



**Metabolic maturity and vigour in neonatal lambs, and subsequent
impacts on thermoregulation and survival**

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Bachelor of Animal Science (Honours)

A thesis submitted for fulfilment of the requirements for the degree of

Doctorate of Philosophy

The School of Animal and Veterinary Sciences

The University of Adelaide

Roseworthy, South Australia

Australia

October 2013

Abstract

Lamb mortality in Australia averages approximately 20%, representing a major constraint to the profitability of sheep enterprises and compromised animal welfare. Most postpartum lamb loss occurs within the first three days of life and is largely caused by starvation, exposure to cold conditions and mismothering from the ewe. In this thesis we developed an over-arching hypothesis that differences in metabolic or physiological maturity exist between lambs, and that these differences relate to early postnatal vigour and survival, particularly during exposure to cold conditions. To test this hypothesis, behaviour associated with initial vigour was quantified in breeds of sheep which differ widely in neonatal survival and more specifically, risk of hypothermia. Pre-suckling blood samples were collected from these animals in order to identify potential markers of maturity chosen to represent the hypothalamic- pituitary- adrenal (HPA) axis, renal function and energy metabolism. A number of metabolite and endocrine shifts were identified in those that were quicker to reach the udder of the ewe and begin sucking. Namely, creatine, non-esterified fatty acids, leptin and ghrelin concentrations were elevated, implying these individuals may be better able to regulate energy mobilisation soon after birth.

Lamb vigour was also strongly associated with rectal temperature at birth, indicating an association between maturity, post-natal behaviour and thermogenesis. A controlled water bath testing system was then used to experimentally induce mild hypothermia in the lambs, and metrics of thermoregulation included time taken for core body temperature to reach 35°C (cold resistance), and time to restore core temperature to 39°C (cold recovery). Lambs that were slow to stand and reach the udder had impaired cold resistance. None of the physiological measures (circulating metabolite and hormone concentrations at birth) were related to performance in the water bath. Somewhat surprisingly, those lambs identified as being more mature, as assessed by speed to perform peri-natal behaviours and physiological blood measures, experienced a delay in cold recovery when compared to those with lower vigour and maturity. We proposed that this may be due to a reduced ability to perform non-shivering thermogenesis in more mature individuals (as is observed to occur with age), but this need further exploration.

Given these strong relationships between maturity, peri-natal vigour and thermogenesis, an attempt to alter the metabolic maturity of newborn lambs was made. Peri-conception nutrition was shown previously to influence fetal HPA axis activation (responsible for the

maturation of a suite of fetal systems) hence differing nutritional treatments (0.7, 1.0 and 1.5 maintenance energy requirement) were applied to the ewes at this time. No effect of peri-conception nutritional manipulation on lamb survival was observed, but lambs from ewes fed a restricted diet around conception exhibited a decreased crown-rump length when compared to those from the high energy treatment. Whilst this had no effect on survival, under more inclement conditions this finding may increase risk of hypothermia through effects on surface area dependent heat loss.

In summary, the findings presented in this thesis provide strong evidence that the metabolic maturity of lambs at birth is related to initial vigour and thermoregulatory ability, two traits that are closely linked with survivability. The attempt to reduce lamb mortality through altering HPA axis activation by nutritional means had limited effects on lamb phenotype. Consequently, peri-conception nutrition failed to influence lamb survival. Future investigations should target other means by which metabolic maturity at birth can be enhanced in order to improve lamb survival.

Thesis Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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Acknowledgements

Even after multiple forewarnings, I was completely unaware of the commitment, thought and dedication this doctorate would require. It is only because of the following people that the submission of this thesis has occurred.

Firstly, the mentoring provided by my three supervisors was instrumental for the completion of the experimental processes presented in the following document. Professor Phil Hynd, your vast endocrine knowledge, critical thinking, enthusiasm at findings and fine wine advice has helped shape the researcher (and drinker) I am today. I hope you can proudly say I now 'think like a PhD student'. Associate Professor Forbes Brien, without your polite, persistent suggestion I commit to a PhD after my honours year I would not have undertaken this challenge. For this, and your unequivocal expertise in lamb survival, I am eternally grateful as you are responsible (good or bad?) for my career in research. Lastly, Dr Michelle Hebart, I promise there will be no more begging for data re-analysis. After many years (and the birth of your three children) we are done with our statistical partnership. My future students and I will gain from the insights you have shared.

Surrounding yourself with amazing people is one way to ensure the successful and enjoyable completion on of PhD. Luca Prisciandaro, Ruth Lindsay and Sarah Truran- we embarked on this challenge together as naive undergraduates and we subsequently became lifelong friends. Thank you for the long days in the lambing shed, long lunches in the feedlot, and long nights in the city- all of which helped relieve anxiety and stress. Additionally, none of the animal work could have been completed without the research team at SARDI Turretfield Research Centre, so I wish to thank Daryl Smith, Kaylene and Anthony Jaensch, Richard Grimson, John Evans, Jack Irvine, Ian Gollan and Greg Matiske. Fellow Davies Building inhabitants Bob Hughes, Phil Stott, Natasha Penno, Nicole Heberle, Kylie Chenoweth and Rebecca Forder, you all helped and contributed in unique ways.

Lastly, none of this could have been achieved without the support of my family. Stu, you really are the best husband going around, I love you with my whole heart. Girls, thank you being makeshift mums to orphaned lambs, and the licks you gave when I needed them most. Mum, you are the world's most patient and compassionate lambing observer. Dad, Clare and Seamus, your love from Glasgow was felt miles away in an old South Australian shearing shed. This thesis is a testament to all of you.

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