

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

The lifecycle and epidemiology of the  
Tomato/Potato Psyllid (*Bactericera  
cockerelli*) on three traditional Māori food  
sources

A thesis in partial fulfilment  
for the degree of  
Master of Science in Plant Protection  
at Massey University,  
Palmerston North, New Zealand



**MASSEY UNIVERSITY**

Aleise Puketapu

2011

# Abstract

The tomato/potato psyllid (*Bactericera cockerelli* (Sulc), TPP) is a species of Psylloidea first detected in New Zealand in 2006. Since its incursion the TPP has proved to be a major insect pest of solanaceous crops, particularly potatoes (*Solanum tuberosum*), tomatoes (*Lycopersicon esculentum*) and capsicums (*Capsicum* L.). The TPP is a vector of Zebra Chip Disease or liberibacter (*Candidatus Liberibacter solanacearum* syn. psyllauros), a lethal plant disease related to Citrus greening disease (*Candidatus Liberibacter asiaticus*). Successive annual population outbreaks coupled with widespread liberibacter infection continues to challenge New Zealand's horticulture sector.

Three traditional Māori food sources, namely taewa (Solanaceae, *Solanum tuberosum* L. ssp. *andigena* and ssp. *tuberosum*), kūmara (Convolvulaceae, *Ipomoea batatas* (L.) Lam.) and poroporo (Solanaceae, *Solanum aviculare* G. Forst syn. *S. Laciniatum* (LINN.)), are known to be susceptible to TPP infestation. Kūmara and taewa are annual summer plants present during the peak TPP development and population growth period. Poroporo flowers and fruits year-round and is therefore theoretically susceptible to infestation throughout the year and may serve as a potential overwintering host and food source for TPP.

Poroporo was assessed as an overwintering host of the TPP and the lifecycle progression of TPP was also compared on the three host plant species; taewa, kūmara and poroporo. The role of these three host plants in the annual lifecycle of this insect pest in the New Zealand environment.

The results showed that poroporo was not an important overwintering host of the TPP in the Manawatu/Rangitikei region; rather it can be viewed as an alternative or refuge host in the absence of the primary solanaceous host species and other volunteer weed host plants. The results indicated that taewa is a more suitable host of the TPP than poroporo and kūmara. In the same vein, poroporo is clearly more suitable as a host than kūmara. The relationship seen in this study in terms of host suitability can be pictorially represented as; Taewa > Poroporo > Kūmara

This study showed that all three host species are capable of supporting TPP and therefore each of the host species should be managed with a view to minimise the impact of TPP across seasons.

## Acknowledgements

This thesis was undertaken in an attempt to amalgamate my undergraduate study in plant protection and my postgraduate study based on Māori natural resource development. It seemed all too convenient that in my first year of postgraduate study the tomato/potato psyllid (*Bactericera cockerelli*) arrived in the Manawatu District and infested the Massey University taewa (Māori potatoes, *Solanum tuberosum* ssp. *andigena*) seed bank managed by Dr Nick Roskruge. Fate some would say, and therein lies the conception of my thesis. The Tomato/Potato psyllid (TPP, *Bactericera cockerelli*) is an interesting insect, so small and some would think insignificant, it is hard to believe the impact this insect and Zebra Chip (*Candidatus Liberibacter solanacearum* syn. *psyllauros*) disease has had on New Zealand horticulture.

I wish to first thank Dr Nick Roskruge, my supervisor and mentor, for without whom this thesis would not have been possible. Your knowledge, experience and endless patience have made this research possible. I am amazed by what you have accomplished and wish you well in your post-doctoral studies

.

I thank the Tahuri Whenua network who have supported me throughout the duration of my research and have become almost like extended whanau. I will continue to support your kaupapa and actively participate in any venture you undertake.

I would also like to thank the researchers at Plant and Food Research for allowing me to attend various industry meetings and freely converse with those at the forefront of TPP research. Your work is invaluable. I am greatly looking forward to being part of your team in the coming year. I thank the Ministry for Science and Innovation (formerly known as the Foundation for Research, Science and Technology (FRST)) who funded my research, I cannot thank you enough for the support.

And to my 'home' of five years, Massey University Manawatu, my journey here has come to an end and I must move on. I would like to acknowledge the Institute of Natural Resources for their friendship and camaraderie.

God Bless.

# Contents

Abstract .....	i
<b>Chapter One: General Introduction .....</b>	<b>1</b>
1.1 <i>Bactericera cockerelli</i> – Tomato/Potato Psyllid .....	1
1.1.1 Description .....	2
1.1.2 Plant Damage.....	3
1.1.3 Current State of Research in New Zealand .....	3
1.2 TPP and Māori Food Sources.....	5
1.2.1 TPP in a traditional context .....	6
1.3 Aim, objectives and research questions.....	6
1.3.1 Aim of the research.....	7
1.3.2 Objectives .....	8
1.3.3 Research questions .....	8
1.3.4 Limitations.....	8
1.4 Thesis Organisation .....	9
<b>Chapter Two: Materials and Methodology .....</b>	<b>10</b>
2.1 Introduction .....	10
2.1.1 Tahuri Whenua – National Māori Vegetable Growers Network.....	12
2.1.2 TPP identification .....	13
2.1.3 Plant monitoring techniques .....	14
2.1.3.1 Survey period.....	15
2.1.3.2 Sampling sites.....	15
2.1.3.3 Open environment assessment.....	15
2.1.3.4 Closed environment assessment .....	15
2.1.3.5 Contained leaf samples.....	16
2.1.4 Assumptions .....	16
2.1.5 Inoculation and biotype .....	16
2.1.6 Seasonality.....	16
2.1.7 Environmental variables .....	17
2.1.7.1 Open environment .....	17
2.1.7.2 Closed environment.....	17
2.1.8 Disease complex .....	17
2.2 Insect identification and sexing TPP .....	18
2.2.1 TPP identification .....	18
2.2.2 Sexing TPP .....	19
2.2.3 Beneficial insects.....	20
2.3 Methods .....	20
2.3.1 Open environment monitoring.....	20
2.3.1.1 Study areas.....	20
2.3.1.2 Site selection.....	21
2.3.1.3 Monitoring technique and data collection .....	21
2.3.2 Closed environment monitoring .....	22
2.3.2.1 Host plants .....	23
2.3.2.2 Inoculation .....	23

2.3.2.3 Data collection.....	24
2.4 Covariates .....	25
2.4.1 Sampling covariates.....	25
2.4.2 Site covariates.....	27
2.5 Analysis .....	28
2.5.1 Closed environment data .....	28
2.5.2 Open environment data.....	28
2.5.3 Contained leaf samples.....	28
Chapter Three: Results .....	29
3.1 Section A: Open environment monitoring .....	29
3.1.1 TPP and natural enemy detection - Bulls monitoring site.....	29
3.1.2 TPP and natural enemy detection – Massey Hill site.....	31
3.1.3 Plant factors affecting TPP detection .....	33
3.1.4 Temperature.....	35
3.2 Section B: Closed environment monitoring .....	36
3.2.1 Temperature.....	36
3.2.2 On-plant development data.....	36
3.2.2a Pre oviposition period.....	37
3.2.2b Egg incubation.....	37
3.2.2c Nymph development.....	37
3.2.2d Survival.....	37
3.2.2e Total development and total lifecycle calculations.....	38
3.3 Section C: Contained leaf samples .....	39
3.3a Pre mating period.....	39
3.3b Female fecundity .....	39
3.3c Longevity .....	39
3.3d Oviposition period .....	40
Chapter Four: <i>Bactericera cockerelli</i> , Tomato/Potato psyllid .....	42
4.1 Hemiptera: Psylloidea.....	42
4.2 Biology and ecology .....	42
4.2.1 Host range.....	42
4.2.1a Host specificity .....	43
4.2.2 Feeding habits.....	44
4.2.3 Disease transmission .....	44
4.2.4 Behaviour .....	45
4.3 Lifecycle .....	46
4.3.1 Reproduction .....	49
4.3.2 Favoured conditions .....	49
4.4 Native range and migration .....	50
4.5 Taxonomy.....	50
4.6 Distinguishing the TPP from other Psylloidea in New Zealand.....	51
4.7 The distribution and dispersal of the TPP in New Zealand.....	53
4.8 TPP management and control.....	56
4.8.1 Monitoring.....	56
4.8.2 Sticky traps .....	56
4.8.3 Plant scouting .....	57
4.8.4 Chemical control .....	58
4.8.5 Biological control .....	59

4.8.6 Tips for TPP control .....	59
4.8.7 Cultural control.....	60
4.9 Chapter summary.....	60
Chapter Five: Māori food sources: History and susceptibility to TPP .....	61
5.1 Māori horticulture.....	61
5.2 Taewa Māori ( <i>Solanum tuberosum</i> spp. <i>andigena</i> ).....	65
5.2.1 Origin and history .....	65
5.2.2 Cropping history .....	67
5.2.3 Taewa in the 21 <sup>st</sup> century.....	68
5.2.4 Taewa and TPP.....	68
5.3 Kūmara (syn. Sweetpotato, <i>Ipomoea batatas</i> ) .....	69
5.3.1 Origin.....	69
5.3.2 Cropping history .....	70
5.3.3 Kūmara and TPP.....	71
5.4 Poroporo ( <i>Solanum aviculare</i> syn. <i>Solanum laciniatum</i> ).....	71
5.4.1 Growth habit .....	72
5.4.2 Uses .....	72
5.4.3 TPP and poroporo.....	73
5.5 Chapter summary.....	73
Chapter Six: Zebra Chip Disease Complex .....	74
6.1 Zebra Chip (ZC) .....	74
6.2 Causal agent identification .....	75
6.3 Acquisition and transmission.....	76
6.4 Disease symptoms in potatoes .....	77
6.4.1 Foliar symptoms .....	77
6.4.2 Tuber symptoms .....	78
6.4.3 Potato seed tuber quality .....	79
6.5 Traditional impact.....	80
6.6 Economic impact .....	80
6.7 Chapter Seven:.....	81
Chapter Seven: Discussion.....	82
7.1 Open environment monitoring .....	82
7.1.1 Comparison of sites: Bulls vs. Massey .....	82
7.1.2 Poroporo as an overwintering host of TPP .....	83
7.2 Closed environment .....	84
7.3 Contained leaf samples.....	85
7.4 Overwintering, host suitability and importance .....	85
Chapter Eight: Conclusion .....	86
8.1 Recommendation .....	89
References .....	90
Personal communications .....	99

Appendices .....	100
Appendix I – TPP factsheet prepared for the ‘Spud in a bucket’ initiative.....	101
Appendix II – Insect identification sheet.....	102
Appendix III – List of chemicals used to control TPP and their availability in New Zealand.....	103
Appendix IV – Glossary of Māori terms .....	105

## List of Figures

1.1) TPP adults; transparent wings and white markings on the abdomen.....	2
2.1) Left: Adult winged Psocid showing wings held over the body like a ten and Right: TPP wings which extend upwards of the body .....	14
2.2) Showing metatibial spurs of the hind leg (left). Trifurcate branching of the TPP forewing (right).....	19
2.3) Male genitalia.....	19
2.4) Female genitalia .....	19
3.1a) TPP population over the monitoring period: Bulls.....	29
3.1b) TPP population during June and July 2010: Bulls .....	30
3.1c) Natural enemy population over the monitoring period: Bulls.....	31
3.1d) TPP population over the monitoring period: Massey Hill .....	31
3.1e) Natural enemy population over the monitoring period: Massey Hill.....	32
3.1f) Bulls: Site 3 in week three of December .....	34
3.1g) Comparison of average weekly temperature at the Bulls and Massey Hill monitoring sites .....	35
3.2a) Daily low and high temperatures during the closed environment monitoring period.....	36
3.2b) Mean lifecycle parameter length (days) for the on- plant measurements for each of the three host species .....	38
3.3a) Contained leaf sample - mean lifecycle parameter length (days) for each of the three host species .....	40
3.3b) Contained leaf samples- mean female fecundity for each of the three host species.....	41



4.1) ‘Psyllid sugars’ .....	44
4.2) Proposed migration pattern of TPP in its home range of North America .....	46
4.3) Left: <sup>1</sup> the complete lifecycle of the TPP including the egg, five nymph stages and winged adult. Right: <sup>2</sup> Magnified image of the five nymph stages.....	47
4.4) Tomato/Potato Psyllid lifecycle at an average temperature of 18°C .....	48
4.5) TPP wing showing trifurcate branching of the basal vein of the forewing and cubital cell.....	52
4.6) Inner metatibial spurs of TPP .....	53
4.7) Distribution of the TPP since its incursion in New Zealand .....	55
4.8) Outdoor potato crop sticky trap placement map .....	57
5.1) Māori whakapapa from the ancient ancestors to humans .....	62
5.2) Poroporo .....	62
5.3) Young kūmara plants in the field .....	63
5.4) Taputini variety of kūmara .....	63
5.5) Taewa field in Ohakea.....	64
5.6) Moemoe variety tubers.....	64
5.7) kūmara whakapapa.....	70
6.1a) Leaf purpling (left) and chlorosis (right) caused by ZC .....	77
6.1b) Severe leaf scorching caused by ZC in potatoes .....	78
6.1c) ZC potato tuber symptoms .....	79

## List of Tables

Table 1: Insects monitored during open environment monitoring .....	22
Table 2: Sampling covariates .....	25
Table 3: Site covariates.....	27
Table 4: Bulls monitoring site plant factors affecting insect detection .....	33
Table 5: Massey Hill monitoring site plant factors affecting insect detection .....	34
Table 6: Lifecycle parameters of <i>B. Cockerelli</i> fed either on taewa, poroporo or kūmara under glasshouse conditions .....	36
Table 7: Survival of <i>B. cockerelli</i> egg and nymph life stages fed either on taewa, poroporo or kūmara under glasshouse conditions .....	37
Table 8: Female reproductive parameters and longevity of <i>B. Cockerelli</i> adults fed on taewa, poroporo or kūmara under greenhouse conditions.....	39
Table 9: Three taxonomic classifications of the TPP .....	51