Reproductive Strategies of Adult Female Weddell Seals (*Leptonychotes weddellii*) and Their Implications for Pup Survival

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Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

University of Tasmania

September, 2007

Declaration of originality

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any tertiary institute, and that, to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Kathryn E. Wheatley September 19th, 2007

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Thesis Abstract

Life history strategies reflect variation in the allocation of an individual's resources (i.e., time, effort and energy expenditure) to competing life functions such as growth, survival and reproduction. For mammals, producing milk is one of the most energetically expensive activities for females, so factors determining its delivery to offspring essentially define the reproductive strategy a species evolves. The efficiency with which energy is transferred via milk also determines the reproductive investment trade-off that exists between survival and future reproduction. The key objective of this study was to examine physiological aspects of lactation in Weddell seals (*Leptonychotes weddellii*), to gain a better understanding of reproductive strategies of an upper trophic level predator that must cope with unpredictable food availability in an extreme and highly variable environment.

Female body mass (and absolute body fat) at parturition differed between the two years of study and this difference appeared to drive the length of the lactation period, maternal energy expenditure, pup mass gain and weaning mass. Effects were more marked in smaller individuals that did not increase energy expenditure to reconcile this disparity.

Milk composition was independent of maternal post-partum mass (MPPM) and condition, but did change over lactation. Protein tripled from post-partum (PP) to end-lactation (EL) while lipid and energy increased to mid-lactation (ML) then slightly decreased. This pattern of changes may be related to the relatively long lactation period demonstrated by this species and the energetic and physiological needs of the mother and pup. There was evidence through both milk energy output and fatty acid transfer that feeding occurred in some individuals later in lactation.

A major source of energy during lactation is provided through the mobilisation of blubber fatty acids (FA). I investigated the extent to which FA were mobilised to support both maternal metabolic requirements and milk production, and how this was reflected in the FA composition of the pups at EL. Fatty acid composition at PP was similar in females from both years indicating similar diets. However, selective mobilisation and transfer did occur during lactation which not only affected the vertical stratification of FA within the blubber layer but also the composition of the pups at EL. This was related to total body lipid stores of females at PP. It appears that

selective mobilisation was most likely related to the physiological requirements of the developing pup. Highly mobilised fatty acids are underestimated in the blubber and affect diet predictions. Failing to account for mobilisation during periods of high turn-over may seriously bias FASA diet estimates. Results suggest that dietary predictions will be improved when samples are taken at parturition.

Differences in MPPM between years reflects environmental variability during the period of prey acquisition, and this manifests as differences in expenditure during lactation. These differences translate to changes in pup mass and condition at weaning with consequences for future survival and recruitment. My results confirm that differences in life history strategies exist within lactating Weddell seals and the trade-off between long-term survival in breeding females and the success of their offspring is contingent on individual size, which is further complicated by feeding to offset nutritional constraints imposed during poor-resource years.

Statement of publication and co-authorship

Publications produced as part of this thesis:

Wheatley, K.E., C.J.A. Bradshaw, R.G. Harcourt, L.S. Davis and M.A. Hindell (2006). Chemical immobilisation of adult female Weddell seals with tiletamine and zolazepam: effects of age, condition and stage of lactation. *BMC Veterinary Research* **2:8**

Wheatley, K.E., C.J.A. Bradshaw, L.S. Davis, R.G. Harcourt and M.A. Hindell (2006). Influence of maternal mass and condition on energy transfer in Weddell seals. *Journal of Animal Ecology* **75(3)**: 724-733 (Featured cover image).

Wheatley, K.E., C.J.A. Bradshaw, R.G. Harcourt and M.A. Hindell (*in review*). Feast or Famine: evidence for mixed capital-income breeding strategies in Weddell seals. *Oecologia*

Wheatley, K.E., P.D. Nichols, M.A. Hindell, R.G. Harcourt and C.J.A. Bradshaw (*in review*). Differential mobilisation of blubber fatty acids in lactating Weddell seals: evidence for selective use. *Physiological and Biochemical Zoology*

Wheatley, K.E., P.D. Nichols, M.A. Hindell, R.G. Harcourt and C.J.A. Bradshaw (*in press*). Temporal variation in the vertical stratification of blubber fatty acids alter diet predictions for lactating Weddell seals. *Journal of Experimental Marine Biology and Ecology*

Additional publications resulting from work during candidature:

Collins, K.T., T.L. Rogers, J.M. Terhune, P.D. McGreevy, K.E. Wheatley and R.G. Harcourt (2005). Individual variation of in-air female 'pup contact' calls in Weddell seals, *Leptonychotes weddellii*. *Behaviour* **142(2)**: 167-189.

Collins, K.T., J.M. Terhune, T.L. Rogers, K.E. Wheatley and R.G. Harcourt (2006). Vocal individuality of in-air Weddell seal (*Leptonychotes weddellii*) pup "primary' calls. *Marine Mammal Science* **22(4)**: 933-951.

Proffitt, K.M., R.A. Garrott, J.J. Rotella and K.E. Wheatley (2007). Environmental and senescent related variations in Weddell seal body mass: implications for age-specific reproductive performance. *Oikos* 116: 1683-1690.

The following people and institutions contributed to the publication of the research undertaken as part of this thesis:

Mark A. Hindell (University of Tasmania) and Corey J.A. Bradshaw (Charles Darwin University) assisted with guidance and supervision in all aspects of the PhD research and producing publishable manuscripts.

Robert G. Harcourt (Macquarie University) assisted with fieldwork and critically reviewing manuscripts for publication.

Peter D. Nichols (CSIRO Marine and Atmospheric Research) provided guidance with fatty acid analysis and producing quality manuscripts.

Lloyd S. Davis (University of Otago) provided assistance with fieldwork and reviewing manuscripts for publication.

We the undersigned agree with the above stated “proportion of work undertaken” for each of the above published (or submitted) peer-reviewed manuscripts contributing to this thesis:

Mark A. Hindell	Susan M. Jones
(Candidate’s Supervisor)	(Head of School)

Acknowledgements

It has been a pleasure and privilege to be able to work with such a magnificent animal, the Weddell seal. It was amazing to have the opportunity to watch the pupping season from beginning to end. Females are so fat, and give so much while the pups are beyond adorable and a source of delight to watch grow up. I hope their success as a species continues.

The work for this thesis was hampered by many problems, from funding to field and laboratory work. Completion was questionable at times, but through perseverance I have grown and learned a lot. This would not have been possible without the support and advice of many, particularly my supervisors Mark Hindell and Corey Bradshaw. Their guidance and encouragement helped me through uncertain times to become a better scientist and person. It has been a pleasure to work with them both. Although not an "official" supervisor, I am also indebted to Rob Harcourt for all of his help and support.

I would like to thank Peter Nichols for his guidance and patience during the fatty acid analysis part of this study. He welcomed me into his lab at CSIRO to the point where it was difficult to leave, and provided valuable advice and knowledge contributing to two chapters of this thesis. Peter further provided lab space for my milk composition analyses, and I thank Mina Brock for her help with protein analysis. Also, I owe a big thanks to Ben Mooney for his help with the gas chromatographic analyses.

I am indebted to my many people for their time, knowledge, experience and help. First of all, I wouldn't have been able to get to Scott Base (New Zealand) without the support of Lloyd Davis and Rob Harcourt. I wouldn't have been able to catch as many seals if it hadn't been for Randy Davis and Weddell World lending me equipment when mine went missing in transit. My fellow postgraduates at the Antarctic Wildlife Research Unit (AWRU) have provided a stimulating and fun environment over the years, making work a good place to be. Volunteers from Scott Base eagerly assisted in the field when needed (both years), and I would especially like to thank my field assistants Charles Littnan, Don Geddes, Willie Cook, Peter Isherwood, Paul Brewin and Ailsa Hall for their energy and enthusiasm.

Funding for this project came from several sources, without which none of this would have happened: the University of Tasmania Institutional Research Grant Scheme

awarded to Mark Hindell, an Australian Research Council Discovery Project grant (DP0342714) to Corey Bradshaw and a Sea World Research & Rescue Foundation Inc. grant to Rob Harcourt. Antarctica New Zealand provided logistics support for my two field seasons and the Australian Antarctic Division provided field clothing for myself in both years.

Finally, I have to say 'thank-you' to all my friends and family, scattered around the world, to my guide dog puppy Rosie, although she didn't 'guide' me in the traditional sense she was a wonderful companion and a constant source of enjoyment through the later stages of my PhD, and the Puppy Walkers who were very supportive in all of my endeavours. To my Grandmother, who has been like another mother and has always given me never ending encouragement, support and love throughout the years, words are not enough.

Table of Contents

List of Abbreviations

Abbreviation	Measurement
%DE	per cent deviance explained by each model
%L	per cent lipid content of milk
%ME	per cent milk energy
%P	per cent protein content of milk
%W	per cent water content of milk
AIC_c	Akaike's Information Criterion corrected for small samples
DF	discriminant function
DFA	discriminant function analysis
dpp	days post-parturition
$\Delta w+$	predictor weight of evidence
EFA	essential fatty acid
EL	end-lactation
ER	information-theoretic evidence ratio
FA	fatty acid(s)
FASA	fatty acid signature analysis
GC	gas chromatographic
GLM	generalized linear model
GLMM	generalized linear mixed-effects model
HDO	deuterium oxide
HTO	tritiated water
IM	intramuscular
IV	intravenous
LC-MUFA	long-chain monounsaturated fatty acid
MI	milk intake
ML	mid-lactation
MPPM	maternal post-partum mass
PCA	principal component analysis
PP	post-parturition
PUFA	polyunsaturated fatty acid
SC-MUFA	short-chain monounsaturated fatty acid
SEM	standard error of the mean
SFA	saturated fatty acid
TAG	triacylglycerol
TBL_{MPPM}	total body lipid at post-partum
TBP_{MPPM}	total body protein at post-partum
TBW	total body water
TWI	total water influx