Interaction of population processes in ragwort (*Senecio jacobaea* L.) and ragwort flea beetle (*Longitarsus jacobaeae* Waterhouse)

A Thesis presented in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Ecology at Massey University.

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April 2000

Declaration of Originality

This thesis represents the original work of the author, except where otherwise acknowledged. It has not been submitted previously for a degree at any University.

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Acknowledgements

I am sincerely grateful to my supervisors, **Professor Brian Springett, Dr Ian Stringer** (Ecology, the Institute of Natural Resources, Massey University), and **Dr Peter McGregor** (Landcare Research) for their encouragement, supervision and patience over this study and their help in drafting this thesis.

I am also indebted to Mr Keith Betteridge (AgResearch) for his valuable advice on the laboratory study on the movement of first instar larvae of ragwort flea beetle in different soils; Dr. Ed Minot (Ecology, Massey University) for explaining how to use the STELLA model; Dr. Jill Rapson (Ecology, Massey University) for comments on my PhD thesis proposal; Dr. Siva Ganesh, Dr. Jenny Brown and Mr. Duncan Hedderley (Statistics, Massey University) for help with univariate and multivariate analyses; and Dr. Kerry Harrington (Plant Science, Institute of Natural Resources, Massey University) for his comments and suggestion on the toxicity of ragwort and its chemical control.

Thanks also to Paul Peterson (Landcare Research) and Brent Page (Food and Crop Research) for their help in collecting ragwort flea beetle and Liz Grant for Figs 2.1 & 3.1. I also thank Barbara Just, Jens Jorgensen, Hamish Mack, Paul Barrett, Tracy Harris, Cathy Lake, Erica Reid, Jodi Matenga and all other staff from the Ecology Group, Institute of Natural Resources, Massey University for their help during my studies.

David J. Bull (Grounds supervisor, Massey University) kindly obtained an area for my field experiments, Dr David Barker, (AgResearch) generously made weather records for Ballantrae available to me, Dr Travis Glare (AgResearch) identified the fungal disease of ragwort flea beetle larvae, and Dr Mike Baxter (Microbiology, Massey University) identified the fungal disease of ragwort flea beetle. Thanks are due to Landcare Research for permission to use the three upper photographs on the title page.

My sincere gratude is due to the **New Zealand Ministry of Foreign Affairs and Trade** under its Official Development Assistance Post Graduate Scholarship **(NZODA-PGS)** Scheme for financial support. In addition, I am grateful to Bruce Graham, Charles Chua, Dianne Rieley, Margaret Smillie, Dianne Fountaine Cody, and Jo Donovan, (all of Massey University) for their help and support during my studies.

I am grateful for the friendship and interest shown by the senior students of the Ecology Group, Institute of Natural Resources, Massey University.

Finally, special thanks to my parents, my wife Daw Yi Yi Thein, my son Aung Myat Thar, and my two daughters Chun Myat Thar and Soe Pyay Thar for their encouragement during this study.

Abstract

The primary goal of this study was to improve understanding of biological control of weeds by investigating how population processes in ragwort and herbivorous insect interact.

Specific aims were to measure the consumption rates of the three larval instars of ragwort flea beetle (*Longitarsus jacobaeae*), to investigate how the process of herbivory by ragwort flea beetle affects the population density of ragwort, and to investigate how soil moisture influences the population densities of ragwort flea beetle and ragwort.

An extraction apparatus was constructed to obtain *L. jacobaeae* larvae from ragwort roots and root crowns. This apparatus was 84% efficient.

A preliminary survey of ragwort flea beetle numbers included ragwort plants from Ballantrae, Turakina, and Pahiatua (Southern North Island, New Zealand). The larval population was highest at Ballantrae but the adult population was highest at Turakina.

Data were collected from Ballantrae from 1996 to 1998 to develop the interaction model between *L. jacobaeae* and ragwort. The interaction depended on the effect that soil water content had on the populations of both *L. jacobaeae* and ragwort, the effect that larval density has on larval mortality, and the effect of ragwort density on the population of *L. jacobaeae* larvae. Soil water content was positively correlated with the increase in numbers of *L. jacobaeae*. *L. jacobaeae* larval mortality was dependent on larval density. High numbers of larvae per plant resulted in a reduction in the number of larvae over time (13.6 larvae/plant on November 1997 to 1.8 larvae/plant in December 1997). The average number of larvae extracted at Ballantrae was lower in October and November 1996 (4.4 and 4.6 larvae/plant) than in October and November 1997 (13.4 and 13.6 larvae/plant). However, the average numbers of rosettes was higher in October and November 1996 (7.6 and 5.78m $^{-2}$) than in October and November 1997 (2.8 and 2.7 m $^{-2}$). There was a significant inverse correlation between the numbers of *L. jacobaeae* larvae and ragwort rosettes (-0.4608). When

0.8983 in 15 day old larvae, 0.9261 in 30 day old larvae, and 0.9454 in 45 day old larvae. The lowest percentage survival (0.9067 in 15 day old larvae) was found at the highest larval density (40 larvae per plant). Finally, the same experiment was tested in a field and the data from this was used to construct an interaction model for *L. jacobaeae* and its food, ragwort. This model was based on the correlation between soil water and populations of *L. jacobaeae* and ragwort; the effect of larval density on the mortality of larvae and on the weight loss of ragwort; and on the effect that ragwort density has on the mortality of *L. jacobaeae* larvae. Mean soil water was 12 ± 0.29 to 76 ± 1.81 % over the first 15 days, then 36 ± 1.10 to 82 ± 0.99% up to 30 days, and 35 ± 0.76 to 65 ± 1.78% up to 45 days of larval life. These were the soil water contents that occurred during the field experiment. The model showed that the highest larval survival again occurred when few larvae were introduced to ragwort plants (17.5% survival from 0-15 days, 14.33% from 16-30 days, and 18.5% from 31-45 days). High larval densities also produced the lowest survival (8.4% survival over 0-15 days, 5.87% over 16–30 days, and 6.7% over 31-45 days).

The effect of plant density on larval survival was also tested in the field. The highest larval survival (10.76%) occurred when there were on 16 plants m^{-2}, and the larvae were 0 to 15 –days old. The lowest larval survival (6.61%) occurred with 16-30 day old larvae on plants at a density of 4 plantsm^{-2}. A cohort life-table was constructed for predicting population fluctuations of *L. jacobaeae*. Values from this life table were used to model populations of *L. jacobaeae*, ragwort and the interactions between these species using "STELLA" software. Data for the ragwort model was obtained from published papers. Additional data from the experimental determination of feeding rates of *L. jacobaeae* larvae were used when both the *L. jacobaeae* and ragwort models were combined to examine the interactions between these species. This latter model was used to estimate population fluctuations of *L. jacobaeae* and its food over two years. It indicated that *L. jacobaeae* is a very effective control agent for ragwort, and that it can cause ragwort populations to decline to extinction within two years.

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