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The incidence and phylogenetic analysis of viruses
infecting New Zealand's native grasses

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Abstract

Grasses form the basis for the meat, dairy, wool and deer industries, which contribute to nearly 50% of New Zealand exports, and are also an important component of natural ecosystems. Worldwide >100 plant viruses infect grass species and even mild and symptomless infections can adversely effect plant populations through reduced reproductive rates and greater susceptibility to environmental extremes. The only previously published study on viruses in New Zealand's natural grasslands found that cereal viruses have invaded the native grass flora of the South Island.

This research provided an extensive survey of New Zealand native grasses, showing that barley yellow dwarf virus diseases (BYDV, *Luteoviridae*) and *Cocksfoot mottle virus* (CoMV, *Sobemovirus*) are widespread in the North and South islands of New Zealand. Significant findings include seven new virus hosts amongst the New Zealand native flora, the first report of BYDV-PAS in New Zealand, detection in *Hierochloe redolens* of a novel virus in the *Luteoviridae* family (proposed name BYDV-To), and in *Festuca novae-zelandiae* a novel dsRNA virus possibly belonging to the *Partitiviridae* family. New virus host reports in New Zealand include CoMV in *Poa anceps*, *P. cita*, *F. novae-zelandiae*, and *Chionochloa rubra*; BYDV-PAV and BYDV-PAS in *Microlaena stipoides* and *Dichelacne crinita*; BYDV-MAV in *P. cita*, *F. novae-zelandiae* and *H. redolens*; and CYDV-RPV in *P. cita* and *M. stipoides*. Molecular techniques for virus detection and identification were developed or improved during this study. Phylogenetic analyses of viral coat protein sequences from native and exotic grass species indicate either frequent or recent virus movement into native ecosystems, and multiple virus introduction events in New Zealand. The likely origins of the virus species are discussed. Two CoMV variants were identified, one of which caused severe necrosis in susceptible cocksfoot cultivars. Reciprocal aphid transmission of BYDV-PAV using cereals and native grasses showed that although transmission to natives was low, the efficiency of transmission from natives to cereals was comparable to that between cereal species, suggesting virus adaptation to the cereal host species.

The findings from this study are discussed in respect to disease management and bio-security in New Zealand, and recommendations are made for future research.

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Quotes

“In the language of history human beings are said to have domesticated the grasses, but in the language of ecology the grasses might as easily be said to have domesticated the hairless apes”. Graham Harvey

“The basis of human proliferation is not our own seed but the seed of grasses”. Evan Eisenberg.



Dedication

I wish to dedicate this thesis to my father, Delmiglio Luigi Mario (Gino), and Iannizzi Assunta (my 'second' mother & dear friend). They supported and believed in me, and it was always my desire to make them proud. Unfortunately, they both died in 2006 during my PhD studies, so they are not able to see me reach this important achievement in life. However, they (as well as my mother) will always be alive in my heart, and will continue to give me the strength to persevere with goals I set in life.

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Abbreviations

SI (Système International) abbreviations are used for chemicals, elements and formulae. Other abbreviations used in the text are listed below.

~	approximately
±	plus-minus
>	greater than
<	less than
≥	greater or equal to
≤	less or equal to
°C	degrees Celcius
µm	micrometer(s)
µg	microgram(s)
µL	microlitre(s)
aa	amino acid
ACP	antigen coated plate
AIC	Akaike Information Criterion
ANOVA	analysis of variance
AP	alkaline phosphatase
ATG	Army training group
BLAST	Basic Local Alignment Tool
bp	base pairs
BSA	Bovine Serum Albumin
BSMV	<i>Barley stripe mosaic virus</i>
BYDV	<i>Barley yellow dwarf virus</i>
BYDVs	Barley and cereal yellow dwarf virus diseases
cDNA	Complementary deoxyribonucleic acid
CP	coat protein
CMV	<i>Cucumber mosaic virus</i>
CnMoV	Cynosurus mottle virus
CoMV	<i>Cocksfoot mottle virus</i>
cv	cultivar
CYDV	<i>Cereal yellow dwarf virus</i>
DAS	double antibody sandwich
DNA	deoxyribonucleic acid
dNTPs	2'-deoxynucleotide 5'-triphosphate
DoC	Department of Conservation
DsMV	<i>Dasheen mosaic virus</i>
E. coli	<i>Escherichia coli</i>
EDTA	ethylene diamine tetra-acetic acid
ELISA	Enzyme-linked immuno-sorbent assay

g.....	grams
GLM.....	general linear model
GPS.....	Geographical Positioning System
h.....	hour(s)
HLRTs.....	Hierarchical Likelihood Ratio Tests
ICTV.....	International Committee on Taxonomy of Viruses
ID.....	identification
ISEM.....	immuno-sorbent electron microscopy
Kb.....	kilobase(s)
L.....	litre(s)
LINZ.....	Land Information New Zealand
m.....	meter(s)
M.....	molar (moles/litre)
MAF.....	Ministry of Agriculture and Forestry
min.....	minute(s)
mL.....	millilitre
ML.....	Maximum Likelihood
mM.....	millimolar (millimoles/litre)
mm.....	millimeter
n/a.....	not applicable
NCBI.....	National Centre for Biotechnology Information
ng.....	nanograms
NI.....	North Island
NJ.....	Neighbour Joining
nm.....	nanometer
nt.....	Nucleotide
NVS.....	National Vegetation Survey
NZ.....	New Zealand
NZMS.....	New Zealand Map Grid
OD.....	optical density
PCR.....	Polymerase Chain Reaction
PEMV.....	<i>Pea enation mosaic virus</i>
pmol.....	picomoles
RDP.....	Recombination Detection Programme
RGCV.....	<i>Ryegrass cryptic virus</i>
RGMV.....	<i>Ryegrass mosaic virus</i>
RNA.....	ribonucleic acid
rpm.....	revolutions per minute
RT.....	reverse transcription
RYMV.....	<i>Rice yellow mottle virus</i>
s.....	second(s)
SBS.....	School of Biological Sciences (The University of Auckland)
SI.....	South Island

sp.....	species (singular)
spp.	species (plural)
SSCP.....	Single Strand Conformation Profile
TBE.....	Tris-Borate-EDTA
TEM.....	Transmission Electron Microscope
TNV.....	<i>Tobacco necrosis virus</i>
Tris.....	Tris(hydroxymethyl)-aminomethane
UV.....	ultraviolet
v/v.....	volume/volume
W.....	Watts
WMTA.....	Waiouru Military Training Area
WMV.....	<i>Watermelon mosaic virus</i>
WSMV.....	<i>Wheat streak mosaic virus</i>
w/v.....	weight/volume
ZYMV.....	<i>Zucchini yellow mosaic virus</i>