

**Invasive Fireweed in Australia:  
Exploring the Invasion Dynamics of *Senecio  
madagascariensis* using Population Genetics**

**By Eleanor Elizabeth Dormontt**

**School of Earth and Environmental Sciences**

**The University of Adelaide**

**Submitted for the degree of Doctor of Philosophy in April 2013**



## Table of Contents

<b>Abstract</b> .....	II
<b>Originality Statement</b> .....	IV
<b>List of Publications and Associated Copyright Holders</b> .....	V
<b>Dedication</b> .....	VI
<b>Acknowledgements</b> .....	VII
<b>Chapter 1</b> Introduction, including excerpt from: Dormontt EE, Lowe AJ, Prentis PJ. 2011. Is rapid adaptive evolution important in successful invasions? In: Richardson DM ed. <i>Fifty Years of Invasion Ecology: The Legacy of Charles Elton</i> . 1st edition, Blackwell Publishing Ltd .....	1
<b>Chapter 2(i)</b> Wilson JRU, Dormontt EE, Prentis PJ, Lowe AJ, Richardson DM. 2009b. Something in the way you move: dispersal pathways affect invasion success. <i>Trends in Ecology &amp; Evolution</i> , 24: 136-144. ....	51
<b>Chapter 2(ii)</b> Wilson JRU, Dormontt EE, Prentis PJ, Lowe AJ, Richardson DM. 2009a. Biogeographic concepts define invasion biology. <i>Trends in Ecology &amp; Evolution</i> , 24: 586-586 .....	63
<b>Chapter 3</b> Dormontt EE, Gardner MG, Breed MF, Rodger JG, Prentis PJ, Lowe, AJ. Sequential genetic bottlenecks in time and space: Reconstructing invasions from contemporary and historical collections.....	66
<b>Chapter 4</b> Dormontt EE, Gardner MG, Prentis PJ, Lowe AJ. Australia First: Is Australia the bridgehead for intercontinental invasions of the global weed, <i>Senecio madagascariensis</i> ? .....	114
<b>Chapter 5</b> Prentis PJ, Wilson JRU, Dormontt EE, Richardson DM, Lowe AJ. 2008. Adaptive evolution in invasive species. <i>Trends in Plant Science</i> , 13: 288-294 .....	137
<b>Chapter 6</b> Dormontt EE, Prentis PJ, Gardner MG, Lowe AJ. Occasional hybridisation between a native and invasive species pair unlikely to contribute to invasive success.....	146
<b>Chapter 7</b> Dormontt EE, Gardner MG, Prentis PJ, Ostendorf B, Lowe AJ. Detecting outlier loci and putative selective agents in a rapid plant invader .....	184
<b>Chapter 8</b> Conclusions, including excerpt from: Dormontt EE, Lowe AJ, Prentis PJ. 2011. Is rapid adaptive evolution important in successful invasions? In: Richardson DM ed. <i>Fifty Years of Invasion Ecology: The Legacy of Charles Elton</i> . 1st edition, Blackwell Publishing Ltd .....	214
<b>Appendices</b> .....	230

## Abstract

*Senecio madagascariensis* (fireweed) is an herbaceous flowering plant native to South Africa and known to be invasive in Australia, Argentina, Brazil, Hawaii and Japan. Fireweed first appeared in the Australian herbarium record in 1918 but little is known about its invasion dynamics. This thesis presents detailed molecular genetic analyses of *S. madagascariensis* in Australia and native South Africa, as well as broad biogeographic analysis of *S. madagascariensis* invasions from around the world. The thesis aims were to elucidate geographic source, mode of introduction, spread dynamics, hybridisation outcomes with an Australian congener, and potential for adaption to the Australian environment.

Using nuclear and chloroplast microsatellites, populations from across the range in Australia and in the KwaZulu Natal province of South Africa were genotyped. Additionally, chloroplast microsatellites were used to genotype all *S. madagascariensis* specimens held in the Queensland Herbarium, National Herbarium of Victoria and National Herbarium of New South Wales, and from contemporary populations in all other known invasive ranges of the species across the world. Amplified fragment length polymorphisms (AFLPs) were used to study the outcome of hybridisation between *S. madagascariensis* and a *S. pinnatifolius* 'dune variant' in natural populations, and to look for evidence of potential selection acting on the genome.

Results indicate that *S. madagascariensis* was introduced at least twice to Australia and has resulted in sequential bottlenecks due to seeding of new invasion foci from material within Australia. Global *S. madagascariensis* invasions have limited diversity and are consistent with secondary invasions originating in Australia. Hybridisation

between *S. madagascariensis* and *S. pinnatifolius* 'dune variant' occurs in natural populations at low levels but does not appear to result adult hybrid plants at least in the populations studied here. Two AFLP loci were highlighted by both population level outlier analyses, and individual level regression analyses against environmental variable data, providing evidence for potential recent selection on the genome and an indication of putative selective agents.

In conclusion, this thesis explores the invasion history and contemporary invasion dynamics of one of Eastern Australia's worst weeds, *S. madagascariensis*. Findings highlight the ongoing need for appropriate biosecurity measures to limit accidental founding of further invasion foci and flag Australia as a potential bridgehead for *S. madagascariensis* invasions worldwide. Location of putative source populations points to areas which may prove fruitful for locating suitable biological control agents. The native *S. pinnatifolius* is unlikely to introgress with *S. madagascariensis* but risks displacement in native environments where the two occur together. Evidence of potential recent selection on the genome associated with rainfall and light availability could indicate that *S. madagascariensis* is adapting to Australian conditions, making further encroachment on the range of *S. pinnatifolius* more likely.

## Originality Statement

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Eleanor Elizabeth Dormontt 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.

I give consent to this copy of my thesis when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

The author acknowledges that copyright of published works contained within this thesis (as listed below) resides with the copyright holder(s) of those works.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library catalogue, and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Signature:.....Date:.....

## List of Publications and Associated Copyright Holders

**Dormontt EE, Lowe AJ, Prentis PJ. 2011.** Is rapid adaptive evolution important in successful invasions. In: Richardson DM ed. *Fifty Years of Invasion Ecology: The Legacy of Charles Elton*. 1st ed., Blackwell Publishing Ltd. (John Wiley & Sons, Inc)

**Prentis PJ, Wilson JRU, Dormontt EE, Richardson DM, Lowe AJ. 2008.** Adaptive evolution in invasive species. *Trends in Plant Science*, **13**: 288-294. (Elsevier Ltd)

**Wilson JRU, Dormontt EE, Prentis PJ, Lowe AJ, Richardson DM. 2009a.** Biogeographic concepts define invasion biology. *Trends in Ecology & Evolution*, **24**: 586-586. (Elsevier Inc)

**Wilson JRU, Dormontt EE, Prentis PJ, Lowe AJ, Richardson DM. 2009b.** Something in the way you move: dispersal pathways affect invasion success. *Trends in Ecology & Evolution*, **24**: 136-144. (Elsevier Inc)

## **Dedication**

I dedicate this thesis to my late Great Grandfather Walter Rothsay Adams. Although I never had the chance to know him personally as an adult, I feel a strong connection through my father and I think my love of all things scientific is somehow in the genes from his side. One of the few pictures of us together is of me as a toddler in the garden, with Grandad patiently explaining something or other to me about the plants. I also like to think he would be the one member of my family with the intestinal fortitude to read this whole thesis, perhaps even with interest! Although other friends and family may pleasantly surprise me yet. It is with great thanks to all of them that I complete this mammoth undertaking. Without their unswerving support and pathological faith in my abilities, I would not be the person I am today or have achieved so much. Read on at your own risk...



## Acknowledgements

Many people have provided assistance to me throughout the course of this PhD and specific contributions are listed at the end of each chapter. Here I would like to acknowledge those who have provided ongoing support to me, both academically and personally.

To Andy, thanks for saving me from a life in the UK; for being consistently understanding and accommodating regarding my personal circumstances (way above and beyond the call of duty); for opening doors and providing opportunities for me that I would never have had otherwise; and for dropping the ball occasionally and letting me pick it up and run with it, proving my worth to myself and others in the process.

To Pete, thanks for sticking with me through your career changes and providing solid “on ground” support both in the field and the lab; for showing me once and for all how NOT to pour an acrylamide gel; for helping me through analyses and finally for inspiring me with your unswerving love of *Senecio*.

To Mike, thanks for being the “go-to” man in the group for all things labby; for helping with analyses (Jolene and I contemplated writing you sonnets, such is the heartfelt appreciation when you are able to single handedly rescue a research project with a carefully applied Bonferroni correction); for always having a kind word and offering a shoulder to cry on; and most importantly for always having a secret stash of teabags.

To Bertram, thanks for teaching me GIS, it's been indispensable (although I am now the groups resident expert, a dubious honour); and for being there when I needed project advice.

To Rod, thanks for always being there, for better or worse; for keeping me grounded and reminding me that there is more to life than my PhD; for cooking me wonderful meals; and for joining me on this rewarding but daunting rollercoaster ride that is parenthood.

To Julie, my partner in crime always and forever, thanks for being the one constant friend in my life. Your friendship grounds me in ways I can't describe but am forever grateful for.

To Jack, although I'm not your mother, to me you mean as much as if I were. Thank you for being the superstar that you are, I feel privileged to have played my part in your young life.

To the multitude of friends I have picked up along the way, life is richer for your presence. Particularly dear to me are the students of the Lowe lab group: Jolene (the girl with the million dollar smile); Martin (the man with 'shiny toys', a bit of a big head and a heart to more than match it); Fran (the lady who proves that age is but a number, and that good friends come from all walks and stages of life). Beyond the lab group Kym A. and Kym O. have partaken in many a beverage with me, shared their ups and downs and listened to mine; Ralph, your grumpiness has brought light to many a lunchtime; Stefan, your friendship keeps me showing up to work; and everyone else, whom I can't think of right now – Thank you.

To my parents, thanks for everything (including getting divorced) – you’ve done a great job and I love you both very much. To Martina, my ‘other mother’, you have inspired me through your hard work and dedication, a truly wonderful role model. And finally to my children Ashley and Zachery, young as you are, I hope you will one day read this (even if you don’t get much further than these acknowledgements) and be inspired to know that if I can do this – you can do anything.

Ok enough nostalgia... on to the good stuff...