# The influence of abiotic factors on the impact of a native stem hemiparasite on introduced versus native hosts.

Robert Cirocco

Thesis submitted for the degree of a Doctor of Philosophy

School of Biological Sciences

The University of Adelaide, South Australia

April 2016

# Table of Contents

# Abstract

Over 100 years, the impact of parasitic plants on their hosts has been a major and fascinating field of research. Recently, there is evidence for native parasites having a greater effect on growth of introduced compared with native hosts. However, there is little known about the mechanisms behind these differential impacts. Further, there have been surprisingly very few studies in the field in general, that have incorporated the influence of abiotic factors on parasite effects on their hosts. A series of glasshouse studies were conducted to explore these gaps in the literature.

Light experiment (Ch. 2): The influence of high (HL) or low light (LL) on the effects of the Australian native stem hemiparasite *Cassytha pubescens* on the native and introduced perennial evergreen shrubs *Leptospermum myrsinoides* and *Ulex europaeus*, respectively. It was hypothesised that as a result of decreased parasite photosynthesis in LL, *C. pubescens* would become more dependent on host carbon and have a greater effect on host performance (particularly, *U. europaeus*) in these conditions. Parasite photosynthesis was significantly lower in LL relative to HL when infecting either host. However, contrary to my prediction, light was not found to influence the effect of *C. pubescens* on overall growth of these two hosts. Independent of light, the parasite did have a significant negative impact on overall growth of *U. europaeus* but not *L. myrsinoides* and also grew much more vigorously on the introduced host.

Pigments (Ch. 3): The influence of high (HL) or low light (LL) and *C. pubescens* on pigment dynamics and photo-damage of *L. myrsinoides*. It was hypothesised that excess light would occur as a result of infection effects on host photosynthesis in HL and in response; the native host would increase its photo-protective capacity (VAZ/Chl) and engagement (de-epoxidation state) in these conditions. As total xanthophyll (VAZ) and chlorophyll content (Chl) significantly decreased in parallel in response to infection, regardless of light, VAZ/Chl of *L. myrsinoides* was unaffected by *C. pubescens* in either HL or LL. The de-epoxidation state of the host was also unaffected by infection in both HL and LL. Consequently, infected *L. myrsinoides* had the same photo-protective capacity/engagement as uninfected plants and thus, showed no signs of photo-damage.

These findings may explain why this native host shows tolerance to *C. pubescens* both in the light experiment (Ch. 2), and in the field.

Nitrogen experiment (Ch. 4): The influence of nitrogen (N) when supplied (HN) or not (LN) on the effect of *C. pubescens* on two leguminous hosts, (native: *Acacia paradoxa*; introduced: *U. europaeus*). It was hypothesised that the combination of infection along with the added carbon burden of rhizobia at LN would result in *C. pubescens* having a greater effect on hosts in these conditions. Contrary to this prediction, N was not found to influence the effect of the parasite on overall growth of hosts. Similarly, as with the light experiment (Ch. 2), *C. pubescens* had a significant negative effect on total biomass of *U. europaeus* but not that of *A. paradoxa*, regardless of N and also grew significantly greater on the introduced host, irrespective of N. Maximum electron transport rates ($ETR_{max}$) of *U. europaeus*, but not *A. paradoxa* were also found to be affected by *C. pubescens* which may explain the parasite's negative effect on growth of *U. europaeus*.

Water experiment (Ch. 5): The influence of water on the effect of *C. pubescens* on *U. europaeus*. It was hypothesised that the parasite would grow better and have a greater effect on the host in well-watered (HW) compared with low water (LW) conditions. Again, as with the experiments above, the parasite negatively affected growth of this introduced host, but in contrast, water did influence the effect of the parasite. Supporting this hypothesis, total biomass of *U. europaeus* was affected by *C. pubescens* in both treatments, but more severely in the HW treatment. This greater effect may be explained by the significantly higher photosynthetic performance ($F_v/F_m$) and increased growth of the parasite in the HW compared with LW. Thus, it seems a more hydrated healthy *C. pubescens* in HW was capable of removing more resources and therefore had a greater effect on growth of *U. europaeus* in these conditions.

These studies have revealed that light and N (specifically when hosts are legumes) may not be important in modulating the effects of stem hemiparasites on their hosts. By contrast, water was an important factor, with the parasite having a more severe effect when the host was well hydrated. It seems that from these experiments, parasite performance is controlled by host supply rather than parasite demand. Such 'fine tuning' between parasite and host has also been reported for the stem holoparasitic vine *Cuscuta*. Nevertheless, studies

looking at the effects of the parasite when these abiotic factors are combined will further clarify potential outcomes of these associations. Results from these experiments also consolidate the idea that native parasites more negatively affect introduced compared with native hosts. Consequently, my data continues to support the potential-use of *C. pubescens* as a native bio-control agent against major introduced weeds in Australia. At the same time, my information adds to the discussion on pre-existing ecological theory; are introduced species successful invaders because their newly encountered enemies lack the effective arsenal. Or are they naïve invaders in the sense that new enemies do have an effective arsenal, my findings support the latter hypothesis.

# Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution 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. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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 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 Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Signed:

Date: 4/4/2016

# Acknowledgements

I greatly thank my supervisors Jenny and José who provided me with a sound theoretical and practical scientific framework which I took with both hands. When needed, they questioned my scientific thinking, as I did theirs. Their brilliant guidance will not be forgotten.

Special thanks to Jane Prider who was also my honours supervisor and integral to my development as a scientist. Her previous work on *Cassytha* was critical to the success of my own. The technique she developed for infecting plants with *Cassytha* using 'mother plants' was fundamental to executing my experiments. Indeed, some of her plants already infected with *Cassytha* were used to infect my own, which saved me much time and potential heartache.

I'm very thankful to Steven Tsang and Elizabeth Maciunas who also shared a passion for working on *Cassytha*. They stimulated and shared many discussions with me on scientific thinking and life in general. I couldn't have asked for better compadres.

I'm extremely grateful to Sharon Robinson and Melinda Waterman who provided time and space to teach me the technique of using HPLC. They were a pleasure to work with and our time together showed me how collaboration is the key to success in the scientific world.

I would like to thank Rob Reid for his expert advice on plant physiology. He always had time to clarify and expand my thinking on the subject.

I would also like to thank Steven Delean for his expert advice on statistics. He too always had time for me and my research is much better for it.

Many thanks to Ron Smernik who headed up writing group which I attended for two years. My scientific writing is much improved from his expertise and tuition.

Many thanks also to John Stanley and David Ladd for their help with infrastructural support; they shaped me into a much handier man.

I’m very grateful to Nenah Mackenzie, Mark Rollog, Teresa Fowles (and Waite Analytical) for their expert elemental analysis of my samples.

Many thanks to The Field Naturalists Society of South Australia Inc, Nature Foundation SA and the Native Vegetation Council for seeing merit in and helping fund my research.

I’m so very grateful to Maria Johns, Russ Sinclair (and the National Trust) and Milton Hearn for being so hospitable, allowing and trusting me to work on their sites in the field. This was paramount for the advancement of my research and development as a scientist. They shared my enthusiasm on *Cassytha,* always keen to hear about what I discovered.

I would like to thank my angels, Matthew Pearson and Sonia Croft for assisting me in the field. It takes a special person who will arise at 2 am for someone else’s research so we can arrive in the field to conduct pre-dawn measurements. They too were a pleasure to work with, being there when I needed them the most.

What can I say to my friends and the Terrestrial Plant Ecology Lab group; thanks so much for the great times and many laughs shared.

Finally, thank you to my family for providing me with a life of strong values, traditions, beliefs and support that have help lead me to this path of science that I have chosen.