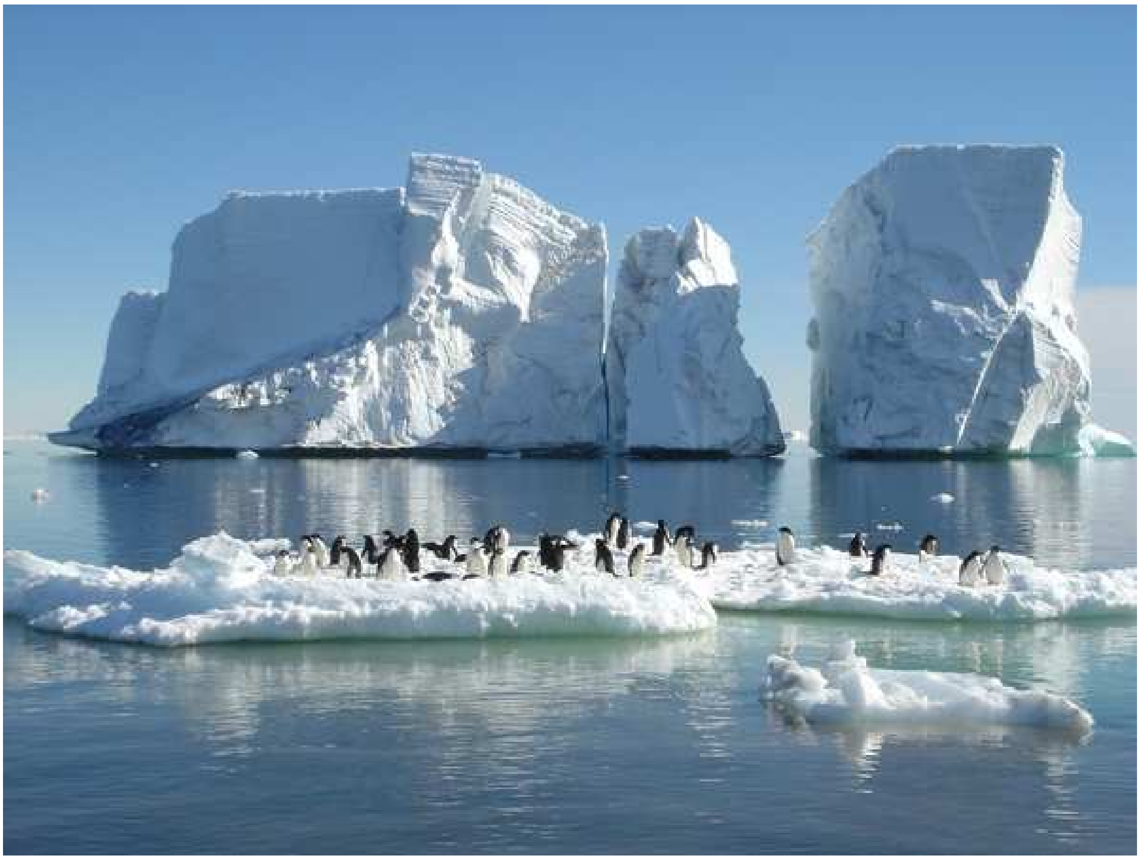
# POLAR EVOLUTION: MOLECULAR GENETIC AND PHYSIOLOGICAL PARAMETERS OF ANTARCTIC ARTHROPOD POPULATIONS

A thesis presented in partial fulfilment of the requirements for the degree of
Doctor of Philosophy in

Molecular Biosciences

at the Allan Wilson Centre for Molecular Ecology and Evolution,
Institute of Molecular Biosciences, Massey University, Palmerston North, New Zealand

Angela McGaughran
2009



Ice floe off Cape Bird, with Adélie penguins on board; January 2007

*To move forward relentlessly in the quest for discovery;*
*And yet to not pass by the moments of perfect tranquillity*

# ABSTRACT

This thesis is presented as a collection of research papers synthesising knowledge gained during the period of candidacy. Its underlying focus is the examination of evolution from a variety of perspectives for terrestrial arthropods (springtails) in an Antarctic setting. These perspectives include investigation of the ways in which springtail populations respond both physiologically and genetically to environmental variability over historical and contemporary time-scales. While the physiological and genetic may seem two worlds apart, this thesis recognises that, in reality the two are inextricably linked. Thus, when genetic differentiation between populations of the same species can be demonstrated, physiological differentiation of these populations may also be predicted (and *vice versa*). Therefore, across several locations and springtail species, physiological and genetic parameters of individuals and populations are examined both separately and, where possible, in concert.

The physiological aspect of this thesis focuses on the springtail *Gomphiocephalus hodgsoni* from continental Antarctica. In addition to providing the first metabolic rate data for a continental Antarctic springtail, seasonal variation in metabolic rates is examined across multiple temporal and spatial scales to evaluate the ways in which individuals and populations respond to environmental variability. Metabolic activity in this species is intricately linked to a variety of factors, both intrinsic and extrinsic. These include biological function, temperature profiles in the local microclimate, and body mass and genetic differences among populations.

In the genetically-focused aspect of this thesis, population genetic patterns of *G. hodgsoni* from several continental locations and *Cryptopygus antarcticus antarcticus* from locations across the Antarctica Peninsula are compared. Here, the importance of differing evolutionary histories in influencing patterns of contemporary genetic population structure is highlighted. While both species have been similarly affected genetically by Pleistocene (2 Ma – present) glacial cycling, it is clear that differences in timing of colonisation events and subsequent population expansions have left distinct genetic signatures in each species. In a separate molecular study, phylogenetic analyses are employed to study members of the circum-Antarctic springtail family Isotomidae.

The genetic ancestry among these closely related species is shown to reflect a diverse evolutionary origin in the Miocene (23 – 5 Ma), subsequent to which both vicariant and dispersal processes have been important. Phylogenetic re-constructions tease out the relationships among sister species, and the identification of several genetically distant lineages suggests that a revision of current species designations is required.

Finally, two studies that integrate the physiological and molecular genetic are presented. First, metabolic rate variation across several locations on sub-Antarctic Marion Island in the springtail *Cryptopygus antarcticus travei* is examined. This variation is related to the genetic structure of populations to show that historical and contemporary environmental characteristics have left their trace in the expression of both genetic and physiological variability of these populations. Second, the perceived association between metabolic rate and genetic (mutation) rate is investigated more closely - a sophisticated Bayesian correlation analysis detects that there is an indirect relationship between metabolic rate and underlying species phylogeny in *C. a. travei*.

Thus, the physiological and molecular genetic elements of this thesis test or advance important hypotheses within their own fields, and the integrated approach applied is a new step in interpreting evidence of physiological adaptation in Antarctic species. In its multi-faceted approach to evolutionary studies, this thesis enhances understanding of the current picture of springtail evolution in polar environments.

## ACKNOWLEDGEMENTS

No thesis would be possible without the input of supervisors, in guise small and large, positive and negative, valuable and annoying! Thus, I wish to start by thanking them all: David Penny, Mark Stevens, Barbara Holland and Pete Convey. I wish to thank David for taking me on in the first place, supporting me financially over the final 6 months, and mostly for making me think differently because you do. Our discussions were always entertaining, always a little side-tracked and often inspirational. Mark drew me to Massey at the beginning and a lot has taken place over the years since. While it didn't all come out smelling roses, we endured, and I think the final result is something we can both be proud of. Barbara, I leaned on a lot over the final six months of my PhD. I really enjoyed the moments where you took the time to properly teach me – with your help I now feel like I actually know (a little) something about phylogenetics! Finally, Pete kind of copped a handful coming on board about a third of the way in to my PhD. For me, our collaboration has been interesting and educational (is there anything you don't know?) and I really appreciate the time you've taken to answer my questions and evaluate my work as well as be a friend. It was also a special bonus having you out at Cape Bird (where I could bug you 24/7!) – maybe one day I'll get over to your side!

I'd like to thank everyone who has helped me in ways both little and small throughout the course of my research. This includes everyone at the Allan Wilson Centre, but especially Renae Pratt and Trish McLenachan who helped me out with the inevitable lab hiccups (always with a smile). What I know of physiology I have essentially 'learnt on the job' and, in addition to a LOT of reading, discussions with Gabe Redding, John Tweedie, Brent Sinclair, Valdon Smith and Pete Convey greatly helped me out. For the administrative side of things, I thank Karen Sinclair, Joy Wood and Susan Adams.

For both work-related things and otherwise, I thank Renae Pratt, Liat Shavit-Grievink, Andrew Clarke, Gabe Redding, Ian Hogg, Tracey Jones, Charlene Scheepers and Emily Atkinson for their friendship, support and advice at various times throughout.

From the first, I have had a sense of awe and excitement about working in Antarctica and my trips south have nourished this. It is with enthusiasm and privilege that I have pursued my research to date (could I really complain about work when I had penguins, seals and killer whales (Cape Bird) and the Royal Society Ranges (Garwood Valley) as back-drop?) and this has fostered in me a life-long love and commitment for Antarctica. In lieu of this, I thank Ian Hogg for the opportunity of the first trip, and I thank Kelly Tarlton's Underwater World, Sir Robin Irvine and Antarctica New Zealand for providing/administering the student scholarships that permitted me to head South for both the first (during my MSc), and three subsequent (PhD) field seasons. I wish to thank Shulamit Gordon especially, whose dealings with me through the years have been friendly, helpful and supportive. While my work in the field was mostly a solo endeavour, I always had people from other science events around, and I'd like to thank them now for their company. This includes everyone from Marion Island station (2007), the penguin group at Cape Bird (2006/07 and 2007/08) and the Waikato group at Garwood Valley (2008/09). Special thanks to Kerry Barton for making the first Cape Bird season so special, and to Grace Tiao for a memorable New Years in 2009!

Finally, and most importantly, I wish to thank my family. In particular, I'd like to thank Liz Phillips – for all of her support, from both near and far. For all the visits, all the phone-calls and all the hugs; but mostly for all the listening and for just being my mum. You've always been there for me and once again, any of my accomplishments are yours to be proud of too.

To the one who was here with me through it all: Nico – I'm not sure how to thank you enough. We've been through so much together over the last three years, and oh yeah, the thesis too! You've supported me, you've listened, you brought me vee in wine glass; you drew me a bath with candles, you bring me Amber and Fossil (who we couldn't do without), you let me sing! Thank you. I love you and look forward to our future together (*sans* the thesis!).

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