DIGESTIVE AND FEEDING PHYSIOLOGY OF GRAPE PHYLLOXERA (*DAKTULOSPHAIRA VITIFOLIAE* FITCH)

KIM BERNADETTE KINGSTON

B. SC (HONS)

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This thesis does not contain any material that has been accepted for the award of any other degree or diploma at this or any other University. To the best of my knowledge, this thesis does not contain any material that has been published previously, except where due reference is made in the text. The research described in this thesis is my own original work, except where due acknowledgement has been made in the text.

Part of the content of Chapters 2 and 5 are currently *in press* for publication for *Proceedings of the Third International Phylloxera Symposium* in *Acta Horticulturae*. For both articles I am the principle author and contributor to the work.

Kim Bernadette Kingston

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Back to a personal level …

I would sincerely like to acknowledge my parents, Rex and Joy Andrews, who have always supported me in my endeavours and ambitions. They mightn't understand the 'nut and bolts' of what I do, but they have provided encouragement ever since I decided (half a lifetime ago) to pursue a career in science. Coming from a small country town, not everyone thought that "girls did science". I share in the pride that mum and dad display for all of their children, and for that I am grateful.

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This thesis has been completed in loving memory of Anya.

ABSTRACT

Grape phylloxera (*Daktulosphaira vitifoliae* Fitch, Hemiptera: Phylloxeridae) is a worldwide pest of the viticulture industry due to damage caused to the root system of the European grapevine, *Vitis vinifera* L. (Vitaceae). The main management option for radicicolae grape phylloxera is the use of resistant rootstocks, however due to the success of this management option a range of questions relating to the biology, nutrition and feeding behaviour of the pest insect remain unanswered. This thesis addressed a number of these questions in order to extend the current knowledge of the biological characteristics of grape phylloxera and the possible influences on host-plant responses.

The internal morphology of grape phylloxera was dominated by a large, non-coiled midgut, and developing eggs in adults. The midgut was compartmentalised by an atypical junction with the hindgut. The hindgut extended to the posterior end of the insect, and although an anus was present, no waste excretion was observed in live insects. Parthenogenetic production of relatively large eggs may compress the digestive system, increasing pressure in both the midgut and hindgut chambers. The evolution of the compartmentalised midgut is suggested to permit the storage of food and ensure the continual supply of food to grape phylloxera during periods of egg production and during dispersal to new *Vitis* plants.

Molecular and microbiological evidence showed that radicicolae grape phylloxera has a transient association with an undefined bacteria species. The association appeared to be related to the health of the grapevine root and the insect population, and may influence the variable survival rates of insects observed in laboratory controlled experiments. The bacteria species differed from a bacterial association identified in

gallicolae grape phylloxera, and unlike the endosymbiotic relationship of Aphididae, was not essential.

The development of an artificial feeding system for radicicolae grape phylloxera was complicated by the size of the insect, the extended survival of 'control' insects, and a lack of detail regarding the composition of the natural food source. Due to the sedentary feeding behaviour of grape phylloxera, the design of the diet chamber was modified to allow renewal of the artificial diet solution with minimal disturbance to the insect. The survival time of grape phylloxera was significantly extended by two diet formulations, however neither result was reproducible. Insect probing activity was generally stimulated by acidic diet formulations containing sucrose and amino acids, indicating that grape phylloxera were attracted to the artificial feeding system although the diet formulation was not optimised.

Electrical penetration graph (EPG) studies identified that the apterous life stages of radicicolae grape phylloxera exhibit differential feeding behaviour on *V. vinifera* root material. The first application of EPG to grape phylloxera research identified 14 waveforms associated with probe penetration and continual feeding activity, with the two most common waveforms anticipated to represent salivation and ingestion. The restrictions of working with a root-feeding insect were overcome by the use of excised root pieces and tissue culture grapevines. Both root systems produced the same EPG waveforms.

The content of this thesis lays the ground work for further research into grape phylloxera host-plant interactions with susceptible and resistant *Vitis* species. The long-term aim of this research is the development of alternative management options for the pest insect, and to ensure the sustainability of resistant rootstocks as the main management option for the viticulture industry.

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