

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.

Welfare and performance of newborn and young dairy calves

A THESIS IN PRESENTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE

IN

PHYSIOLOGY

AT MASSEY UNIVERSITY, PALMERSTON NORTH,
NEW ZEALAND.

TAMARA JOHANNA DIESCH

2002

Widmung

Ich widme diese Thesis den beiden wichtigsten Menschen in meinem Leben – meinen Eltern. Eure Liebe, Euer Vertrauen in mich und Eure Unterstützung haben mir geholfen einen Traum zu erfüllen. Ich hab' Euch ganz doll lieb.

I dedicate this thesis to the two most important people in my life – my parents. Your love, trust and support helped me fulfil one of my dreams. I love you so very much.

Acknowledgements

Foremost, I would like to thank my supervisors Professor David Mellor and Associate Professor Kevin Stafford for their continual support and guidance throughout my Masterate. Our meetings motivated me to go on and do my best. I am very grateful for all the time you invested in me. It has been a great experience. Thank you for having me as your student.

Special thanks to my parents without whose financial and moral support and love this endeavour would not have been possible. Thanks for the long phone calls and emails, the photos you send me of the whole family and the parcels filled with chocolates, which continually cheered me up when I got homesick. Also, thanks to the rest of my family for their love and to all my friends all over the world for supporting me.

Special thanks also to my best friend Nicole Tubach and my partner Cedric Priest. You were there when I needed someone to talk to, when I needed someone to let my frustration out at, and when I needed cheering up. Thanks for being there for me and believing in me.

I would also like to thank my fellow students Ngaio Beausoleil, Philippa Mello, Kate Littin and Shauna Sylvester. Thanks for your help in the field (especially for being out there during those cold and rainy nights), but also for your support and friendship during the last two years. Thanks also to Rene Corner for her help with formatting this thesis, for giving me the opportunity to relax with some more calf work and for her friendship.

I would also like to acknowledge Neil Ward for technical assistance, Aimee Charteris for her help with setting up the experiments, Phil Pearce and Marie Russel for the analysis of plasma samples, Colin Holmes for recording the cow body condition scores, Debbie Twiss for her help taking cow blood samples, for her advice and for providing me with information on the veterinary records for the calves of Dairy Farm No. 4, Chris Hunt from AgResearch Palmerston North for supplying me with weather data for the

period of August 2001 and Anne Ridler and her veterinary students for helping blood sampling the cows.

I appreciate the invaluable help and support given by Dairy Farm No. 4 manager Michael-John Burry, by farm supervisor Gareth Evans and the farm staff, which was given generously whenever needed.

Special thanks also to Dean Burnham and Geoff Purchas whose experience in field trial work kept me from being discouraged several times.

Advice and assistance regarding statistical analysis was kindly supplied by Duncan Hedderley. Without your help I would have been lost trying to come to grips with statistical theory ☺!

Lauren Elgie, Glenn Thomas, Hadley Charteris, Jeremy Darby, Ema Tocker, Cheryl McMeekan, Andrew Shepherd, Lauren Weaver, Jo Wrigley, Ximena Tolosa and Gabrielle Stanley provided invaluable assistance sampling newborn calves, sometimes in cold and wet weather and during cold and dark nights. Thank you!

I gratefully acknowledge the financial support for this research project by the Ministry of Agriculture and Forestry (MAF policy), and the scholarship and financial support by the Livestock Improvement Corporation (LIC).

Thanks also to all those calves, which -involuntarily-, participated in the experiments described in this thesis and without which this research would not have been possible.

Approval from the Massey University Animal Ethics Committee has been obtained for the experiments described in this thesis.

Abstract

Physiological evaluation of newborn lambs at birth revealed four main causes of hypothermia and death: placental insufficiency, intrapartum hypoxaemia, inadequate heat production and starvation. No similar evidence seems to be available for calves and thus the present study measures parameters used in previous lamb studies to evaluate the physiological status of calves and the incidence of the four factors in newborn dairy calves.

The study was carried out in the Manawatu region during spring 2001. Multiparous and primiparous cows about to calve were observed continuously. All dystocias were assisted. Within 30 minutes of birth the rectal temperature of each calf and a jugular blood sample were taken. Time to stand on all four feet and birth weight were also measured. The packed cell volume and plasma concentrations of glucose, fructose and lactate were analysed as indices of prenatal and intrapartum status. A subset of calves was then followed up after pick-up to 4 days of age taking rectal temperature twice daily and a jugular blood sample at approximately 24, 48, 72 and 96 hours after birth. Plasma was analysed for glucose, beta-hydroxybutyrate, urea and gamma-glutamyl transferase concentrations to determine energy status of the calves for the first four days after birth and to determine whether calves had sufficient colostrum intake indicative of passive immunity.

The physiological status of calves at birth was fairly uniform. Calves born after dystocia had significantly higher plasma lactate concentrations, took significantly longer to stand and had significantly lower packed cell volumes than normally born calves. The higher plasma lactate concentrations and longer time to stand in these calves indicate hypoxia at birth and reduced vigour. As packed cell volume was not significantly elevated in calves with significantly elevated plasma lactate concentrations it is suggested that placental insufficiency was not a major problem. The majority of calves had relatively high rectal temperatures suggesting that thermogenesis was not impeded.

The majority of calves followed up to 4 days of age were in good energy balance. Starvation and hypothermia were not major issues as judged by relatively high plasma urea and beta-hydroxybutyrate concentrations and rectal temperatures. The majority of

calves had adequate gamma-glutamyl transferase concentrations suggesting effective passive uptake of immunoglobulins. However, all calves that died (n=8) had significantly lower concentrations than calves that became sick and subsequently recovered and those calves that remained healthy.

Overall, the physiological status of the calves of the present study between birth and 4 days of age was adequate. However, immune status plays an important role for the health and welfare of the newborn calves as judged by the fact that all calves that died failed to take in colostrum before pick-up.

Table of Contents

<i>Chapter One:</i>	1
Table of Contents.....	2
1.1 What is animal welfare?.....	3
1.2 What do we know about neonatal calf welfare?.....	10
1.3 Animal welfare implications of neonatal ill-thrift and mortality in calves and lambs.....	11
1.4 Physiological and physical status of calves between birth and 4 days of age	
1.5 Outline of thesis.....	30
<i>Chapter Two:</i>	31
Abstract.....	32
Table of Contents.....	33
2.1 Introduction.....	35
2.2 Materials and Methods	45
2.3 Results.....	52
2.4 Discussion	80
2.5 General Discussion.....	92
<i>Chapter Three:</i>	95
Abstract.....	96
Table of Contents.....	97
3.1 Introduction.....	99
3.2 Materials and Methods	116
3.3 Results.....	126
3.4 Discussion	167
3.5 General discussion.....	182
<i>Chapter Four:</i>	185
4.1 Major conclusions	186
4.2 Experimental design and limitations.....	188
4.3 Practical considerations.....	192
4.4 Where do we go from here?	194
<i>References:</i>	195
<i>Appendix 1:</i>	209

List of Figures

Figure 1.1: The five domains of animal welfare compromise [modified from Mellor & Stafford (2001)].	4
Figure 2.3.1: Correlation of lactate levels between sodium-heparin tubes (Y) and fluoride-oxalate tubes (X).	53
Figure 2.3.2: Percentage of Friesian (blue) and Angus (red) calves in each time to stand bracket (Friesian n=153, Angus n=34).	54
Figure 2.3.3: Mean time to stand (\pm standard error) of Friesian and Angus calves.	55
Figure 2.3.4: Percentage of Friesian (blue) and Angus (red) calves in each rectal temperature bracket (Friesian n=167, Angus n=50).	56
Figure 2.3.5: Mean rectal temperature (\pm standard error) of Friesian and Angus calves.	57
Figure 2.3.6: Percentage of Friesian (blue) and Angus (red) calves in each plasma glucose concentration bracket (Friesian n=169, Angus n=50).	64
Figure 2.3.7: Mean glucose levels (\pm standard error) of Friesian and Angus calves.	65
Figure 2.3.8: Percentage of Friesian (blue) and Angus (red) calves in each plasma lactate concentration bracket (Friesian n=169, Angus n=50).	66
Figure 2.3.9: Mean lactate levels (\pm standard error) of Friesian and Angus calves.	67
Figure 2.3.10: Percentage of Friesian (blue) and Angus (red) calves in each weight bracket (Friesian n=160, Angus n=46).	68
Figure 2.3.11: Mean weight (\pm standard error) of Friesian and Angus calves.	69
Figure 2.3.12: Percentage of Friesian (blue) and Angus (red) calves in each PCV bracket (Friesian n=162, Angus n=48).	70
Figure 2.3.13: Mean packed cell volume (\pm standard error) of Friesian and Angus calves.	70
Figure 2.3.14: Percentage of Friesian (blue) and Angus (red) calves in each plasma fructose concentration bracket (Friesian n=169, Angus n=50).	71
Figure 2.3.15: Mean fructose levels (\pm standard error) of Friesian and Angus calves.	72
Figure 2.3.16: Percentage of Friesian (blue) and Angus (red) calves in each maternal BSC bracket (Friesian n=158, Angus n=48).	73
Figure 2.3.17: Mean maternal body condition score (\pm standard error) for the dams of Friesian and Angus calves.	73
Figure 2.3.18: Percentage of Friesian (blue) and Angus (red) calves born in the six time of day at birth categories, the four weather categories, and the percentage of calves born during different air temperatures (Friesian n=169, Angus n=50).	75
Figure 2.3.19: Summary of significant correlations between different birth variables in Friesian and Angus calves (+ positive correlation, - negative correlation).	78
Figure 3.3.1: Means and standard errors for the plasma glucose concentrations in assisted (n=21) and unassisted (n=85) calves calculated by repeated measures ANOVA.	129
Figure 3.3.2: Means and standard errors for the plasma glucose concentrations in calves with high (n=78) and low (n=28) plasma GGT concentrations calculated by repeated measures ANOVA.	132
Figure 3.3.3: Means and standard errors plasma glucose concentrations in healthy (n=23), sick (n=15) and dying (n=8) calves calculated by repeated measures ANOVA.	133

Figure 3.3.4: Means and standard errors for plasma glucose concentrations in calves younger (n=82) and older (n=24) than 24 hours at pick-up calculated by repeated measures ANOVA.	134
Figure 3.3.5: Means and standard errors for plasma beta-hydroxybutyrate concentration in assisted (n=21) and unassisted (n=85) calves calculated by repeated measures ANOVA.	135
Figure 3.3.6: Means and standard errors for plasma beta-hydroxybutyrate concentrations in calves with high (n=78) and low (n=28) GGT concentrations calculated by repeated measures ANOVA.	137
Figure 3.3.7: Means and standard errors for plasma beta-hydroxybutyrate concentrations in healthy (n=23), sick (n=15) and dying (n=8) calves calculated by repeated measures ANOVA.	138
Figure 3.3.8: Means and standard errors for plasma beta-hydroxybutyrate concentrations in calves younger (n=24) and older (n=82) than 24 hours at pick-up calculated by repeated measures ANOVA.	139
Figure 3.3.9: Means and standard errors for plasma urea concentrations in assisted and unassisted calves calculated by repeated measures ANOVA.	140
Figure 3.3.10: Means and standard errors for plasma urea concentrations in calves with high (n=78) and low (n=28) plasma GGT concentrations calculated by repeated measures ANOVA.	143
Figure 3.3.11: Means and standard errors for plasma urea concentrations in healthy (n=23), sick (n=15) and dying (n=8) calves calculated by repeated measures ANOVA.	144
Figure 3.3.12: Means and standard errors for plasma urea concentrations in calves younger and older than 24 hours at pick-up calculated by repeated measures ANOVA.	146
Figure 3.3.13: Means and standard errors for plasma GGT concentrations in assisted (n=21) and unassisted (n=85) calves calculated by repeated measures ANOVA.	147
Figure 3.3.14: Means and standard errors for plasma GGT concentrations in healthy (n=23), sick (n=15) and dead (n=8) calves calculated by repeated measures ANOVA.	149
Figure 3.3.15: Means and standard errors for plasma GGT concentrations in calves younger (n=24) and older (n=82) than 24 hours at pick-up calculated by repeated measures ANOVA.	150
Figure 3.3.16: Means and standard errors for rectal temperature in assisted (n=21) and unassisted (n=85) calves calculated by repeated measures ANOVA.	152
Figure 3.3.17: Means and standard errors for rectal temperature in calves with high (n=78) and low (n=28) plasma GGT concentrations calculated by repeated measures ANOVA.	154
Figure 3.3.18: Means and standard errors for rectal temperature in healthy (n=23), sick (n=15) and dying (n=8) calves calculated by repeated measures ANOVA.	155
Figure 3.3.19: Means and standard errors for rectal temperature in calves younger (n=24) and older (n=82) than 24 hours at pick-up calculated by repeated measures ANOVA.	156
Figure 3.3.20: Canonical scores of calf follow-up data.	160

List of Tables

Table 1.1: Five domains of potential welfare compromise and how problems may be prevented or minimised (Mellor & Stafford, 2001).....	6
Table 1.2: Symptoms of hypothermia observed in humans (Schimmelpfenig and Lindsey, 1991).....	14
Table 1.3: Criteria to help determine the cause of death in lambs, based on altered blood or plasma composition, birth weight, rectal temperature and age at death (adapted from Barlow <i>et al.</i> , 1987; Mellor, 1988).....	29
Table 2.3.1: Summary of calf data.....	52
Table 2.3.2: Correlations between different variables at birth in Friesian calves. (Correlation coefficient (x), p-value (y), number of animals (z)).....	59
Table 2.3.3: Results of non-parametric one-way ANOVA for Friesian calves (p-values).....	60
Table 2.3.4: Correlations between different variables at birth in Angus calves (correlation coefficient (x), p-value (y), number (z)).....	61
Table 2.3.5: Results of non-parametric one-way ANOVA for Angus calves (p-values).....	62
Table 2.3.6: Results of non-parametric one-way ANOVA for breed comparison (Friesian versus Angus calves) (p-values).....	63
Table 2.3.7: Summary of ANOVA results for significant differences between groups in Friesian (F/+) and Angus (A/*) calves.....	79
Table 3.3.1: Percentages of sick, dead and healthy calves (not sold and remaining healthy for the first 1.5 months of age) in the various groups.....	127
Table 3.3.2: Percentage of calves, younger than 24 hours or older than 24 hours at pick-up in the various groups. (Healthy calves included those remaining healthy for the first four days and being sold shortly thereafter and those remaining healthy between 12 hours and 1.5 months of age on the farm of origin).....	128
Table 3.3.3: Results of repeated measures ANOVA (p-values) for glucose.....	129
Table 3.3.4: Means and standard errors of the mean (SEM) for plasma glucose concentrations (mmol/L) of the various groups (n=number of calves).....	130
Table 3.3.5: Results of repeated measures ANOVA (p-values) for glucose.....	131
Table 3.3.6: Results for repeated measures ANOVA (p-values) for glucose.....	132
Table 3.3.7: Results of repeated measures ANOVA (p-values) for glucose.....	133
Table 3.3.8: Results of repeated measure ANOVA (p-values) for beta-hydroxybutyrate.....	135
Table 3.3.9: Means and standard errors of the mean (SEM) for plasma beta-hydroxybutyrate concentrations (mmol/L) of the various groups (n=number of calves). [As these values were transformed back from a log transformation, two SEM are given (+ and -)].....	136
Table 3.3.10: Results of repeated measure ANOVA (p-values) for beta-hydroxybutyrate.....	137
Table 3.3.11: Results of repeated measure ANOVA (p-values) for beta-hydroxybutyrate.....	138
Table 3.3.12: Results of repeated measure ANOVA (p-values) for beta-hydroxybutyrate.....	139
Table 3.3.13: Results of repeated measure ANOVA (p-values) for urea.....	140
Table 3.3.14: Means and standard errors of the mean (SEM) for plasma urea concentrations (mmol/L) of the various groups (n=number of calves). [As these	

values were transformed back form a log transformation, two SEM are given (+ and -)]	142
Table 3.3.15: Results of repeated measure ANOVA (p-values) for urea	143
Table 3.3.16: Results of repeated measure ANOVA (p-values) for urea	144
Table 3.3.17: Results of repeated measure ANOVA (p-values) for urea	145
Table 3.3.18: Results of repeated measure ANOVA (p-values) for GGT	146
Table 3.3.19: Means and standard errors of the mean (SEM) for plasma GGT concentrations (IU/L) of the various groups (n=number of calves). [As these values were transformed back form a log transformation, two SEM are given (+ and -)].	148
Table 3.3.20: Results of repeated measure ANOVA (p-values) for GGT	149
Table 3.3.21: Results of repeated measure ANOVA (p-values) for GGT	150
Table 3.3.22: Results of repeated measure ANOVA (p-values) for rectal temperature.	152
Table 3.3.23: Means and standard errors of the mean (SEM) for rectal temperature (°C) of the various groups (n=number of calves).	153
Table 3.3.24: Results of repeated measure ANOVA (p-values) for rectal temperature.	154
Table 3.3.25: Results of repeated measure ANOVA (p-values) for rectal temperature.	155
Table 3.3.26: Results of repeated measure ANOVA (p-values) for rectal temperature.	156
Table 3.3.27: Results of the ANCOVA for rectal temperature (relationship between rectal temperature with both air temperature and weather together).	158
Table 3.3.28: Results of non-parametric one-way ANOVA (p-values) (coats n=3, no coats n=103).....	158
Table 3.3.29: Pooled Within-Class Standardized Canonical Coefficients for CDA of follow-up data	159
Table 3.3.30: One-way ANOVA for maternal variables and birth weight (breed and assistance separation).	161
Table 3.3.31: One-way ANOVA for maternal variables and birth weight for healthy, sick and dying calves (no breed separation).	161
Table 3.3.32: Means and standard errors of the mean (SEM) for the maternal variables of mothers of assisted and unassisted calves (n=number of calves).	162
Table 3.3.33: Means and standard errors of the mean (SEM) for the maternal variables of mothers of healthy, sick and dying calves.....	163
Table 3.3.34: Means and standard errors of the mean for all calves followed up during the first four days after birth for all parameters measured.	165