td>
<td>hour(s)</td>
</tr>
<tr>
<td>HFRO</td>
<td>Hill Farming Research Organisation</td>
</tr>
<tr>
<td>HP</td>
<td>heat production</td>
</tr>
<tr>
<td>I</td>
<td>intake</td>
</tr>
<tr>
<td>IU</td>
<td>International unit(s)</td>
</tr>
<tr>
<td>kg</td>
<td>kilograms(s)</td>
</tr>
<tr>
<td>l</td>
<td>litre</td>
</tr>
</tbody>
</table>
LCT lower critical temperature
MJ megajoules
ME metabolisable energy
m metre(s)
μg microgram(s)
μm micrometre(s)
mg milligram(s)
meq milliequivalent
ml millilitre(s)
mm millimetre(s)
mmol millimol
Min minimum
min minute(s)
NEFA non-esterified fatty acids
ng nanogram(s)
N nitrogen
OF oesophageal fistulated
OM organic matter
OMD organic matter digestibility
OMI organic matter intake
pg picogram(s)
PMSG Pregnant Mare Serum Gonadotropin
RT rectal temperature(s)
SSU sheep stock unit
SSH sward surface height(s)
3OHb 3-hydroxybutyrate
s second(s)
vs versus
W watts
Y tristimulus value (green)
Y-Z tristimulus value (yellow)
Z tristimulus value (blue)

Statistical Terms

PSE Pooled Standard Error of Mean
SEM Standard Error of Mean
LSmean Least Square of Mean
SELSM Standard Error of Least Square Mean