EVALUATION OF DEHORNING DISTRESS AND ITS ALLEVIATION IN CALVES.

A thesis presented in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in Physiology at Massey University

Shauna P. Sylvester
2002
ACKNOWLEDGMENTS

I wish to acknowledge my supervisors, Professor David Mellor and Associate Professor Kevin Stafford for their guidance throughout this work leading to the thesis. I am especially grateful to Professor Mellor for encouraging me to resume my research after a break of several years, and for his inspirational teaching and research leadership. I would like to particularly thank Mr Neil Ward for his willingness to provide expert help and advice, well beyond the call of duty. His computing knowledge, his wide range of technical expertise and his "can-do" attitude were invaluable to me.

I also acknowledge advice on cortisol assays from Associate Professor Keith Lapwood and technical advice from Jane Candy. Funding for the cortisol assays was provided by Massey University research Fund (MURF) and the Ministry of Agriculture and Fisheries (MAF Quality Management).

Field work cannot be carried out alone, but only as a team. That team included Neil Ward, David Mellor, Kevin Stafford, Robert Bruce and Natalie Petrie. Their sense of humour, good conversation and good fellowship helped me through many long hours. I am grateful to Steve Lees, Dave Grant, Gerard Poff and other farm staff at Keebles farm, Tuapaka farm and Jennersmead farm, along with Alan Alexander, who was the director of Animal Health Service Centre.

I wish to thank postgraduates and friends Steve Fox, Natalie Petrie, Cheryl McMeekan, Kate Littin, Janet Sayers, John Sanders and Julie Best-Simanu et al., for their many discussions on the physiological, quotidian and philosophical aspects of this and their work. I would also like to acknowledge other members of the “animal welfare” team, Mark Foreman, Andrew Dinnis, Tamarra Diesch, Phillipa Mello and Ngaio Beausoleil. A special thank you to the many friends, flatmates and family who have supported and encouraged me over the years including: Kath Best and Andrea Lowe, as well as Caroline, Glenn, Marion, Elmar, Paul, Lee and Nancy.
ABSTRACT

In this thesis, the pain-induced distress caused by the husbandry practice of dehorning cattle is assessed and methods to alleviate it are evaluated. At the time this work was conducted there were no comprehensive studies on the effects of amputation dehorning upon the welfare of the cattle. The aims of the study were to assess the distress response after dehorning and to explore the possibilities of alleviating that distress through the use of different dehorning tools, local anaesthetic and/or cauterity of the scoop wound. Changes in plasma cortisol concentrations and behaviour were used as indices of distress. It was anticipated that this research would provide scientific data to aid in the writing of welfare codes and advisory material concerning the dehorning of cattle.

The cortisol and behavioural responses of six-month-old male Friesian calves after treatment were studied. In the cortisol studies, blood samples were taken by venipuncture from the jugular vein of each calf prior to, for the first 9 hours and at 36 h after treatment. Behavioural responses were scored by point scan behaviour sampling for the first 10 h after and on day two between 26 and 29 h after treatment.

Amputation dehoming elicited a marked, biphasic cortisol response that lasted six hours. Dehorning elicited similar cortisol responses irrespective of the tool employed. ACTH bolus (i.v. 0.28µg/kg) elicited a maximal cortisol response. The similarity of the magnitude of the dehorning and ACTH responses suggests that dehorning was extremely distressing. The plateauing of the plasma cortisol values between 1.5 and 3 hours after dehoming suggests the appearance of a second phase of pain, presumably from inflammation. Local anaesthesia virtually abolished the first three hours of the cortisol response after dehoming, after which cortisol concentrations rose transiently. Overall, this equated to a 50% reduction in the integrated cortisol response. Cauterizing the scoop wounds effected a marginal reduction in the cortisol response. The combination of local anaesthesia plus cautering the scoop wound virtually abolished the cortisol response to amputation dehorning. This striking result is reminiscent of pre-emptive analgesia. The destruction of, and the prevention of sensitization of, nociceptors in the wound is thought to contribute to this effect. The four behaviours of tail shaking, head shaking, ear flicking and rumination, met the criteria required to use behaviour as evidence of distress. The interpretation of the behaviour data corresponded with that of the cortisol data.

Taken together, the cortisol and behaviour data from this study, along with the subsequent work it generated, indicate that scoop dehorning is extremely noxious. If the cattle are older and amputation dehorning is necessary, it is recommended that local anaesthetic be given and if practicable combined with either ketoprofen (McMeekan et al., 1998b) or wound cautery. However, it is preferable to dehorn calves when they are younger by cautery disbudding (Petrie et al., 1996b).
# TABLE OF CONTENTS

Title page........................................................................................................... i  
Acknowledgements.............................................................................................. ii 
Abstract .............................................................................................................. iii  
Table of contents.................................................................................................... iv  
List of figures and tables......................................................................................... ix 

## CHAPTER ONE General Introduction ............................................................. 1  
1.0 History of this work ......................................................................................... 1  
1.1 Introduction ..................................................................................................... 1  
1.2 Animal Welfare ............................................................................................... 2  
   1.2.1 Ethics........................................................................................................ 2  
   1.2.2 Legislation ............................................................................................... 3  
   1.2.3 Animal welfare ....................................................................................... 4  
1.3 Stress .............................................................................................................. 6  
   1.3.1 Background ........................................................................................... 6  
   1.3.2 Terminology ........................................................................................... 7  
   1.3.3 Pain.......................................................................................................... 8  
   1.3.4 The Stress Response .............................................................................. 10  
1.4 Measurement of stress ................................................................................. 12  
   1.4.1 Cortisol and behaviour ......................................................................... 12  
   1.4.2 Behaviour ............................................................................................. 12  
   1.4.3 Interpretative problems ........................................................................ 14  
   1.4.4 Critique of analyses ............................................................................. 15  
1.5 Alleviation of pain-induced distress .............................................................. 16  
   1.5.1 Local anaesthetic ................................................................................. 16  
   1.5.2 Cautery ................................................................................................. 16  
1.6 Aims and format of the thesis ........................................................................ 16  

## CHAPTER TWO Critique of the analyses of the cortisol responses .................. 19  
2.0 Abstract ......................................................................................................... 19  
2.1 Introduction ................................................................................................... 19  
2.2 Experimental overview ............................................................................... 21  
   2.2.1 Scientific method .................................................................................... 21  
      Experimental design .................................................................................... 21  
      Data transformations ................................................................................... 21  
      Statistical theory ....................................................................................... 22
2.2.2 Cortisol data analyses ......................................................... 22
2.2.3 Assumptions and limitations of baseline transformations ............. 23
   Raw data ........................................................................ 23
   Adjusted data ............................................................ 24
2.2.4 The problem - 28% of the responses were unusual ...................... 25
   Changing baseline .................................................. 27
   Refractory period to cortisol secretion .................................. 28
   Circadian rhythm .................................................. 28
   Sensitive to pretreatment stress ...................................... 28
2.2.5 Can post-treatment values be used as reference values? .............. 29
2.2.6 Aims ........................................................................ 31

2.3 Materials and Methods .................................................... 32
2.3.1 Data transformations .................................................. 32
2.3.2 Statistical analyses .................................................. 32
2.3.3 Sample data .................................................................. 34

2.4 Results ........................................................................... 36
2.4.1 Cortisol timecourse analyses ........................................ 36
2.4.2 Integrated response analyses ........................................ 37

2.5 Discussion ................................................................. 40

CHAPTER THREE The acute cortisol responses of calves following four
   methods of dehorning ......................................................... 42
3.0 Abstract ........................................................................ 42
3.1 Introduction ................................................................. 42
   3.1.1 Dehorning and production studies ................................ 43
   3.1.2 Dehorning and welfare studies ................................... 45
   3.1.3 Aims of study ................................................... 45
3.2 Materials and Methods .................................................... 47
   3.2.1 Experimental design ............................................. 47
   3.2.2 Blood sampling .................................................. 48
   3.2.3 Treatments .......................................................... 48
   3.2.4 Plasma Cortisol Analysis ....................................... 49
   3.2.5 Statistical Analyses ............................................. 49
3.3 Results ........................................................................... 54
   3.3.1 Pretreatment Cortisol Concentrations ......................... 54
   3.3.2 Control Calves .................................................... 54
   3.3.3 Dehorned Calves .................................................. 54
   3.3.4 ACTH Calves ..................................................... 55
3.3.5 Cortisol timecourse gradients .................................................. 55
3.3.6 36 hour cortisol sample .......................................................... 55
3.3.7 Integrated cortisol responses .................................................... 55

3.4 Discussion ................................................................................. 60
3.4.1 The response to dehorning ....................................................... 60
3.4.2 ACTH (maximal frame of reference) ......................................... 61
3.4.3 Control (minimal frame of reference) ....................................... 62
3.4.4 Biphasic pattern of response to dehorning ................................ 63
  Physiological and anatomical substrates of pain ............................ 63
  Components of the response to dehorning ..................................... 65
3.4.5 Choice of dehorning method ..................................................... 67
3.4.6 Critique of the experimental design .......................................... 68
3.4.7 Conclusions ............................................................................ 69
3.4.8 Epilogue .................................................................................. 69

CHAPTER FOUR Cortisol responses of calves to scoop dehorning with
local anaesthesia and/or cautery of the wound ............................... 70
4.0 Abstract .................................................................................... 70
4.1 Introduction ................................................................................. 70
  4.1.1 Aims of study .......................................................................... 72
4.2 Materials and Methods ............................................................... 73
  4.2.1 Experimental design ............................................................... 73
  4.2.2 Blood sampling ...................................................................... 74
  4.2.3 Treatments ........................................................................... 74
  4.2.4 Plasma Cortisol Analysis ....................................................... 75
  4.2.5 Statistical Analyses ................................................................ 76
4.3 Results ....................................................................................... 80
  4.3.1 Pretreatment Cortisol Concentrations ..................................... 80
  4.3.2 Data excluded from the analyses as outliers .......................... 80
  4.3.3 Cortisol responses to treatment .............................................. 80
    Control and LA-Control ................................................................ 80
    Scoop ........................................................................................ 81
    LA-Scoop .................................................................................. 81
    Scoop compared to LA-Scoop and LA-Control .......................... 81
    Scoop+Cautery ......................................................................... 81
    Scoop+Cautery compared to Scoop .......................................... 82
    LA-Scoop+Cautery .................................................................... 82
CHAPTER SIX General Discussion .................................................. 137

6.1 Conclusions ........................................................................... 137
   6.1.1 Dehorning ....................................................................... 138
   6.1.2 Local anaesthetic ........................................................... 138
   6.1.3 Local anaesthesia and cautery of the wounds ................ 140
   6.1.4 Recommendations .......................................................... 141

6.2 Subsequent work ................................................................. 141
   6.2.1 Amputation dehorning ...................................................... 141
   6.2.2 Disbudding ..................................................................... 143

6.3 Pain-induced distress - insights .............................................. 143

6.4 Future directions and Critique of the experimental design ........ 145

BIBLIOGRAPHY ............................................................................ 147

APPENDICES ............................................................................. 165

A Presentations and publications of this work ................................. 165
   Sylvester et al., 1993 ............................................................... 166
   Sylvester et al., 1998b .............................................................. 167
   Sylvester et al., 1998a .............................................................. 171

B Data excluded from the analyses .............................................. 176

C The cortisol radioimmunoassay ................................................ 179
LIST OF FIGURES AND TABLES

Table 1.1  Major attributes of pain  ................................................................. 9
Fig 1.1  Schematic diagram of the major components of the hypothalamic-
pituitary-adrenal axis  ........................................................................ 11
Fig 2.1  Schematic diagram showing the calculation of the integrated
cortisol responses using raw and adjusted\textsuperscript{pre.tmt} data .................................. 24
Fig 2.2  Schematic diagram of the cortisol timecourse of the subpopulation ...... 26
Table 2.1  Sample data, data series 5, 3, 4 and 2 .............................................. 34
Table 2.2  Statistics of the pretreatment and post-treatment cortisol reference
values .................................................................................................. 36
Table 2.3  Integrated responses (ng.hr/ml) of data series "5", "3", "4" and "2"
using raw, adjusted\textsuperscript{pre.tmt} and adjusted\textsuperscript{post.tmt} data (mean ±
SEM) ................................................................................................ 37
Fig 2.3  Cortisol timecourse of data series 5 and 3, using raw,
adjusted\textsuperscript{pre.tmt} and adjusted\textsuperscript{post.tmt} data ........................................ 38
Fig 2.4  Cortisol timecourse of data series 4 and 2, using raw,
adjusted\textsuperscript{pre.tmt} and adjusted\textsuperscript{post.tmt} data ........................................ 39
Fig 3.1  Dehorning equipment ........................................................................... 51
Fig 3.2  Horn removal using the embryotomy wire ........................................... 51
Fig 3.3  Horn removal using the scoop dehorner .............................................. 52
Fig 3.4  The blood sampling procedure ............................................................. 53
Fig 3.5  Relationship between the pretreatment cortisol concentrations and
order in which the calves were sampled .................................................. 56
Fig 3.6  Changes in plasma cortisol concentrations of calves in response to
Scoop dehorning and Control handling and bloodsampling .......................... 57
Fig 3.7  Changes in plasma cortisol concentrations of calves in response to
Scoop, Saw, Guillotine shears and Embryotomy wire dehorning .................... 57
Fig 3.8  Changes in plasma cortisol concentrations of calves in response to
ACTH bolus and Control handling and bloodsampling ............................... 58
Fig 3.9  Changes in plasma cortisol concentrations of calves in response to
Scoop dehorning, ACTH bolus and Control treatment ................................. 58
Table 3.1  Characteristics of the cortisol responses for each group ..................... 59
Fig 3.10  Schematic diagram of the cortisol timecourse after dehorning .......... 66
Fig 4.1  Injection of local anaesthetic ............................................................. 78
Fig 4.2  The cautery iron .................................................................................. 79
Fig 4.3  Relationship between the pretreatment cortisol concentrations and
order in which the calves were sampled .................................................. 84
Fig 4.4 Changes in plasma cortisol concentrations of calves in response to Control and LA-Control treatment .................................................. 85
Fig 4.5 Changes in plasma cortisol concentrations of calves in response to Scoop dehorning and Control handling and bloodsampling ..................... 85
Fig 4.6 Changes in plasma cortisol concentrations of calves in response to LA-Scoop and LA-Control treatment .............................................. 86
Fig 4.7 Changes in plasma cortisol concentrations of calves in response to LA-Scoop and Scoop treatment .................................................. 86
Fig 4.8 Changes in plasma cortisol concentrations of calves in response to Scoop+cautery and Control treatment ......................................... 87
Fig 4.9 Changes in plasma cortisol concentrations of calves in response to Scoop+cautery and Scoop treatment ......................................... 87
Fig 4.10 Changes in plasma cortisol concentrations of calves in response to LA-Scoop+cautery and LA-Control treatment ...................................... 88
Fig 4.11 Changes in plasma cortisol concentrations of calves in response to LA-Scoop+cautery and LA-Scoop treatment ...................................... 88
Table 4.1 Characteristics of the cortisol responses for each treatment group .. 89
Table 5.1 Percentage incidence of all behaviours (day 1) .............................................. 116
Fig 5.1 Number of calves ruminating (day 1) ...................................................... 118
Fig 5.2 Number of calves tail shaking (day 1) ...................................................... 119
Fig 5.3 Number of calves head shaking (day 1) .................................................... 120
Fig 5.4 Number of calves ear flicking (day 1) ...................................................... 121
Fig 5.5 Number of calves neck extending (day 1) ................................................ 122
Fig 5.6 Number of calves leg scratching to face (day 1) ....................................... 122
Fig 5.7 The timecourse of the restlessness index of calves after Scoop, LA-Scoop and Control treatment (day 1) ............................................. 123
Fig 5.8 Changes in the cortisol concentrations of calves after Scoop, LA-Scoop and Control treatment (day 1) ............................................. 123
Table 5.2 The percentage of calves head shaking, ear flicking, tail flicking or ruminating on day two after treatment ............................................. 124
Fig B.1 The cortisol timecourse of calves with aberrant responses ...................... 178
Fig B.2 The cortisol timecourse of calves where the local anaesthetic did not work ................................................................. 178
Fig B.3 The cortisol timecourse of calves experiencing a pre-existing stress ................................................................................. 178
Table C.1 The setting up of the radioimmunoassay and the appropriate controls ................................................................. 181