Benefits of seed dispersal for escaping seed predation and examining the life history, host suitability/preference and impact of the polyphagous obligate seed predator *Cryptaspasma querula*

A thesis presented in partial fulfilment of the requirements for the degree of Master of Science in Ecology

at Massey University, Manawatu, New Zealand

Robert B. Silberbauer

2013
“The creation of a thousand forests is in one acorn”

- Ralph Waldo Emerson
Abstract

*Cryptaspasma querula* is an endemic moth (Family Tortricidae) that is the only known polyphagous obligate post-dispersal seed predator in New Zealand. It is suggested to have multiple hosts including tawa (*Beilschmiedia tawa*), taraire (*Beilschmiedia tarairi*), hinau (*Elaeocarpus dentatus*), karaka (*Corynocarpus laevigatus*), and acorns from exotic oaks (*Quercus sp.*). There have been few studies clarifying these claims and fewer still showing the effects *C. querula* has on the host plants’ seeds’ germination and establishment. Little is also known about the life history, host preferences, specialist predators/parasitoids and host cues of *C. querula*. The drilling damage *C. querula* does to its hosts has been noted in several studies but none have recorded the extent of this damage over the course of the season or what the end percentage of damaged seeds are.

Of the described hosts, the broadleaf tree tawa has had been studied the most. The apparent rarity of good germination and establishment under the parent canopy has been noted previously. It is unclear however, whether the impact of seed predators make dispersing seed away from the parent canopy (where fewer seed predators are in theory) more beneficial for tawa. If it is more beneficial, then the extent of dispersal through faunal influences will be important to know.

Life history and host cues (in the form of wind tunnel tests used to test olfactory attractants) of *C. querula* were examined in a controlled environment where rearing observations were taken and variables could easily be manipulated. The host preference and suitability for *C. querula* was examined in two settings: Laboratory and Field. The controlled environment utilised the seeds of tawa, taraire, hinau, and miro to see whether these were plausible hosts. The field experiments utilised the species miro, karaka, and acorns from exotic oaks. The examination of potential specialist predators or parasitoids took place in two settings: Field and Glass house (semi-controlled environment).

In captivity, mating of *C. querula* adults raised from field collected larvae frequently occurred and many eggs were produced which could be used in choice
tests and behavioural assays. Females lay a variable number of eggs and seemed to prefer ovipositing on smooth surfaces. The time spent in each instar and pupation varied greatly among individuals. Wind tunnel tests were inconclusive for both adult and larvae specimens. However, in choice tests and even when given no other hosts, many of the proposed hosts of *C. querula* appeared to be unsuitable and were not occupied by *C. querula* larvae in the lab. These included miro, hinau, and karaka where *C. querula* either ignored the fruits provided, or, if endosperm was utilised, the larvae did not complete their lifecycle. The only suitable and preferred hosts in these trials were tawa and taraire. However, it is highly likely acorns from exotic oaks are also suitable and preferred by *C. querula* since field trials showed frequent occupancy in acorns. Only one potential competitor (no specialist predators/parasitoids) of *C. querula* was discovered and it was a generalist facultative diptera (*Sylvicola sp.*).

In a factorial field experiment (repeated at three sites) in which fruit density, the presence or absence of fruit flesh, and the position either under or away from a tawa canopy were assessed, germination and establishment of tawa were highest in high seed density treatments showing potential predator satiation may be occurring. Seeds dispersed away from tawa canopy also had a higher establishment rate than seeds under the parent canopy, suggesting the importance of faunal dispersers. The effect of flesh removal was variable but generally favoured establishment. Several additional factors such as vertebrate seed predators/predators, abiotic influences, and site differences appeared to have influenced the results. Drilled/damaged seeds could still germinate/establish but their chances were much lower than undamaged seeds.

In these same three sites, plus an additional 8 sites added to widen the study, seed predation at the end of season was very high despite a very heavy fruiting season. As the season progressed, over 90% of tawa seeds ended up being drilled by *C. querula* suggesting the likelihood of very heavy influences on tawa regeneration. The proportion of bird dispersed seeds was also unexpectedly low (maximum of 8% of seeds beneath the canopy were bird dispersed). The surrounding floral species composition (and dominance) did not appear to influence the damage received to tawa seeds.
Information on *C. querula’s* life history, host preferences/suitability and the impact on hosts are better understood through this thesis. Seed dispersal and high seed density are shown to offer the best strategy for tawa seeds’ establishment and survival. The extent of drilling damage on tawa fruits over the course of the season has been shown to be higher than expected and strongly detrimental and demonstrates the importance of predation escape. Thus, tawa is highly dependent on the remaining kereru populations and will be sensitive to further declines to dispersal service.
Acknowledgements

This Master of Science thesis could not have been come to pass without the assistance of Alastair Robertson and Steve Trewick who have been exceptional supervisors in their guidance and assistance throughout the research and study process. I would like to thank them for the time, patience and expertise they employed in helping me in this thesis.

I would like to thank the following post-graduate students for their time in assisting me with advice, their time, and/or comments: Daniel Smiley, Kyleisha Jaydid, Briar Smith and Matthew Krna. Their influence in this thesis has been of great help.

I’d like to thank the four Massey technicians: Tracy Harris, Shaun Nielsen, Cleland Wallace and Paul Barrett for their technician expertise and assistance. Without their help many of the experiments in this thesis would not have been able to be performed. My two field helpers Natalie Eustace and Daniel Smiley have been an amazing help and I’d like to thank them for accompanying me through horrible terrain and less than desirable weather. They made the process much more efficient and enjoyable and I’d highly recommend them for future work.

Furthermore I’d like to make a special mention of my friend Natalie Eustace who has been a great support and motivator for me during my research and write up. She not only helped me with field work but provided me with pleasant company during long trips and camping trips; she gave sound advice during my write up and provided continual support and joy during hardships. The full extent of my appreciation goes to her.

My family and close friends have all been of great support and help throughout the thesis process and I’d like to thank them all individually: Shirley Silberbauer, Stan Silberbauer, Malcolm Silberbauer, Clare Silberbauer, Mary Dwen, Erin Loveridge, Melinda Rawlings, Amanda Martens, Hayley Stewart, Rosanne Eustace, Glen Eustace, Bethani Eustace, Alastair Manning, Carolin Doerfel, Inge Anderson, Grant
Douglas, Mike Dodd, Ross Gray, Chris Carran, Josef Beutrais, and everyone in Auckland and Palmerston North who helped me in this thesis.

I’d also like to thank Rhys Mills for his assistance at Nga Manu Reserve. Many thanks to the Palmerston North City council for the permits to access Turitea Water Catchment; and the Department of Conservation for the permits to access many of the sites used in this thesis.

This thesis is dedicated to my sister Clare Silberbauer, who is loveliest, most wonderful person I have ever known.
Table of Contents

Abstract ................................................................................................................................. iv
Acknowledgements ........................................................................................................... ix
1. Introduction .................................................................................................................... 1
  1.1 Invertebrate Seed Predators ...................................................................................... 1
  1.2 Introduction to Cryptaspasma querula ....................................................................... 4
  1.3 Focal Host-Species ..................................................................................................... 8
2. Testing host species of Cryptaspasma querula & analysing its life history in a laboratory and field setting ................................................................................. 11
  2.1 Introduction ............................................................................................................... 11
  2.2 Methods ................................................................................................................... 14
    2.2.1 In-Lab Rearing and Experiments ......................................................................... 14
      2.2.1.1 Monoculture Experiments ............................................................................ 14
      2.2.1.2 Tawa Predation Rates ................................................................................. 16
      2.2.1.3 Choice Experiments ................................................................................. 17
    2.2.2 Behavioural Wind Tests ....................................................................................... 17
      2.2.2.1 Larval Wind Tunnel Tests ......................................................................... 17
      2.2.2.2 Adult Wind Tunnel Tests .......................................................................... 18
    2.2.3 Field Host Tests .................................................................................................. 19
  2.3 Results ....................................................................................................................... 19
    2.3.1 In-Lab Rearing and Experiments ......................................................................... 19
      2.3.1.1 Monoculture Experiments ............................................................................ 19
      2.3.1.2 Tawa Predation Rates ................................................................................. 20
      2.3.1.3 Choice Experiments ................................................................................. 21
      2.3.1.4 Rearing observations ................................................................................. 23
    2.3.2 Behavioural Wind Tunnel Tests .......................................................................... 23
    2.3.3 Field Species-Host Tests .................................................................................... 24
  2.4 Discussion & Conclusions ......................................................................................... 26
    2.4.1 In-Lab Rearing and Experiments ......................................................................... 26
      2.4.1.1 Monoculture Experiments & Tawa Predation Rates ..................................... 26
      2.4.1.2 Choice Experiments ................................................................................. 27
      2.4.1.3 Rearing observations ................................................................................. 28
    2.4.2 Behavioural Wind Tunnel Tests .......................................................................... 30
2.4.3 Field Species-Host Tests ................................................................. 31

3. The benefits of seed dispersal in *Beilschmiedia tawa*: a field experiment ................................................................. 33
   3.1 Introduction ............................................................................ 33
   3.2 Methods ............................................................................. 36
   3.3 Results ............................................................................... 41
   3.4 Discussion & Conclusions ......................................................... 63
      3.4.1 Drilling & Rodent Damage effects on Germination & Establishment .................................................. 63
      3.4.2 Drilling Proportions & Invertebrate Seed Predators .......... 63
      3.4.3 Rodent Attacked/Damaged Seeds ................................. 67
      3.4.4 Germination .................................................................. 70
      3.4.5 Establishment ................................................................. 72
      3.4.6 Conclusions ................................................................. 74

4. Seasonal progression of seed predation and fruit degradation in fallen *Beilschmiedia tawa* fruits at three lower North Island sites .......... 77
   4.1 Introduction ........................................................................ 77
   4.2 Methods ........................................................................... 82
      4.2.1 Monthly Surveys .......................................................... 82
      4.2.2 Plant Growth Unit (PGU) Setups ................................. 83
   4.3 Results ............................................................................. 83
      4.3.1 Monthly Surveys .......................................................... 83
      4.3.2 Plant Growth Unit (PGU) Setups ................................. 85
   4.4 Discussion & Conclusions ....................................................... 85
      4.4.1 Monthly Surveys .......................................................... 85
      4.4.2 Plant Growth Unit (PGU) Setups ................................. 90

5. High seed predator damage found in *Beilschmiedia tawa* across the North Island of New Zealand in a multi-area survey .................... 91
   5.1 Introduction .................................................................... 91
   5.2 Methods ....................................................................... 93
   5.3 Results ....................................................................... 95
   5.4 Discussion & Conclusions ................................................. 99

6. Overall Discussion and Conclusions ............................................. 101

7. References ........................................................................... 109