ICBI 2023

Fourth International Congress on Biological Invasions

ORAL ABSTRACT & PROGRAMME BOOK

Christchurch Town Hall, Aotearoa New Zealand **1–4 May 2023**

INNOVATION **COLLABORATION** **PARTNERSHIP**

www.icbi2023.com

Plant & Food Research
Rangahau Ahumāra Kai

B3 Science Solutions for Better Border Biosecurity
AOTEAROA NEW ZEALAND

100% PURE NEW ZEALAND
businessevents.newzealand.com

Thank you to our Congress sponsors

Biosecurity New Zealand
Ministry for Primary Industries
Manatū Ahu Matua

CABI

NIWA
Taihoro Nukurangi

Lincoln University
Te Whare Wānaka o Aoraki

CSIRO

New Zealand's Biological Heritage
Ngā Koiora Tuku Iho
National Science Challenges

cebra
Centre of Excellence for Biosecurity Risk Analysis

forestgrowers
levy trust inc

Manaaki Whenua
Landcare Research

Murdoch University
Harry Butler Institute

New Zealand Plant Protection Society
Protecting Plants with Science

University of Canterbury
Te Whare Wānanga o Waitaha
Christchurch New Zealand

Plant Biosecurity Research Initiative

B3
Science Solutions for Better Border Biosecurity
AOTEAROA NEW ZEALAND

agresearch
āta mātai, mātai whetū

Horticulture New Zealand
Ahumāra Kai Aotearoa

Australian Centre for International Agricultural Research

Australian Aid

Te Tira Whakamātaki
Indigenous solutions for a better world

KVH

FAR

NeoBiota
A peer-reviewed open-access journal
Advancing research on alien species and biological invasions

Plant & Food Research
Rangahau Ahumāra Kai

Congress Partners

Plant & Food Research
Rangahau Ahumāra Kai

B3
Science Solutions for Better Border Biosecurity
AOTEAROA NEW ZEALAND

100% PURE NEW ZEALAND
businessevents.newzealand.com

ICBI 2023

E ngā mana, e ngā reo, e ngā karangaranga maha, ō ia iwi, o ia takiwā, ō ia motu

Tenei te mihi maioha ki a koutou katoa.

E ngā iwi ō ngā hau e wha

Nau mai Haere mai, whakatau mai.

On behalf of the organising committees, I would like to welcome you to the 4th International Congress on Biological Invasions (ICBI2023) in Christchurch/Ōtautahi, Aotearoa New Zealand. This Congress brings together about 400 researchers from throughout the world and we thank all the attendees whose contributions have made the scientific programme so interesting and diverse.

The global threat posed by Invasive Alien Species (IAS) is greater than ever before, and it is becoming more evident that no country is immune from the immense, insidious and often irreversible economic, environmental and social impacts they present.

ICBI2023 marks the first time this Congress has been held outside China. Aotearoa New Zealand is especially vulnerable to IAS. Its economy relies heavily on primary production and its geographic isolation has given rise to unique flora and fauna and a high degree of endemism. Defending the country from IAS is a top priority and we have world-leading research programmes in border biosecurity science, integrated pest management, offshore and onshore island predator eradication, and meaningful partnerships with Māori.

As international trade, tourism and transportation networks continue to expand, ICBI2023 will provide a science forum to explore, share and develop effective responses to the global challenges and threats that IAS present to biodiversity, ecological systems, food production and food security in terrestrial, freshwater and marine ecosystems.

Innovation, Collaboration, and Partnership are the high-level themes for ICBI2023 and the Congress has a particular emphasis on partnering with indigenous and Pacific communities. The Congress also provides a platform for the exchange of new research and tracking of technical innovation among participants from different backgrounds and countries.

Enjoy and benefit from the Congress

Dr David Teulon
Chair, Local Organising Committee

Contents

Chinese Academy of Agricultural Sciences
China

The Chinese Academy of Agricultural Sciences (CAAS) is a national, integrative agricultural scientific research organization with responsibility for carrying out both basic and applied research, as well as research into new technologies impacting agriculture. CAAS is dedicated to overcoming a broad range of challenges impacting agricultural development and support of the local rural economy. Importantly, CAAS promotes sustainable agriculture within and outside China, extending its reach through technology exchange and cooperative research agreements with agricultural research institutions/universities domestically and internationally and global non-governmental organizations. CAAS, established in 1957 and headquartered in Beijing, oversees 42 institutes. Among those, research especially at the Institute of Plant Protection, the Agricultural Genomics Institute at Shenzhen, and the Western Research Institute cover a broad range of topics in the field of biological invasions.

www.caas.cn/en

Congress Committees

Local Organising Committee	Science Steering Committee	International Advisory Committee
David Teulon – Plant & Food Research / Better Border Biosecurity (B3), NZ	Graeme Inglis – National Institute for Water and Atmosphere, NZ	Andy Sheppard – Commonwealth Scientific and Industrial Research Organisation, Australia
Mark McNeil – AgResearch, NZ	Marty Deveney – South Australian Research and Development Institute, Australia	Philip Hulme – Lincoln University, NZ
Philip Hulme, Lincoln University, NZ	Linda Ford – Charles Darwin University, Australia	Fang-Hao Wan– Institute of Plant Protection, Chinese Academy of Agricultural Sciences, China
Veronica Herrera – Ministry for Primary Industries, NZ	Chad Hewitt – Murdoch University, Australia	Silvia Ziller – The Horus Institute for Environmental Conservation and Development, Brazil
Graeme Inglis – National Institute for Water and Atmosphere, NZ	Debra Hofstra – National Institute for Water and Atmosphere, NZ	Piero Genovesi – Institute for Environmental Protection and Research, Italy
Andy Sheppard – Commonwealth Scientific and Industrial Research Organisation, Australia	Jo Luck – Plant Biosecurity Research Initiative, Australia	Sofia Consuegra – Department of Biosciences, Wales/UK
Murray Fea – Department of Conservation, NZ	Jean-Yves Meyer – Research Dept Government of French Polynesia, French Polynesia	Greg Ruiz – Smithsonian Environmental Research Center, USA
Arapata Reuben – Ngāi Tūāhuriri, Aotearoa	Andrew Robinson – University of Melbourne, Australia	Helen Roy – Centre for Ecology and Hydrology, England/UK
Alby Marsh – Plant & Food Research / Better Border Biosecurity (B3), NZ	Dan Tomkins – Predator Free 2050, NZ	Bharat Babu Shrestha – Tribhuvan University John Wilson – Centre for Invasion Biology
Aurelie Castinel – Ministry for Primary Industries, NZ	Nianwan Yang – Institute of Plant Protection, Chinese Academy of Agricultural Sciences, China	
Sathish Puthigae – Ministry for Primary Industries, NZ	Axel Heiser – AgResearch, NZ	
Yvonne McDiarmid – Plant & Food Research, NZ	Tame Malcom – Department of Conservation, NZ	
Associate Members Megan Jones – Plant & Food Research, NZ Liz Duston – Plant & Food Research, NZ	Susanna Findlay-Smits – Manaaki Whenua Landcare Research, NZ	

Social Programme

Monday 1st May

Welcome Reception – Christchurch Town Hall, Foyer – 7pm
(included in full registration)

Drinks and nibbles served

Sponsored by: University of Canterbury

Tuesday 2nd May

Poster Session – Christchurch Town Hall, Foyer – 6.15pm
(included in full registration)

Drinks and nibbles served

Music: Ngā Reo Tioriori

Wednesday 3rd May

Gala Dinner – Te Pae Convention Centre, Waitaki Room, 188 Oxford Street, Christchurch – 6.45pm
(Note: not included in full registration – separate payment required)

Dress: Smart Casual/Cocktail

Entertainment: Mirror Band

Sponsored by: Murdoch University / Harry Butler Institute

Thursday 4th May

B3 Dinner – Christchurch Town Hall (Avon room) – 6.30pm
(Note: not included in full registration – separate payment required)

Pre-dinner drinks – Christchurch Town Hall Foyer

Congress Keynote Speakers

Prof. Ruth Wallace

Professor Ruth Wallace is the Dean of the College of Indigenous Futures, Education and the Arts. She is also the Director of the Northern Institute at Charles Darwin University. Ruth was the first woman to be awarded the Fulbright Distinguished Chair in Agriculture and Life Sciences Scholarship. Her research interests relate to the links between identity, marginalised learners, and the development of effective learning and workforce development pathways. This work is situated in regional and remote areas of Northern Australia and Indonesia, with a specific focus in research approaches to improve service delivery and adaptation, undertaken with Aboriginal people in remote and regional areas. Ruth's research connects to digital systematic learning pedagogies, and approaches to workforce development through remote-based enterprises. Ruth leads the workforce development research theme of the Northern Institute at Charles Darwin University and focuses on collaborative approaches to workforce development and engagement with community, governments and industry that are sustainable and scalable. Ruth has extensive experience in educational practice development and as a teacher at all educational levels.

Prof. Helen Roy

Professor Helen Roy MBE Hon. FRES, is an ecologist at the UK Centre for Ecology & Hydrology. Her research focuses on the effects of environmental change, particularly biological invasions, on biodiversity and ecosystems. Helen leads many collaborative national and international research projects on biological invasions with a focus on enhancing information flow to inform understanding of the impacts of invasive alien species. She is leading research for the EC on enhancing understanding and awareness of invasive alien species. Helen also enjoys science communication and public engagement with research, which led to her interest in citizen science; an approach that she has implemented in a number of contexts perhaps notably the collaborative studies she has led alongside volunteers to track the spread of the harlequin ladybird, *Harmonia axyridis*. Helen leads a Defra-funded project to produce a comprehensive information portal on non-native species in Great Britain, which also includes annual reports on status and trends of invasive alien species and the development of an alert system for people to report sightings of concern. Over the last few years she has had the privilege of working with the UK Overseas Territories to predict and prioritise invasive non-native species. Her research on invasive non-native species has received international recognition and she is currently leading a global assessment on invasive non-native species for the Intergovernmental Panel on Biodiversity and Ecosystem Services.

Prof. Philip Hulme

Philip Hulme is the Distinguished Professor of Plant Biosecurity at Lincoln University, New Zealand and Director of the Centre for One-Biosecurity Research, Analysis and Synthesis (COBRAS). His research interests span the biosecurity continuum and addresses pathways of introduction, invasive species risk assessment, dispersal and spread as well as impacts on ecosystems, and designing effective management strategies. He has examined invasions in both aquatic and terrestrial ecosystems examining the invasion of New Zealand by fungal pathogens, weeds and mammals. He is keen to see a more integrated and transdisciplinary approach to invasion science under the umbrella of One Biosecurity.

Dr. Kevin Lafferty

Kevin Lafferty is a senior scientist with the US Geological Survey and adjunct faculty at the University of California Santa Barbara. He studies marine diseases and has long been interested in the role of species introductions and the ecology of climate change and infectious disease.

Kevin's main research interests lie in how parasites affect ecosystems and, in turn, how ecosystems affect parasites. He is also involved in research on the conservation of marine resources, investigating strategies for protecting endangered shorebirds, fish and abalone. He has also assessed the effects of marine reserves.

CABI

Prevention, early detection and management of invasive pests

CABI has worked on invasive species for over 100 years. Our scientists are world leaders in biocontrol research and we are currently working on the management of over 80 invasive species around the world.

We produce a range of dedicated knowledge tools on how to prevent the spread of invasive species, how to detect outbreaks and best practice solutions. We also help create policies, strategies and action plans at national and regional level.

www.cabi.org/invasives

NIWA
Taihoro Nukurangi

NIWA's biosecurity experts work with our clients to develop practical, risk-based solutions to marine and freshwater biosecurity threats that are informed by world-leading research.

Climate, Freshwater & Marine Science

CSIRO

Australia's National Science Agency

Delivering biosecurity solutions through innovative science and technology

CSIRO has a strong record of delivering breakthrough innovations and technologies with real-world impact. We collaborate to deliver a better future for everyone: people, our planet and our economy.

Come talk to us at our display in the exhibition space.

csiro.au/biosecurity

Programme

Day 1. Monday 1 May 2023

Time	
	ICBI2023 Congress
15.00	Congress Registration (CHCH Town Hall Entrance Foyer)
16.30	Congress Opening (CHCH Town Hall James Hay Theatre) • Mihi Whakatau and Opening Comments: Ngāi Tūāhuriri • Response from First Nations • Welcome from Local Organising Committee Chair: David Teulon • Welcome to Christchurch: Councillor Sara Templeton • Honorary Address by previous ICBI host: Fanghao Wan • Opening of Congress (TBC)
18.15–19.00	Congress Keynote: One Biosecurity: Building better responses to biological invasions in the wake of a global pandemic **Philip Hulme** James Hay Theatre
19.00	Welcome reception with refreshments Welcome reception sponsor: *University of Canterbury*

The speakers, topics and times are correct at the time of publishing. In the event of unforeseen circumstances the organisers reserve the right to alter or delete items from the Congress programme

Day 2. Tuesday 2 May 2023

Time				
8.00	Registration in CHCH Town Hall Foyer			
8.30–9.15	Congress Keynote: Policy co-design: opportunities, challenges and risks for community, government and industry **Ruth Wallace** *Keynote sponsor: Plant Biosecurity Research Initiative* James Hay Theatre			
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	One Biosecurity	Trans-national collaboration	Māori in biosecurity *Session sponsor: B3*	Coconut rhinoceros beetle *Session sponsor: AgResearch*
9.30-9.50	One Biosecurity: An aquatic invasions perspective **Jonathan Bray**	Strengthening phytosanitary research programming and collaboration: from European to global phytosanitary research coordination **Baldissera Giovani**	Bringing tikanga Māori (Māori values) into biosecurity research: Te Haere huihui tahi (A journey gathering together) **Teresa Waiariki**	The long history of *Oryctes rhinoceros* (CRB) invasion into the Pacific **Trevor Jackson**
9.50-10.10	One Biosecurity approach to research prioritisation **Cassandra Edmunds**	Transdisciplinary and transbounday partnerships: New models of collaboration for management of invasive alien species **Alison Watson**	Kaitiakitanga, science and better, border biosecurity **Waipaina Awarau-Morris**	Retrospective and future directions for management of coconut rhinoceros beetle in Hawai`i **Keith Weiser**
Session	Evaluation & optimisation of biosecurity systems	Trans-national collaboration	Māori in biosecurity	Coconut rhinoceros beetle
10.10-10.30	Darwin and the exploding trousers: assessing an existential risk after two centuries of biological invasions in New Zealand **John Kean**	Enhanced Pacific Biosecurity Partnership: A programme to protect plants from invasive pests and diseases **Disna Gunawardana**	Pests and pathogens of native plants from the Pacific: what risks for New Zealand taonga? **Kiryn Dobbie**	Progress towards improving pest management strategies against *Oryctes rhinoceros*, a re-emerging invasive pest in the Pacific **Sean Marshall**

Time				
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
10.30-10.50	A national approach to improving integration of invasive species and wildland fire management **Stas Burgiel**	Biosecurity and Antarctica – an overview of an international effort to protect a critical environment with global significance **Rachel Innes**	Culturally directed engagement with Māori on fall armyworm in Te Tai Tokerau/Northland **Jorden Pickering**	The incursion of the coconut rhinoceros beetle (CRB) into the Pacific Region and its management efforts **Sarlesh Kumar**
10.50-11.10	Morning tea/coffee in Foyer			
Session	Evaluation & optimisation of biosecurity systems	Semi-autonomous platforms	Indigenous responses	Coconut rhinoceros beetle
11.10-11.30	Networked socioecological models for integrating agency-led and public-led invasive species incursion responses under climate change – a regional-scale analysis of the grassland weed *Nassella neesiana* **Chris Buddenhagen**	Leveraging technological advances in robotics and computer vision for management of marine pests **Leigh Tait**	Taonga Māori myrtaceae threatened by Myrtle rust (*Austropuccinia psidii*) **Alby Marsh**	Coconut rhinoceros beetle in Papua New Guinea: An ongoing threat **David Tenakanai**
11.30-11.50	Predicting the invasiveness of the global pathogen genus *Phytophthora* **Treena Burgess**	Cold PAWS: Exploring the effectiveness of label-efficient deep learning approaches in biosecurity applications **Nathaniel Bloomfield**	Potential impacts on rata vines (*Metrosideros* spp.) of myrtle rust caused by *Austropuccinia psidi*i **Hone Ropata**	CRB invasion genomics for biosecurity and management strategies **Wee Tek Tay**
11.50-12.10	Developing a mathematical model to evaluate biosecurity inspection policies at the border **Chris Baker**	Using artificial intelligence to detect submerged aquatic weeds to protect Aotearoa New Zealand's waterways **Daniel Clements**	Māori inclusive research programmes lead to greater science outcomes. **Beccy Ganley**	The Pacific Ecological Security Congress Strategic Action Plan for coconut rhinoceros beetle **Phil Andreozzi**
12.10-12.30	Modelling emerging biosecurity threats: choosing complexity is not so simple **Isobel Abell**	Real-time invasive marine species detection using computer vision deployed on remotely operated vehicles **Rose Pearson**	Te Whakahononga an approach that elevates mana whenua into the biosecurity and research system **Waitangi Wood**	Discussion
12.30-13.30	Lunch in Foyer			

Time				
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Evaluation & optimisation of biosecurity systems	Semi-autonomous platforms & surveillance	Risk assessment	Aggregating & organising knowledge
13.30-13.50	A century of weed change in New Zealand's forage seed multiplication industry **Jesse Rubenstein**	Semi-automated surveillance using image segmentation of street-level urban trees **Paul Benden**	A sentry for the flock: An intelligence approach to forecasting biosecurity **Madeline Marshall**	Leveraging biodiversity infrastructure for biosecurity surveillance and analysis **Andrew Turley**
13.50-14.10	The application of adaptive resource management to reptile eradications: A case study for achieving functional eradication of brown tree snakes **Melia Nafus**	Automatic detection of contaminants on sea container exteriors to improve detection of unwanted exotic organisms **Rhys Fitzgerald**	Employing horizon scanning to prioritize invasive alien pests with the potential to threaten agriculture, biodiversity, and forestry in Africa **Joseph Mulema**	The database of invasive alien species in China and its roles in their management **Xiaoqing Xian**
14.10-14.30	Early detection and eradication of invasive ants via New Zealand's national invasive ant surveillance programme (NIAS) **Lora Peacock**	Ultra violet lights and molecular diagnostics for wide area surveillance of recent invasive species establishments **Steve Pawson**	Risk analysis of alien fishes invasion in inland waters of Guangxi, China **Jiayang He**	Biosecurity research portal: connecting key questions to research **Les Kneebone**
14.30-14.50	Celebrating 20-years of a national marine pest surveillance programme **Abraham Growcott**	Determination of hourly distribution of *Tuta absoluta* using sex pheromones and ultraviolet-light traps in protected tomato crops **Gui-Fen Zhang**	Advancing quantitative pre-border risk assessment frameworks for forecasting invaders and invasions **Arman Pili**	Biological invasions in Australia's forests across space, time and the biosecurity continuum **Helen Nahrung**
14.50-15.10	Forest biosecurity in New Zealand – A plantation forestry perspective **Brendan Gould**	Towards passive traps for marine pest species using novel acoustic methods **Serena Cox**	How many ways are there to manage the biosecurity risks from global trade?: A Menu of Measures for effective risk reduction **Rieks van Klinken**	Asserting status to marine species in oceanic islands: native vs non-native **Manuela Parente**
15.10-15.50	Afternoon tea/coffee in Foyer			

Time				
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Evaluation & optimisation of biosecurity systems	Predator eradication	Indigenous perspectives *Session sponsor: Te Tira Whakamātaki*	Insect/pathogen interactions
15.50-16.10	A systems approach to biosecurity pays off: a case study investigating introduction pathways and interceptions of non-indigenous species at a biosecurity border **Barbara Kachigunda**	The breakthrough science needed for Predator Free 2050 success **Dan Tompkins**	Engaging with and learning from how Indigenous Rangers contribute to biosecurity in Northern Australian **Renae Todd**	From red-listed to rogue: current research on the biology and management of the native planthopper *Pentastiridius leporinus* that became an invasive vector of the new sugar beet disease syndrome "basses richesses" **Michael Rostas**
16.10-16.30	Development of an integrated island biosecurity framework **Yang Liu**	The global contribution of invasive vertebrate eradication as a key island restoration tool **James Russell**	Indigenous perspectives and experiences of biological invasions **Simon Lambert**	The invasive plant virus (Tomato spotted wilt orthotospovirus) benefits its vector, the invasive *Frankliniella occidentalis*, due to metabolite re-arrangement in the host plant **Zhijun Zhang**
16.30-16.50	Optimal post-border surveillance against invasive pests to protect a valuable nature reserve and island asset **Tom Kompas**	Tooling up for predator eradication **Olivia Rothwell**	The secret sauce in the fight against predators is Indigenous knowledge: how government and research can support, not capture **Tame Malcolm**	Suppression of vector immune response promotes the global invasion of tomato yellow leaf curl virus **Xiao-Wei Wang**
16.50-17.10	Valuing the biosecurity system – measuring the costs of invasives **Michael Ormsby**	Predator Free from mountains to sea **Melissa Brignall-Theyer**	Lessons learned from Indigenous communities who are protecting spaces and places of importance from biological invasions **Micheal Heimlick**	Preparing for a *Xylella* incursion: Presence and movement of spittlebugs in New Zealand landscapes **Jessica Vereijssen**
17.10-17.30	The value of New Zealand's biosecurity system **Julia Polak**	Involving island communities in biosecurity – What will it take to keep our inhabited islands pest free? **Julie Alach**	Its our future: taking action to protect our environment and our communities, whilst driving innovative technologies **Marcus-Rongowhitiao Shadbolt**	Chemical communications mediates symbiosis invasion among pinewood nematodes, its vector beetle, associated microbes and pine trees **Lilin Zhao**

Time				
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
17.30-17.50	Prospect study for wild fishery or culture of non-native crustaceans **Yvonne Matthews**	How can we get people to care about invasive species management? Insights from recent social research in Australia **James Trezise**	Remembering our future in order to protect the living web of the world **Melanie Mark-Shadbolt**	The immune homeostasis between pinewood nematodes and its vector beetle **Jiao Zhou**
18.15	Poster session (refreshments) Poster abstracts can be found at **bit.ly/3zyKYIM** or by scanning the QR code If you require the full link to the website: Full link: **https://www.scienceevents.co.nz/icbi2023/about** Music: Ngā Reo Tīoriori CHCH Town Hall Foyer			

Day 3. Wednesday 3 May 2023

Time				
8.00	Registration in CHCH Town Hall Foyer			
8.30–9.15	Congress Keynote: Documenting and predicting future risk of biological invasions **Helen Roy** James Hay Theatre			
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Climate change *Session sponsor: B3*	Quarantine treatments *Session sponsor: B3*	Genomic mechanisms of invasion success	Behaviour change *Session sponsor: Horticulture NZ*
9.20-9.50 **Session Keynote**	Response of invasive species to climate change and implications in agriculture and horticulture **Chun-Sen Ma**	Choosing the best stress: Using insect physiology to inform quarantine treatments and limit invasions **Leigh Boardman**	Genomic basis of adaptation in an invasive sea squirt (*Styela clava*) **Bo Dong**	Biosecurity and the Australian citrus industry: working across stakeholders to plant seeds of resilience **Jessica Lye**
9.50-10.10	Range reshuffling: climate change, invasive conifers, and the future of beech forests in Aotearoa New Zealand **Matt Larcombe**	Egg morphology of key insect pests as related to fumigation efficacy **Spencer Walse**	A new model system for investigating the key predictors of invasion success **Ang McGaughran**	The team of 4.7 million? Biosecurity perceptions and practices in and around the Port of Tauranga **Susanna Finlay-Smits**
10.10-10.30	Integrating biogeographic approach into the early warning and classical biological control of ragweeds (*Ambrosia* L.) under climate change **Haoxiang Zhao**	Heat stress responses of insects and their life stages: Implications for quarantine treatments and predictive models **Kambiz Esfandi**	Population genomics of invasive lantana and implications for improved biological control **Patricia Lu-Irving**	Funding biosecurity systems efficiently, fairly and sustainably **Susan Hester**
10.30-10.50	On the incorporation of insects' mitigation responses to climate change into prediction models **Gang Ma**	X-ray technology as a biosecurity treatment for New Zealand: current use, prospects & potential **Lisa Jamieson**	Genomic signals of local adaptation across the invasive ranges of the Queensland fruit fly, *Bactrocera tryoni* **Eli Parvizi**	Biosecurity alerts – early detection via Australia's largest biodiversity data infrastructure **Erin Roger**

Time				
10.50-11.10	Morning tea/coffee in Foyer			
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Climate change	Quarantine treatments	Applying molecular tools	Building social partnerships
11.10-11.30	*Phytophthora cinnamomi* in a changing climate **Leann Vinson**	Development of the Comet Assay for diagnosis of irradiated insects and fruit in the phytosanitary treatments used to prevent establishment of exotic invasive species **Ela Hiszczynska-Sawicka**	Retracing the world-wide invasion of the pine bark beetle *Hylurgus ligniperda* **Eckehard Brockerhoff**	Developing a biosecurity system tool that encourages and supports inclusive, equitable and regenerative practices **Will Allen**
11.30-11.50	Prediction of the current and future distributions of the Hessian fly, *Mayetiola destructor*, under climatic change in the world **Hao Zhang**	Reducing risks on root crops from Pacific Island nations **Alan Woolf**	Giant African snail genomes provide insights into molluscan whole genome duplication (WGD) and aquatic-terrestrial transition **Conghui Liu**	Shared responsibility for biosecurity: Organisational challenges and opportunities **Vaughan Higgins**
11.50-12.10	Climate change will increase the global risk of Tephritidae pests **Yuan Zhang**	Exploring pest mitigation research and management associated with wood packaging in the international supply chain: what and where are the weak links? **Leigh Greenwood**	Components of *Sirex noctilio* and *Sirex nitobei* venoms and their parasitic nematodes **Zhengtong Wang**	Aotearoa New Zealand's Biosecurity System for the future **Ursula Torres**
12.10-12.30	Pre-adaptation to novel climates facilitates invasion of globally widespread weeds in New Zealand **Thomas Carlin**	From studies to applications: the development of invasion mechanism and key phytosanitary technology on agricultural insect pests in China **Zhihong Li**	Gene editing takes on the Spotted Wing Drosophila invasion **Ying Yan**	Enabling large scale community surveillance and action on invasive species **Andreas Glanznig**
12.30-13.30	Lunch in Foyer Early career and student only lunch, with Congress Keynotes Avon Room			

Time				
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Adapting to climate	Pacific biosecurity *Session sponsor: Australian Centre for International Agricultural Research*	Applying molecular tools	Building social partnerships
13.30-13.50	Protected agriculture matters: Year-round persistence of *Tuta absoluta* in China where it should not **Zhaozhi Lu**	Strengthening Biosecurity in Hawaii and the Pacific **Leyla Kaufman**	MicroRNA regulation of distinct gene expression responses to thermal acclimation in Oriental fruit fly, *Bactrocera dorsalis* **Yan Zhao**	Co-designing UAV technologies and operational protocols for biosecurity: transdisciplinary approaches in biosecurity technology design **Andrea Grant**
13.50-14.10	Potential geographical distribution of the little fire ant, *Wasmannia auropunctata* in China based on MaxEnt model **Jun Ma**	25 years of invasive alien species management in the islands of French Polynesia (South Pacific): successes... and failures **Jean-Yves Meyer**	ICE1 -demethylation mitigated cold-tolerance drives range expansion of *Ageratum conyzoide* in China **Xin Zhou**	Integrated Landscape Management for sustainable control of invasive non-native plants **Hariet Hinz**
14.10-14.30	Niche shifts and range expansions after the invasions of two major pests: Asian longhorned beetle and citrus longhorned beetle **Yuting Zhou**	Developing a biosecurity plan for the Papua New Guinea coconut industry **Sivapragasam Annamalai**	Comparative biochemical and transcriptome analyses in tomato and eggplant reveal their differential responses to *Tuta absoluta* infestation determines the host fitness of pests **Youming Hou**	The complexity of biosecurity in aquaculture in New Zealand **Anjali Pande**
14.30-14.50	Temperature adaptation of the South American tomato pinworm, *Tuta absoluta*, a newly invaded pest in China **Xiao-wei Li**	New marine biosecurity toolkit for Pacific Island countries and territories **Kimberley Seaward**	Implementing molecular surveys for marine pests: addressing doubt **Marty Deveney**	What makes a good risk-based decision in biosecurity? **Melanie Newfield**
14.50-15.10	Disease climatic risk model interpretations at multiple spatial scales **Rebecca Campbell**	Addressing the threat of invasive species to deliver a resilient Pacific **Richard Griffiths**	Across land, islands, and sea: the power of metabarcoding for multiple biosecurity industries, targets, and environments **Francesco Martoni**	Russell lupin – a beautiful but harmful species; Harnessing the power of the tourism industry in the management of invasive weeds **Brent Lovelock**
15.10-15.50	Afternoon tea/coffee in Foyer			

Time				
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Optimising biological control	Pacific biosecurity	Improved diagnostics	Building social partnerships
15.50-16.10	Biological control programmes for the global invader *Drosophila suzukii*, Spotted-wing Drosophila **Judith Stahl**	Cockroaches in the coalmine: bioindicators of lost ecological resiliency **Scott Goetz**	Development of a LAMP method for the rapid detection of Hessian fly for quarantine and field application **Qi Ma**	Integrating biosecurity into the tourist experience: Prospects and issues **Kevin Moore**
16.10-16.30	The nectar resource plant buckwheat enhances the potential of the parasitoid *Eretmocerus hayati* in the augmentative biological control of the whitefly *Bemisia tabaci* **Yin-Quan Liu**	Policy development for biofouling management in the Pacific region. The GloFouling Partnerships initiative **Mohammed Zullah**	Rapid and accurate diagnostics of invasive species using CRISPR/ Cas12a technology **Xiaoping Hu**	Elaborating on invasive species management: The influence of increasingly engaging communication on management acceptance **Ingrid Schneider**
16.30-16.50	The inducement and cytological mechanism of thelytoky and the comparative biological control potential of two strains of *Diglyphus wani* **Weijie Wan**	Enhancing biosecurity to sustain eradication outcomes in Palau **Loyola Darius**	Diagnostic test performance of visual assessment and soil bioassay for *Phytophthora agathidicida* to improve survey design and interpretation for the causal pathogen of kauri dieback in *Agathis australis* using Bayesian latent class analysis **Karyn Froud**	**** 1080 – Whanganui Pig Hunters and their thoughts about the use of 1080 **Claire Dowsett**
16.50-17.10	Pre-emptive classical biological control: a novel approach to increase preparedness for potential biosecurity threats **Gonzalo Avila**	Working towards strengthening the biosecurity capability in the Cook Islands **Pavai Taramai**	Growing rust fungi on artificial substrates – A step closer to studying infection in the laboratory without the use of plants **Sarah Sale**	Working together to address invasive species on islands **Salit Kark**
17.10-17.30	Using the PRONTI tool to select non-target scale species for prey-range testing with *Neoleucopis* n. sp. B **Jacqui Todd**	Natural Enemies – Natural Solutions for Invasive Weeds in the Pacific **Chris McGrannachan**	Rapid fingerprinting metabolomics: a new complementary tool for biosecurity and quarantine diagnostics **Alastair Ross**	Indigenous-led approaches to design and deliver effective biosecurity and invasive species management systems in Northern Australia **Andy Sheppard**
18.45	Congress dinner Dinner sponsor: *Murdoch University / Harry Butler Institute* Entertainment: Mirrors Band Venue: Te Pae, Christchurch Convention Centre			

Day 4. Thursday 4 May 2023

Time				
8.00	Registration in CHCH Town Hall Foyer			
8.30–9.15	Congress Keynote: Parasites as lost baggage and unwelcome hitch hikers **Kevin Lafferty** James Hay Theatre			
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Fall armyworm *Session sponsor: Foundation for Arable Research*	Brown marmorated stink bug *Session sponsors: NZ horticultural industries*	*Ceratocystis* & Rapid ʻŌhiʻa Death *Session sponsor: Kiwifruit Vine Health*	New control technologies *Session sponsor: Plant & Food Research*
9.20-9.50 **Session Keynote**	The ongoing challenge of managing fall armyworm: a west Australian perspective **Helen Spafford**	Brown marmorated stink bug biosurveillance, management and biological control: Progress made in managing this invasive pest and continued knowledge gaps **Tracy Leskey**	*Ceratocystis* diseases rising in South Africa – and elsewhere in the world **Irene Barnes**	Double-stranded RNA as a novel control for myrtle rust **Anne Sawyer**
9.50-10.10	Refined forecasting capabilities to diagnose trans-Tasman dispersal within Aotearoa/New Zealand, dispersal of fall army worm **Richard Turner**	3D-printing of the brown marmorated stink bug for community engagement **Joel Tregurtha**	Rapid ʻŌhiʻa Death: Ongoing research to protect native forests in Hawai'i and the Pacific **Lisa Keith**	Next-generation and highly targeted pest control: using dsRNA for varroa mite control in beehives **Phil Lester**
10.10-10.30	Where in New Zealand can fall armyworm survive winter? **Craig Phillips**	Biological control research of *Halyomorpha halys* in kiwifruit in China **Jin-Ping Zhang**	Hawaiian forest mortality trajectories associated with Ceratocystis wilt of ʻōhiʻa **Ryan Perroy**	Characterisation of the epiphytic microbiome of myrtaceous species and implications for infection by *Austropuccinia psidii* **Hayley Ridgway**

Time				
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
10.30-10.50	A cooperative response to fall armyworm in New Zealand: government and Industry working together **Scott Hardwick**	Inside the BMSB gut – biosecurity measures and pest management potential **Chandan Pal**	Mapping pan-Pacific distributions of *Metrosideros* species as potential *Ceratocystis* hosts: a fuzzy geographic approach given occurrence data uncertainty **Thomas Etherington**	A Māori perspective on new technologies for invasive species control, and their potential application on our whenua (lands) **Melanie Mark-Shadbolt**
10.50-11.10	Morning tea/coffee in Foyer			
Session	Fall armyworm	Brown marmorated stink bug	*Ceratocystis* & Rapid ʻŌhiʻa Death	New control technologies
11.10-11.30	Bacterial community structure in *Spodoptera frugiperda* and the prevalence of the endosymbiont *Wolbachia* **Yuan Liu**	The tunnel trap: Aerodynamic design principles for improved brown marmorated stink bug trapping **Racheal Horner**	Survey and monitoring techniques of ʻŌhiʻa impacted by Ceratocystis wilt **Dustin Swan**	RNAi prospects to control invasive Ant species in Australia **Amol Ghodke**
11.30-11.50	A potential parasitoid *Microplitis prodeniae* with effective control of *Spodoptera frugiperda* larvae **Yaru Wang**	New Zealand's contribution to a global solution: collaborative research approaches to developing new tools for managing brown marmorated stink bug **Lloyd Stringer**	An extension program to protect forest health in Hawai'i **James Friday**	Delimitation and response to a novel marine pest incursion on Aotea/ Great Barrier Island, New Zealand **Irene Middleton**
11.50-12.10	Development projects in SE Asia support biosecurity incursion responses and management of potential invasive insect pests in New Zealand and PICTs **Graham Walker**		Haumana speak for ʻŌhi›a lehua and manu of the forest-engaging students to participate in Hawai'i's legislature to advocate for native species conservation **Kailee Lefebvre**	Technologies and tools for marine invasion control – innovation to underpin vector management, establishment prevention, and eradication **Patrick Cahill**
12.10-12.30	Including climate change impacts posed on ecological niche overlap of three Spodoptera species in China maize planting areas **Yanling Xu**	Host plant adaptation mechanisms of the South American tomato pinworm, *Tuta absoluta* **Yaobin Lu**	Assessing the risk of establishment of rapid ʻōhi ʻa death: using knowledge of *Ceratocystis* species already in New Zealand **Luna Hasna**	Potential dissolved oxygen impacts from hessian benthic barriers smothering *Lagarosiphon major* **Iñigo Zabarte-Maeztu**
12.30-13.30	Lunch in Foyer			

Time				
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Environmental impacts	Understanding invasion processes	Pathway risk	Animal pathogens *Session sponsor: AgResearch*
13.30-13.50	Establishing a health baseline of the culturally significant bivalve pipi (*Paphies australis*) from Aotearoa New Zealand to improve disease investigations **Joanne Howells**	Global macroecology of historical insect invasions **Andrew Liebhold**	The threat of *Ceratocystis* species to the New Zealand Kiwifruit industry **Matt Dyck**	An interface between Government and the private veterinary profession. Lessons from the *Mycoplasma bovis* eradication programme in New Zealand **Richard Campbell**
13.50-14.10	New Zealand's largest aquaculture export, green-lipped mussels, and an aquatic parasite *Perkinsus olseni*: An incidental or emerging relationship? **Henry Lane**	Exploring the behavioural mechanism for successful cryptic invasion of the black cocoa ant, *Dolichoderus thoracicus*, in Taiwan **Feng-Chuan Hsu**	Evaluation of the likelihood of establishing false codling moth (*Thaumatotibia leucotreta*) in Australia via the international cut flower market **Xingyu Li**	Enhancing Animal Health and Biosecurity through partnership in the Pacific region **Oliver Quinn**
14.10-14.30	How do plant communities respond following the removal of a landscape invader? **Elise Arnst**	Local and landscape-scale drivers of non-native plant richness and cover in New Zealand native shrublands **Laureline Rossignaud**	Vector ecology and management to combat disease spread in aquaculture **Bailey Lovett**	Development of RPA based advanced molecular diagnostics assays with potential for in-field applications **Sandeep Gupta**
14.30-14.50	Invasive weeds can disrupt chemical communication between native plants and insects **Andrea Clavijo McCormick**	Exploring the two-way relationships between fire and two Australian fire-adapted plant invaders to support ecosystem management **Joaquim Silva**	Developing the evidence base for effective biosecurity of aquatic invaders within raw water transfers **Zoe Cole**	Use of Whole Genome Sequencing (WGS) for improving understanding of linkages between livestock and wildlife *Mycobacterium bovis* infection in New Zealand **Marian Price-Carter**
14.50-15.10	Cage closed: the effects of introduced herbivores in forest regeneration in Isla de los Estados, Argentina **Amira Salom**	Polyploidy in invasive *Solidago canadensis* increased plant nitrogen uptake, and abundance and activity of microbes and nematodes in soil **Shuqi Wu**	Is this "low risk" pathway truly low risk? A risk-based sampling approach **Thao Le**	Proteomic profiling of small extracellular vesicles isolated from an in vitro cell culture bioreactor simulating *Mycoplasma bovis* infection **Axel Heiser**

Time				
15.10-15.50	Afternoon tea/coffee in Foyer			
	James Hay Theatre	Limes Room	Avon Room	Victoria Room
Session	Environmental impacts	Understanding invasion processes	Pathway risk	Animal pathogens
15.50-16.10	Species and distribution of exotic fishes invasion in inland waters of Guangxi **Hao Liu**	The mechanism of polyploidy-enhanced photosynthetic capacity endowing Solidago canadensis L. with heat tolerance **Zhongsai Tian**	Biosecurity and pathways into Aotearoa New Zealand: relating biosecurity detections to tourism **Andrew Robinson**	Bovine tuberculosis an old problem that has relevance to emerging animal disease **Natalie Parlane**
16.10-16.30	Predation by invasive portunid crabs on functionally and culturally important bivalves in New Zealand **Michal Ferries**	Construction sand trade network topology shapes the patchy distribution pattern of an invasive plant, *Flaveria bidentis* **Rui Wang**	Biosecurity: A Systems Perspective, a new book on effective management across the biosecurity continuum **Sana Bau**	*Mycoplasma bovis* past, present, future **Grant Matthews**
16.30-16.50	Assessing the effect of Amazonian catfish (*Pterygoplicthyes* sp.) on the growth of the Indian major carps: a mesocosm-based study **Suman Mallick**	Changing gut bacteria diversity using antibiotic suppressed the reproduction of *Bactrocera dorsalis* **Lijun Liu**	Anthropogenic risk pathways for marine disease in New Zealand **Anca Hanea**	*Mycoplasma bovis* past, present, future – continued **Grant Matthews**
	Scientific Programme Concludes			
17.00	Student presentation & poster prizes Student prize sponsors: *NZ Biological Heritage NSC, NZ Plant Protection Society, Manaaki Whenua Landcare Research*			
17.20	Closing remarks			
18.30 19.00	Better Border Biosecurity (B3) Pre-dinner drinks – Foyer Better Border Biosecurity (B3) Dinner – Avon Room			

Index of Presenting Authors

Index of Presenting Authors

Index of Presenting Authors

Index of Presenting Authors

Index of Presenting Authors

Oral Presentation Abstracts

Modelling emerging biosecurity threats: choosing complexity is not so simple

Isobel Abell

School of Mathematics and Statistics, The University of Melbourne, Melbourne, Australia

isobel.abell@unimelb.edu.au

When designing mathematical models to support real-time decision making, it is not always clear which level of complexity is "right" for a given scenario. There are many factors that contribute to model design: knowledge of the system being modelled, time and resources available, and purpose of the modelling. To effectively support decision making, we need to choose our model complexity to account for each of these factors, as well as communicating our modelling to ensure results can be understood and interpreted unambiguously. In this talk we focus on discussing ideas about model complexity in the context of real-time modelling of infectious diseases. We look at modelling in a rapid prototyping framework, aiming to compare how a range of mathematical models answer specific policy questions, as well as how they can be explained to decision makers, often non-mathematicians. Through exploring how we think about complexity when designing models for decision makers, we hope to facilitate conversation about, and further understanding of, the mathematical models providing support in real-time for emerging biosecurity threats.

Involving island communities in biosecurity – What will it take to keep our inhabited islands pest free?

Julie Alach [1], Richard Griffiths [1] and Pete Corson [2]

[1] Island Conservation, 561 Woodcocks Road, RD 1, Warkworth 0981, New Zealand
[2] Quality Conservation, 25 Wharenui, Rotorua 3010

julie.alach@islandconservation.org

Removing introduced predators from inhabited islands is the next frontier in the realisation of New Zealand's Predator Free 2050 vision. However, so long as predators remain on the main islands of New Zealand, such interventions will need to be sustained through ongoing prevention and early detection and rapid response efforts. A heightened risk of incursions exists for inhabited islands due to the increased number of people and materials travelling to and from the islands. On the other side of the coin, having a permanent set of eyes and ears on an island can assist in the detection and elimination of newly arrived invasive species. How island communities buy into biosecurity measures will make-or-break the viability of proposed eradication efforts. Using the Hauraki Gulf as an example, we show that there is hope that eradications can be sustained so long as enduring partnerships are built with the community and biosecurity implementation is undertaken with a spirit of inclusivity and transparency.

Developing a biosecurity system tool that encourages and supports inclusive, equitable and regenerative practices

Will Allen [1], Susanna Finlay-Smits [2], Maria Ayala [3]

[1] Learning for Sustainability, Ōtautahi Christchurch, Aotearoa New Zealand
[2] Manaaki Whenua Landcare Research, Lincoln, Aotearoa New Zealand
[3] University of Canterbury, Ōtautahi Christchurch, Aotearoa New Zealand

willallennz@gmail.com

The Aotearoa New Zealand biosecurity framework is based on a partnership and relational approach. This recognises that everyone has a role to play; we need to learn from each other, collaborative approaches and wide participation are enabled and encouraged, and the role of tangata whenua as kaitiaki and mātauranga Māori are recognised and provided for. However, the analysis of interviews and focus groups with those working within the biosecurity system has highlighted the difficulties and challenges with embedding these aims as mainstream practice within the biosecurity system. Drawing on the findings of this empirical work, international evaluation and instructional literature, and practice change expertise within the team, we identified a number of dimensions of collective practice that we deem would support those within the biosecurity system to work in more inclusive, respectful, pluralistic, and relational ways. We have subsequently developed an initial rubric as a tool (being both a process and a product) to support biosecurity research and operational teams and partnerships who wish to improve their performance around the execution of these different practice dimensions. The rubric outlines the performance standards a practitioner or group must meet to feel confident they are performing well for each component of the broader task or activity. Future work will engage with biosecurity groupings to further ground and refine this rubric through its application in practice. In this manner, the rubric development and evaluation process itself can contribute towards identifying, implementing and cementing an underpinning pluralistic and inclusive system culture in a way that grows and strengthens over time within the Aotearoa New Zealand biosecurity system.

The Pacific Ecological Security Congress Strategic Action Plan for Coconut Rhinoceros Beetle

Phil Andreozzi

United States Department of Agriculture Washington, District of Columbia United States

Phillip.c.andreozzi@usda.gov

The coconut rhinoceros beetle (CRB) has caused devastating damage to palms in the Pacific Basin by reducing yields and causing tree death. The resulting loss of coconuts and oil palm threatens livelihoods, economic development, and food security in the region. If uncontrolled, CRB is predicted to spread through the rest of the Pacific, on to the Americas (where it is expected to have similar devastating impacts), and beyond. This critical invasive species issue was a focal point at the first Pacific Ecological Security Congress (PESC1). PESC1 was the first ever high-level Congress focused solely on Pacific basin invasive species and their impacts on other high-priority issues facing PICTs. The PESC had two main goals: (1), to highlight the critical importance of preventing, controlling, and eradicating invasive species to enhance and protect PICT climate resilience, food security, livelihoods, and cultural resources, as well as protect biodiversity and quality of life; and (2), to fine-tune Pacific-wide Strategic Action Plans (SAPs) that address three of the most pressing invasive species issues facing the PICTs—the coconut rhinoceros beetle (CRB), invasive ants, and enhancing biocontrol options targeting priority invasive species. This presentation will provide ICBI participants an overview of the CRB SAP and current efforts and opportunities for implementation.

Developing a biosecurity plan for the Papua New Guinea coconut industry

Sivapragasam Annamalai [1], Alan Aku [2], Arnaud Costa [1], Jane Crozier [3], Eremas Tade [2], Sathis Sri Thanarajoo [1], Muhamad Faheem [1] and Julie Flood [3]

[1] CAB International, Building A19, MARDI 43400, Serdang Selangor, Malaysia
[2] Kokonas Indastri Koporesen, Cuthbertson Street, Downtown P.O.Box 81, Port Moresby National, Papua New Guinea
[3] CAB International, Nosworthy Way, Wallingford OX10 8DE, United Kingdom

a.siva@cabi.org

The Center for Agriculture and Biosciences International (CABI) and Kokonas Indastri Koporesen (KIK), in collaboration with a number of private and public stakeholders, developed a Biosecurity Plan (BP) for the coconut industry in Papua New Guinea (PNG). The overall objectives were to enhance preparedness, protect and secure the future of the coconut industry against intrusions of exotic pests (includes diseases) and to maintain a sustainable level of productivity to meet the goals of the PNG coconut industry's Strategic Plan 2016-2025. The BP was timely considering the challenges posed by recent threats to the PNG coconut industry by the Coconut Rhinoceros Beetle (Guam strain (CRB-G)) and the Bogia Coconut Syndrome (BCS). The BP was aligned with related PNG's quarantine laws and procedures, i.e., the proposed Biosecurity Act (BA- 2014) and the existing Acts such as the NAQIA Act, 1997; Animal Disease Control Act 1952 and the Plant Pest and Disease Control Act 1953. This was exemplified by two case studies on the recent intrusions of both CRB-G and BCS. It also provided an overview of the BP followed by the necessary steps for its implementation, the use of Pest Risk Analysis (PRA) tools and focused on effective mitigation strategies and emergency procedures that should be implemented in the face of a possible risk scenario. Finally, it presented recommendations on communication and awareness for biosecurity planning that included the need to promote an interactive communication system to create awareness amongst various coconut stakeholders in PNG and the region. As an industry-wide plan, the BP should be used as an initial framework by all industry stakeholders and national partners to help identify the potential risks of exotic pests to reduce their impact and facilitate their management should the pests become established in PNG. As a national contingency planning tool, the BP provides an overall framework for better preparedness against potential exotic pests and pathogens threats. The BP is a dynamic document and thus needs to be continually improved based on updated pest's information and distribution with the active and collective engagement between all the stakeholders in the PNG coconut and other related industries (e.g. oil palm and other palms).

How do plant communities respond following the removal of a landscape invader?

Elise Arnst [1, 2], Hannah Buckley [2], Bradley Case [2] and Duane Peltzer [1]

[1] Manaaki Whenua – Landcare Research, Lincoln, New Zealand
[2] School of Science, Auckland University of Technology, Auckland, New Zealand

arnste@landcareresearch.co.nz

Non-native Pinaceae (hereafter wilding pines) are a significant economic and biodiversity issue impacting many regions across the Southern Hemisphere, including areas with high conservation values. Substantial funding and effort (>$30M/year over >1M ha) are currently being spent on eradicating wilding pines across New Zealand. However, such efforts have focused on removing undesirable species but typically do not assess either the effectiveness of control to stop invasions or the potential subsequent outcomes for diversity and ecosystem properties, which are implied benefits of the management. Invasive, non-native species can fundamentally change the ecosystems they invade. They often cause long-term changes to ecosystems (referred to as legacy effects), such as changes to soil properties and microbiota, which remain after the invader has been removed and can be difficult to reverse. While removal of the weed species is often the primary goal of management, we also need to consider what the longer-term consequences of these activities are for ecosystem recovery and how we measure success. We used field surveys to quantitatively characterise the outcomes of Pinus contorta control, measure ecosystem impacts of removal and assess the overall effectiveness of weed control in short-tussock grasslands in the Mackenzie Basin, New Zealand. Vegetation plots were measured to quantify indices of species composition, species diversity and structure along with key environmental variables. Sites were selected to represent variation in both the invasion stage (i.e., pine density) at which control was undertaken and the timescale post-control. This study provides a unique assessment of the impacts on plant communities following the control of a landscape invader.

Pre-emptive classical biological control: a novel approach to increase preparedness for potential biosecurity threats

Gonzalo Avila [1, 2], Barbara Barratt [2, 3], Asha Chhagan [1, 2] and Neil Audsley [4]

[1] The New Zealand Institute for Plant & Food Research Limited, Private Bag 92169, Auckland 1142, New Zealand
[2] Better Border Biosecurity, New Zealand
[3] AgResearch, Invermay Agricultural Centre, Private Bag 50034, Mosgiel 9053, New Zealand
[4] Fera, Sand Hutton, York, YO41 1LZ, UK

Gonzalo.Avila@plantandfood.co.nz

Recent years have seen a substantial increase in invasive insect species invading countries worldwide. Many of these insect species (e.g. brown marmorated stink bug) are highly polyphagous and are considered serious as high-risk biosecurity threats to valued plant systems in many countries, and can result in multi-billion dollar losses to agriculture and horticulture industries. Classical biological control (CBC) is frequently adopted for sustainable management of invasive arthropod pests, and has often proved highly cost effective. However, the severity and imminent nature of some new high-risk insect threats means that it would be highly advantageous if we could avoid waiting for a pest to arrive before adopting CBC. Pre-emptive biocontrol is a novel approach that provides the opportunity to develop CBC for invasive pests before they arrive in the country at risk of introduction. A critical aspect of this approach is that risk assessment is carried out in advance of the arrival of the pest. Implementing pre-emptive biocontrol risk assessment means that natural enemies can be selected, screened in containment or abroad and potentially pre-approved prior to a pest establishing in the country at risk, thus improving CBC effectiveness. However, such an approach may not always be feasible (e.g., suitable natural enemies may not be available, logistic aspects may not allow this). This presentation will show the results of two pre-emptive biocontrol projects, and will discuss a decision framework that can be used to assess the feasibility of conducting pre-emptive risk assessment for candidate biological control agents against high-risk insect pests.

Kaitiakitanga, Science and Better, Border Biosecurity

Waipaina Awarau-Morris [1, 2] and Waka Paul [1, 2, 3]

[1] AgResearch, Ruakura
[2] The New Zealand Institute for Plant & Food Research Limited, Ruakura
[3] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

waipaina.awarau-morris@agresearch.co.nz

Indigenous peoples have been practising biosecurity for generations, intrinsic to their role as cultural guardians involving the protection of native species. The use of traditional and contemporary knowledge systems, values and concepts that define cultural authority, allow people to live, engage and interact with their environment. With this knowledge and expertise, indigenous peoples have much to offer when it comes to managing biosecurity risk and biosecurity systems across all layers of the system and at the international, national, and local levels. A successful biosecurity system in Aotearoa would apply knowledge from a range of sources and B3 is recognising the significance of Te Ao Māori (Māori worldview). Some key B3 research focuses include community empowerment, natural systems networks, and connecting the potential of mātauranga Māori. These important concepts align with Te Ao Māori values and present B3 with unique opportunities to have meaningful connections with Te Tiriti partners and to also deliver great science. This study presents an overview of three B3 kaupapa currently initiated around community empowerment (building and maintaining capabilities), natural systems networks (working with taonga plant species) and indigenous engagement – all aimed at connecting the potential of mātauranga Māori throughout the B3 research platform. These kaupapa also demonstrate the significance of working with mana whenua (people of the land). An overview of each B3 kaupapa will be presented: • He Waka Hourua – Based on the waka hourua model where mātauranga is assumed equal weight alongside western science in EPA applications of the potential introduction of biocontrol agents, we use EPA's Mātauranga Māori Framework with tangata whenua who already provide feedback to these applications. Empowering Te Ao Māori responses to biosecurity encompasses the B3 community empowerment concept involving working with tangata mana whenua groups and building capability in biosecurity practices. Assessing the risk of Rapid Ōhi'a Death ROD to Aotearoa New Zealand and the South Pacific involves practising Kaitieki of Metrosideros sp and working with iwi/hapū groups in Aotearoa alongside our Pacifica and Hawai'ian ohana. These kaupapa demonstrate how Te Ao Māori can improve B3 science research and the influence of whanaungatanga[1] to effect Māori inclusion into biosecurity decisions. For indigenous peoples, biosecurity is about protecting the environment, the Taiao/'Āina. Recognising the cultural authority of indigenous peoples as kaitieki will greatly assist central and local government to ensure that biosecurity outcomes are achieved locally as well as nationally and incursions are minimised and mitigated.

Developing a mathematical model to evaluate biosecurity inspection policies at the border

Christopher M. Baker [1, 2, 3], Thao P. Le [1, 2, 3], Thomas K. Waring [1, 2, 3] and Andrew P. Robinson [2]

[1] School of Mathematics and Statistics, The University of Melbourne, Melbourne, Australia
[2] Centre of Excellence for Biosecurity Risk Analysis, The University of Melbourne, Melbourne, Australia
[3] Melbourne Centre for Data Science, The University of Melbourne, Melbourne, Australia

cbaker1@unimelb.edu.au

Many countries, including Australia, seek to prevent new invasive species from establishing by implementing biosecurity controls at the border. Because thoroughly inspecting everything that crosses the border is unreasonable, we instead design risk-based systems that both intercept many consignments and provide important information about system performance. However, developing system-wide inspection and risk profiling policy is challenging because of the large volume of consignments and the wide range of biosecurity risks entailed. To help inform border policy, we have developed a flexible mathematical model that can simulate consignments and the associated processing and inspection processes. Our generalised framework allows us to integrate multiple pieces of biosecurity research into a single place, providing a comprehensive approach to exploring different inspection policies and processes. Our model evaluates different candidate inspection policies to estimate the amount of detected and undetected contamination, the required search effort, and the level of surveillance information they provide on the system.

Ceratocystis diseases rising in South Africa – and elsewhere in the world

Irene Barnes [1], Kira M.T. Lynn [1], Jolanda Roux [2] and Michael J. Wingfield [1]

[1] Department of Biochemistry, Genetics and Microbiology, Forestry and Agricultural Research Institute (FABI), University of Pretoria, Private Bag X20, Pretoria 0028, South Africa
[2] Department of Plant and Soil Science, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, South Africa. Sappi Forests, Howick, South Africa

irene.barnes@fabi.up.ac.za

Ceratocystis species include many important plant pathogens, some of which are emerging as serious threats to natural woody ecosystems, plantation forestry and agriculture. Until relatively recently, these fungi have not been particularly well-known in South Africa. The emergence of a canker and wilt disease caused by *Ceratocystis albifundus* on non-native *Acacia mearnsii* trees utilized in commercial forestry approximately 34 years ago raised an interest in this group of pathogens. Research on *Ceratocystis albifundus* during the course of the last three decades has shown that it is a native pathogen that has acquired the ability to infect plants grown for commercial purposes. More recently, a serious canker and wilt disease has emerged in *Eucalyptus* plantations. DNA sequence data have been used to identify this fungus as *Ceratocystis eucalypticola*. Interestingly, population genetic studies have shown that it has been present in South Africa for many years, where it has infected wounds on trees in the absence of causing disease. This fungus can easily be isolated from the soil in areas where it is infecting Eucalyptus trees, raising concerns that it could easily spread to new environments. In 2021, a *Ceratocystis* canker and wilt disease emerged for the first time on Kiwi plants in South Africa. Isolates of the causal agent were identified as those of *C. eucalypticola*, raising questions as to how the two hosts and the pathogen might be connected. *Ceratocystis* diseases are clearly rising in South Africa, as they also appear to be doing in various other countries of the world. Dealing with them will require intensive research including techniques for rapid species recognition, as well as a much clearer understanding of their pathways of global movement.

Biosecurity: A Systems Perspective, a new book on effective management across the biosecurity continuum

Sana Bau [1], Susie Hester [2] and Lucie Bland [1]

[1] Centre of Excellence for Biosecurity Risk Analysis, The University of Melbourne, Australia
[2] UNE Business School, University of New England, Armidale, Australia

ssbau@unimelb.edu.au

The book *Biosecurity: A Systems Perspective* will be published by CRC Press in 2023. Written by leading researchers from the Centre of Excellence for Biosecurity Risk Analysis (CEBRA) and collaborators from academia and government, this book provides an overview of biosecurity as a system of related components, actors and risks. Directed to the biosecurity practitioner, generalist scientist and student, the book outlines overall features of biosecurity systems and walks the reader through the most up-to-date research on each step of the biosecurity continuum (i.e. pre-border, border and post-border). In addition, it covers a selection of innovative methods to inform policy and management practice. This presentation provides an overview of the 15 book chapters with a special emphasis on novel contributions to biosecurity research, including: incorporating incentives in biosecurity regulations, improving research uptake in biosecurity agencies, and reliable methods for eliciting technical predictions as well as stakeholder preferences to inform decision making. *Biosecurity: A Systems Perspective* will be the first book on the market that journeys through the biosecurity continuum as a whole as well as describing the interrelations between different components within it. By explicitly incorporating economic and social dimensions within varied decision-making contexts, this book aims to pave the way for a more systemic approach to biosecurity risk management.

Semi-automated surveillance using image segmentation of street-level urban trees

Paul Benden [1], Steve Pawson [2], Varvara Vetrova [1] and Richard Green [3]

[1] Mathematics and Statistics, Level 4, Jack Erskine Building, University of Canterbury, Christchurch 8140, New Zealand
[2] School of Forestry, Forestry Road, University of Canterbury, Christchurch 8140, New Zealand
[3] Computer Science and Software Engineering, Erskine Building, Corner Science and Engineering Roads, University of Canterbury, Christchurch 8140, New Zealand

paul.benden@pg.canterbury.ac.nz

Urban forests contribute to community health and wellbeing and provide economic, environmental, and social benefits. However, diverse urban forests also have a high likelihood for the establishment of new invasive species as most biosecurity risk goods, e.g., cargo, passengers, and mail are processed in urban centres. Surveillance techniques often focus on known threats using traps baited with species specific lures, e.g., pheromones. However, the scale and diversity of urban forests make widespread surveillance and early detection of unknown threats time-consuming and resource intensive. Unknown threats are generally found by inspectors monitoring transects of vegetation, looking for symptoms of pests and diseases. Frequently, such incursions are not identified until after they have spread to such an extent that eradication is both expensive and unlikely to be successful. Semi-automated wide-spread surveillance from street-level vehicles is a cost-effective manner to survey urban forests to prioritise trees for inspection. Street-level surveillance, using high-resolution cameras mounted on vehicles, allows the capture of fine-grained detail not possible from aerial remote sensing of tree canopies. A model of digital tree twins could be constructed from fine-grained digital images. The ultimate aim of this model is the ability to assess the health of individual trees over time. When a model detects that an individual tree shows symptoms or signs of a known threat, e.g., Dutch elm disease, authorities can be automatically notified and the tree inspected. Unknown threats can be detected if an individual, or a geographical cluster of a particular species, exhibits anomalous changes over time, indicating a possible unknown threat. Here, we present the first step towards digital tree twin health model. We will introduce a data analysis pipeline showing how we perform segmentation on images of trees, classifying and partitioning them on a fine-grained pixel-by-pixel basis. Specifically, we created a novel dataset of segmented street tree made up of 3,000 images which were manually annotated by humans and trained a model to automate the process. Our model can identify six species of street trees and identify which image pixels belong to which, even when surrounded by dense vegetation. This is a surprisingly difficult task for humans, even those with forestry experience. Our pipeline could serve as a blueprint for communities' burdened with similar levels of biological invasion threats.

Cold PAWS: Exploring the effectiveness of label-efficient deep learning approaches in biosecurity applications

Nathaniel Bloomfield

Centre of Excellence for Biosecurity Risk Analysis (CEBRA), The University of Melbourne, Melbourne, Australia

nathaniel.bloomfield@unimelb.edu.au

As the scale of cargo and passenger movements continues to increase, it will become necessary to deploy tools such as deep learning and computer vision to make biosecurity interventions more effective, scalable, and affordable. However, implementing these approaches within a biosecurity context often presents significant challenges. Specifically, it is often necessary to have a large library of labeled images to train models, which can be expensive and time-consuming to produce. Fortunately, recent advancements in deep learning have led to highly effective semi-supervised learning techniques that can provide comparable results to fully supervised approaches, with only a fraction of the data requiring manual annotation. In this study, we investigate the effectiveness of label-efficient deep learning methods on three problems of interest to biosecurity practioners: detecting the presence and severity of biofouling on vessels, detecting invasive weeds in the field, and identifying agricultural locations in satellite imagery. Additionally, we examine the effectiveness of a novel cold-start approach that aims to identify which images, when labeled, will provide the best results for a small, fixed labeling budget.

Choosing the best stress: Using insect physiology to inform quarantine treatments and limit invasions

Leigh Boardman

Department of Biological Sciences & Center for Biodiversity Research, University of Memphis, Memphis, Tennessee, United States of America

leigh.boardman@memphis.edu

Insects live in diverse, multifaceted environments, where several abiotic factors occur concurrently. These abiotic factors can become stressful, either alone, or in combination with other abiotic factors. Most research to date focuses on individual stressors studied in isolation, or in series. When stressors are combined, the results are often unpredictable because we do not know how insects sense and respond to interactive environmental stressors. From an applied perspective, understanding multiple stress interactions can lead to more effective, chemical-free pest control methods. For example, by using temperature in combination with modified atmospheres (low oxygen and/or high carbon dioxide) in postharvest treatments, pest insects can be removed from fruits and vegetables prior to export/import – thus reducing the invasive risk. However, in the lab, anoxia (no oxygen) appears to enhance the cold tolerance of some insects, while our data suggests that hypercapnia (high carbon dioxide) with cold is a more viable post-harvest disinfestation option – at least for inducing insect mortality. These findings have direct implications for phytosanitary treatments that rely on cold temperatures. Another phytosanitary option, irradiation, is also impacted by the presence of other abiotic factors. When insects are irradiated under extreme hypoxia, a radioprotective effect is induced. This can reduce the efficacy of these treatments, resulting in restrictions on the use of phytosanitary irradiation for commodities with modified atmospheres. In collaboration with colleagues, we demonstrated that we could measure the level of oxygen below which an insect's metabolism is impaired to predict the induction of a radioprotective response, thereby theoretically reducing the number of dose–response experiments needed. Reciprocally, this radioprotective response can be intentionally induced to produce better-quality, high-performance insects, for release as part of a Sterile Insect Technique (SIT) program. These insects are irradiated to induce sterility, and the sterile insects are released to mate with wild insects, thereby reducing population numbers. When the radiation is performed in conjunction with hypoxia or cold, sterility is maintained, but other negative "side effects" of radiation are reduced. Using these examples, I will illustrate how a better understanding of insect stress responses could help direct quarantine treatment research, as well as provide physiology data that could be integrated into demographic models of potential invasives.

One Biosecurity: An aquatic invasions perspective

Jonathan Bray and Philip Hulme

The Centre for One Biosecurity Research, Analysis and Synthesis (COBRAS); Department of Pest Management and Conservation; Lincoln University

jon.bray@lincoln.ac.nz

Predicting and assessing risks to aquatic biosecurity, with ever increasing trade, new trade routes, amid global change drivers like climate change, is both increasingly complex and pressing. One Biosecurity is a holistic, interdisciplinary biosecurity framework encompassing, human, animal, plant and environmental health. Sectorial divisions fail to recognise similarities in the processes and problems underpinning biological invasions, which often impact more than one component of biosecurity. A shift from a siloed approach, that often focusses on individual organisms within specific sectors, is critical to properly understanding potential linkages, synergies, problems, common mitigations, and enable appropriate policy development. The original One Biosecurity concept has largely been developed and described with reference to terrestrial interactions among plant, animal, human and environmental health. Here, the concept is adapted to the issue of weed, pest and pathogen invasions in freshwater and marine ecosystems There are numerous examples of cross-sectorial biosecurity risks in aquatic ecosystems that would benefit from an interdisciplinary approach. For example, salmon poisoning disease in farmed and wild fish, also has known human health effects. Aquaculture as an animal production system should utilise cross sectorial approaches to reduce disease outbreaks and spillover events into free-living population as well as limit the escape of introduced seaweeds, fish, molluscs and crustaceans. Invasive harmful algal blooms are becoming more frequent in both marine and freshwater ecosystems affecting environmental and human health but also aquaculture production through the direct impacts of toxins as well as through changes in water quality. Emerging introduced pathogens in marine environments such as *Vibrio* spp. are expected to have increasing impacts on human, animal and ecosystem health under a changing climate. Similarly, aquatic vector-borne diseases are expected spread, with prevalence increases under climate change. Understanding key processes and effects of aquatic biosecurity incursions using a One Biosecurity approach may aid in managing aquatic biosecurity both pre- and post-border. Ultimately, One Biosecurity will help to implement aquacultural, environmental and development policies that improve food, environmental and human health outcomes.

Predator Free from Mountains to Sea

Melissa Brignall-Theyer, Brett Butland and Nathan McNally

Predator Free 2050 Limited, PO Box 106040, Auckland 1143, New Zealand

melissab@pf2050.co.nz

Predator Free 2050 Limited (PF2050 Ltd) now supports 17 landscape-scale Predator Free projects across Aotearoa. The total area covered by the projects has more than doubled in size over the last couple of years. This has created both opportunities and challenges. Some of the initial projects are already nearing eradication of their target species, and in total they are aiming for predator eradication on nearly 300,000 hectares of mostly mainland Aotearoa, as well as contributing an additional 400,000 hectares towards predator suppression. Each project is unique, ambitious and adopts leading-edge approaches to help accelerate the national journey towards a Predator Free Aotearoa. These projects have to be agile and adapt to the changing social, economic and environmental landscapes they operate in. PF2050 Ltd will discuss the collaborative model of support for projects – a bottom up, rather than top-down approach, as well as what the projects are learning in more detail and how this is helping drive New Zealand, collectively and with urgency, towards a Predator Free future.

New insect associations of invasive aphids and Pinaceae trees in the Christchurch Botanic Gardens

Eckehard G. Brockerhoff [1], John Clemens [2], Dean Pendrigh[2], David A. J. Teulon[3, 4] & Sarah Redlich [5]

[1] Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland
[2] Christchurch Botanic Gardens, Rolleston Avenue, PO Box 73036, Christchurch, 8154
[3] The New Zealand Institute for Plant & Food Research Ltd, Private Bag 4704, Christchurch, 8140, New Zealand
[4] Better Border Biosecurity (B3), New Zealand [www.b3nz.org.nz/]
[5] Department of Animal Ecology and Tropical Biology, Julius-Maximilians-University Wburg, Würzburg, Germany

eckehard.brockerhoff@wsl.ch

This presentation summarises work previously published by Redlich et al. (2019) for the purposes of discussion in this workshop. Predicting the identity of potentially damaging insects is complex because they are often unknown as pests in their natural geographical range. We assessed host ranges of invasive aphids across 62 conifer species originally sourced from around the world but now grown in the Christchurch Botanic Gardens. We obtained 600 observations of aphid abundances (4731 individuals), mainly for four aphid species (i.e. pine aphids, *Eulachnus brevipilosus* and *Essigella californica*, and spruce aphids, *Cinara pilicornis* and *Elatobium abietinum*). These aphids were highly genus-specific to plant host, despite the spatially mixed distribution of host trees within the Garden. Pine aphid host preferences showed that abundances of species varied among pine subgenera and the geographic origin of trees. *Essigella californica* occurred abundantly on many pines across most subsections in the subgenus *Pinus*, whereas *E. brevipilosus* was largely restricted to a few species in the subsection *Pinus*. Our study revealed several previously unknown aphid-host relationships, and identified numerous novel insect-plant interactions that are likely to materialise if these aphids colonise new host plants, confirming the utility of the plant sentinel approach.

Redlich et al. 2019. Biological Invasions 21: 217–228 (2019) https://link.springer.com/article/10.1007/s10530-018-1817-x

An abstract for a presentation at the pre-Congress workshop on the Value of Botanic Gardens to Biosecurity

Retracing the world-wide invasion of the pine bark beetle *Hylurgus ligniperda*

Eckehard Brockerhoff [1], Dimitrios Avtzis [2], Lea Bischofberger [1], Carolina Cornejo [1], Massimo Faccoli [3], Julia Kappeler [1], Jana Mittelstrass [1], Beat Ruffner [1], Amira Tiefenbacher [1] and Simone Prospero [1]

[1] Swiss Federal Institute for Forest, Snow and Landscape Research WSL, CH-8903 Birmensdorf, Switzerland
[2] Forest Research Institute, Hellenic Agricultural Organization Demeter, GR-57006 Vassilika, Thessaloniki, Greece
[3] University of Padua, IT-35020 Legnaro, Padova, Italy

eckehard.brockerhoff@wsl.ch

The red-haired pine bark beetle *Hylurgus ligniperda* (Coleoptera: Scolytinae) is considered the most successful invader among all bark beetles. Native to Europe and other parts of the Palearctic Region, it has invaded numerous countries in Australasia, Africa, Asia and South and North America. To investigate the invasion routes of *H. ligniperda* and to determine whether there is evidence for 'bridgehead effects' (secondary invasions originating from invaded areas), we carried out a population genetic study with individuals from numerous native and non-native populations across all continents where the species occurs. We analysed a mitochondrial marker (Cytochrome oxidase I, COI) and a nuclear marker (Arrestin 2, Arr2) and performed a haplotype network analysis and other analyses in R. In addition, we used invasion records of *H. ligniperda* in each country and interception data compiled by several national plant protection agencies to reconstruct the timeline of invasions. The results indicate that several independent invasion events originating from Europe occurred as early as pre-1940 and that some of the invasive populations served as the origin of subsequent invasions within and between continents. This study is an illustrative example of a highly successful invasive species that benefits from effective invasion pathways and abundant availability of host material (i.e., widely planted plantations of non-native trees), resulting in large non-native populations that lead to further (secondary) invasions via bridgehead effects.

Networked socioecological models for integrating agency-led and public-led invasive species incursion responses under climate change – a regional-scale analysis of the grassland weed *Nassella neesiana*

Christopher E. Buddenhagen [1], Shona Lamoureaux [2], Graeme Bourdot [2], Karen Garrett [3] and Norman Mason [4]

[1] Agroecology Team, AgResearch Ltd, Ruakura, Hamilton, New Zealand
[2] Weeds Pests and Biosecurity Team, AgResearch Ltd, Christchurch, New Zealand
[3] Plant Pathology Department, Global Food Systems Institute, and Emerging Pathogens Institute, University of Florida, Gainesville, FL, USA
[4] Manaaki Whenua – Landcare Research, Hamilton, New Zealand

chris.buddenhagen@agresearch.co.nz

Invasive species incursion responses are a complex interplay of ecological processes (establishment, growth, natural and human-aided dispersal), management actions (surveillance, local eradication and spread reduction) and multiple actors (central and local government, industry bodies and private citizens). Network-based simulation is increasingly used to integrate these social and ecological processes. We present an example which builds on recent advances (specifically, the impact network analysis, INA, framework) and provides unprecedented flexibility in modelling the co-evolution of invasive species incursions and management responses. The functionality we added to INA permits inclusion of habitat (e.g., climate and land use) affects establishment, with potential to incorporate temporal variation in habitat suitability. There is explicit provision for separate natural and human-aided dispersal processes and temporal variation in invasion threat from external sources (e.g., national, or regional border incursions). The system separates the management response into detection, local eradication, spread reduction (e.g., restricted movement of plant material and livestock, cleaning machinery and other equipment) and management adoption components. Various incursion response strategies can be explored including sentinel sites (selecting locations of higher detection probability), preventative management in locations threatened by newly discovered incursions, enforcement of hygiene or movement-restriction measures and awareness raising in target population (e.g., farmers, seed companies, garden centres). The system retains the key functionality of INA, particularly inclusion of socioeconomic network structure in modelling information sharing (about the presence of the pest and management practices). To illustrate the potential of this approach we examine the spread of a regionally restricted harmful weed, *Nassella neesiana* (Chilean needle grass, CNG). During seeding in late summer for 3 months of the year, the sharp seeds can penetrate animal hides and can be spread by livestock or contaminated equipment, so farmers typically do not graze these paddocks. CNG is regulated by three different regional authorities in New Zealand because of the risk to the sheep and beef sector. With CNG established in Hawke's Bay Region, we examine the biosecurity risk posed to the currently uninvaded adjacent region of Manawatu-Wanganui under current and future climate, and with and without management of the current infestations in Hawke's Bay. Climate change increases the area potentially impacted in Manawatu-Wanganui. With the zero-management scenario in Hawke's Bay the annual incursion rate on farms in Manawatu-Wanganui eventually exceeds 12 incursions per year, while under realistic management settings in Hawke's Bay incursions decline to 0.4 events per year.

Predicting the invasiveness of the global pathogen genus *Phytophthora*

Treena Burgess [1], Peter Scott [2] and Bruce Marcot [3]

[1] Harry Butler Institute, Murdoch University, 90 South St, Murdoch, WA 6150, Perth, Australia
[2] Sustainability and Biosecurity, Department of Primary Industries and Regional Development, Level 5.130 – 1 Nash Street, Perth WA 6000, Australia
[3] USDA Forest Service, Pacific Northwest Research Station, 1220 SW 3rd Ave., Suite 1400, Portland OR 97204, USA

t.burgess@murdoch.edu.au

The *Phytophthora* genus is associated with significant plant diseases in natural ecosystems, agriculture, and urban environments globally. Phytophthora pathogens pose formidable biosecurity challenges as they are increasingly spread globally and often cause major diseases within newly invaded environments. Many significant new diseases, including Kauri dieback and sudden oak death, are caused by species that were identified only after discovering the disease. Based on the rate of identifying new species, models suggest there may be up to four times more Phytophthora species than are currently described. These new species may have serious impacts, even if they are not currently associated with serious diseases. Therefore, it is difficult to determine the management requirements of these new species when they are initially identified. We conducted a multivariate Bayesian analysis to determine if biological traits easily measured within the laboratory can usefully predict the impact of these newly identified species. Our Bayesian network model correctly predicts the known invasion risk of Phytophthora species and can effectively be used for new species to warn of their potential invasiveness. This approach can be used to develop risk models for other genera of plant pathogens.

A national approach to improving integration of invasive species and wildland fire management

Stas Burgiel [1], Michele Crist [2] and Mike Zupko [3]

[1] National Invasive Species Council (NISC), c/o Department of the Interior, 1849 C Street NW, MS-2061, Washington, DC 20240 USA
[2] Bureau of Land Management, Fire Planning and Fuels Management Division, National Interagency Fire Center, 3833 S. Development Avenue, Boise, ID 83705 USA
[3] Wildland Fire Leadership Council, PO Box 690, Monroe GA 30655 USA

stanley_burgiel@ios.doi.gov

In recent years the incidence, frequency, and severity of wildfires has increased across the U.S. landscape with consequent impacts on public safety, livelihoods, and the environment. Invasive species, along with climate change, are playing a major role in altering fire regimes and shifting vegetation recovery patterns after fire. For example, invasive species, and non-native grasses in particular, have the potential to increase available fuel in ecosystems and change fuel properties; wildfire size by creating horizontal and vertical fuel continuity; wildfire intensity from larger fuel loads; and wildfire frequency with an increase in invasive species post-fire. Recognizing the growing importance of this dynamic, the National Invasive Species Council (NISC) and the Wildland Fire Leadership Council (WFLC) launched a partnership in 2020 designed to identify and advance opportunities to better align invasive species and wildland fire management. This effort has included major US federal agencies including the Department of the Interior, the U.S. Department of Agriculture, and the Department of Defense, along with a growing range of non-federal actors including state and local governments, tribes, researchers, and other land managers. The effort has focused on addressing needs and opportunities at the national, regional, and landscape scales. This presentation will provide some initial background on the situation with invasive species and wildfire in the U.S., review priority actions identified by NISC and WFLC, and discuss ongoing and future steps for implementation. This information will be framed across six broad themes, three of which relate to the stages of engagement with wildfire (1. proactive and pre-fire management, 2. wildfire response, and 3. wildfire recovery and restoration) and three cross-cutting issues (4. funding, 5. information and data management, and 6. research and development). Additionally, it will highlight potential areas for collaboration with other resource managers facing similar issues with invasive species and wildland fire.

Technologies and tools for marine invasion control – innovation to underpin vector management, establishment prevention, and eradication

Patrick Cahill, Grant Hopkins, Johan Svenson and Ian Davidson

Cawthron Institute, 98 Halifax St East, Nelson

Patrick.Cahill@cawthron.org.nz

Managing marine invaders is inherently challenging and there is a lack of fit-for-purpose proactive and reactive control tools at our disposal. This shortfall has undermined vector management to prevent range expansions and hamstrung marine eradication attempts. Our research aims to shift this paradigm to enable effective marine biosecurity systems via bespoke control technologies for vector management, for enhancing resistance to establishment in high-risk locations, and for eradication. Three examples will be discussed in this talk: (1) A novel functionalised surface that traps and retains a metastable layer of air to prevent invasive biofouling pests establishing on infrastructure in high-risk sites (e.g., ports and marinas). This technology enables biofouling control in static conditions without collateral risk. It is based on a high-tech, scalable surface modification technology. We have developed an effective product that is being pursued commercially. (2) A new class of eco-friendly antifouling biocide based on peptides. Effective antifouling technologies are critical for vector management in the sea, but existing options incur a heavy toxicity toll and are being phased out. We have developed, optimised, and applied a new class of antifouling biocide that is effective against a wide range of biofouling taxa but breaks down fully in the environment to prevent harm. (3) An Integrated Pest Management Framework for aquaculture to direct pest management strategies that optimise environmental and economic outcomes. The framework is founded on knowledge of pest ecology, bioeconomic cost-benefit, continual monitoring, proactive control, and reactive control. The framework tackles critical implementation issues for invasive pest management in aquaculture and has spawned several specific control tools. Through these examples, we highlight the need for cross-disciplinary collaborations to deliver workable solutions for challenging biosecurity applications in natural environments, built environments, and marine farming. Successful application will provide impetus to overcome defeatist attitudes to marine invasion management and promote operational freedom for productive maritime and aquaculture sectors in healthy coastal ecosystems.

Disease climatic risk model interpretations at multiple spatial scales

Rebecca Campbell [1] and Robert Beresford [2]

[1] The New Zealand Institute for Plant & Food Research Limited, Motueka Research Centre, 55 Old Mill Rd, Motueka, New Zealand 7198
[2] The New Zealand Institute for Plant & Food Research Limited, Mt Albert Research Centre, Private Bag 92169, Mt Albert, Auckland 1142

rebecca.campbell@plantandfood.co.nz

Climatic risk models are often used to help understand the areas and seasons where invading organisms will have the greatest risk of establishing and causing a negative impact. These risk models often make predictions for a large spatial scale using inputs of time-averaged climatic data (e.g. annual). However, many organisms respond to, or have mechanisms influenced by, much shorter time scales (e.g., diurnal effects) and finer spatial scales (e.g., microclimate effects). Large-scale averaging may hide important information and could lead to misrepresentation of the dynamics of pathogen and pest populations and their spread in time and space. This risks misinterpretation of risk and errors in surveillance and management efforts. We use the existing myrtle rust (*Austropuccinia psidii*) climatic risk model in conjunction with field data, as an example to explore the scale of variability in microclimate variables across forest edges and what that could mean for risk model interpretations. These are compared with risk predictions from the national forecast grid, regional weather stations and local weather stations. We discuss the implications of these comparisons to risk predictions for future incursion responses, for example *Xylella fastidiosa*, and what resolution is 'good enough' for what particular purpose.

An interface between Government and the private veterinary profession. Lessons from the *Mycoplasma bovis* eradication programme in New Zealand

Richard Campbell

Veritag, and SVS Labs, 524 Te Rapa Road, Hamilton 3241, New Zealand

richardc@svslabs.nz

Mycoplasma bovis was diagnosed in New Zealand in July 2017. The initial finding was in dairy cattle in the South Island. The New Zealand dairy industry is characterised by a high level movement of animals across both Islands and through both the dairy and beef sectors. By February 2018 there were 25 infected farms and the disease had been found in the North Island. In May 2018 a world-first eradication programme was launched with a committed budget of $880 million over a 10-year period. A State-Owned Entity was the sole contractor charged with the on-farm sampling at the outset of the programme. Rapid geographical and numeric expansion of the outbreak placed great strain on this field force just at a time they were also faced with a massive increase in the demand for the on farm testing of cattle destined for live export. This upswing was due to exporters looking to capture opportunities in front of a ban on shipments scheduled for April 2023. In March 2020 the Ministry for Primary Industries (MPI), charged with running the eradication programme, were confronted with a significant backlog in testing. This brought about significant animal and human welfare issues. Animals were unable to be moved in the face of feed shortages while farmers came under enormous stress through uncertainty and the suspension of their ability to sell or move their stock. In response MPI reached out to Veritag, a privately owned Recognised Agency created to also provide verification of livestock prior to export. Veritag operates without their own field force instead engaging private veterinary practices. With overlapping ownership and management SVS Labs, a veterinary diagnostic company, was also admitted to the programme as the laboratory samples taken by the Veritag network would be tested at. With a network exceeding 220 locations supported by a laboratory well versed in high throughput protocols the backlog was quickly alleviated. Several independent reviews have since pointed to the introduction of the private veterinary profession as a turning point in the the eradication programme. There are three key and common themes to the benefits gained: – A reduction in the turn around time for testing and reporting – The strong personal relationships between farmers and their vets – The introduction of people with a high degree of technical and farming systems knowledge This presentation explores the mechanisms and benefits of the interface between MPI, veterinarians and farmers.

Engaging with and learning from how Indigenous Rangers contribute to biosecurity in Northern Australian

David Cann

Indigenous Ranger Biosecurity Program (IRBP)
Department of Agriculture, Fisheries and Forestry, Australia.

david.cann@aff.gov.au

Northern Australia is a unique biosecurity operating environment, with a vast coastline, sparse population, and the risk of biosecurity incursion through unregulated pathways. In recognition of these considerations, the Indigenous Ranger Biosecurity Program (IRBP) engages Traditional Owners across northern Australia to conduct surveillance for invasive plant, animal, and aquatic pests and diseases. Sixty-five Indigenous ranger group organisations from Western Australia, Northern Territory and Queensland have fee-for-service contracts with the Department of Agriculture, Fisheries and Forestry (DAFF) to complete biosecurity activities as part of the IRBP.

The IRBP consists of three key tenets – scientific rationale, a focus on enhancing rangers and ranger group capability, and community engagement. Scientific support and training are provided by the Northern Australia Quarantine Strategy, a DAFF program that has conducted surveillance in the region for over 30 years. Capability is built through a series of grants, training workshops and procurement of equipment. Engagement with Indigenous rangers acknowledges their deep connection to Country, traditional methods of protecting Country, and the threats that biosecurity incursions hold for Aboriginal and Torres Strait Islander lore, culture, and way of life. The IRBP employs Community Liaison Officers (CLO) to engage rangers through on-Country visits, and successive evaluations of the program have highlighted the importance of the CLO network to the ranger groups they work alongside.

As both the biosecurity and cultural value of the IRBP, and the awareness and capability of Indigenous rangers to conduct biosecurity surveillance alongside it, continues to grow, opportunities exist to learn from past experiences, to amplify the role of First Nations people in designing and building similar programs, and to strengthen biosecurity networks into the future.

Pre-adaptation to novel climates facilitates invasion of globally widespread weeds in New Zealand

Thomas Carlin [1, 2], Jennifer Bufford [2], Philip Hulme [2] and Will Godsoe [2]

[1] Scion, 10 Kyle Street, Riccarton, Christchurch, New Zealand
[2] The Bio-Protection Research Centre, PO Box 84, Lincoln University, Christchurch, New Zealand

tom.carlin@scionresearch.com

Understanding how species will respond under novel climates is crucial for predicting biological invasions and is becoming increasingly important as climate change progresses. Despite this, most modelling efforts largely focus on climate matching, and avoid predictions under novel climates. Invasive *Rumex* species have been shown to undergo climatic niche shifts across their introduced ranges into diverging climates that are unrecognisable compared to their native range. Such climatic niche shifts could reflect that *Rumex* have rapidly evolved to novel climates, or that they possess pre-adaptations to environments outside of their native range. Determining between these alternatives is required to understand how fast establishment of invasives can occur and how quickly species will respond to climate change, if at all. Here we combine detailed macroecological insights with a large common-garden experiment to determine whether introduced *Rumex* populations have differentiated themselves from their native counterparts under novel climates. We provide the first in-depth experiment of performance differences under both analogue and non-analogue climates in the introduced range, finding little evidence that *Rumex* have rapidly evolved to New Zealand's climates. Despite large differences in performance between gardens, individuals from the native range showed similar germination, survival, and fecundity to individuals from the introduced range under all-climates. Likewise, no performance advantages were observed between populations grown in their home environment. We demonstrate that significant range expansion can occur through pre-adaptation in even globally widespread species – something thought to mainly occur in range restricted island endemics. Current species distributions are likely to be a poor indicator of their future distributions under climate change, or when species are introduced to new ranges by humans. Risk assessments must be aware of the potential to underestimate the impacts of even widespread species.

Using artificial intelligence to detect submerged aquatic weeds to protect Aotearoa New Zealand's waterways

Daniel Clements [1] and Jeremy Bulleid [2]

[1] National Institute of Water and Atmospheric Research (NIWA), Freshwater Biosecurity, Gate 10 Silverdale Road, Hillcrest, Hamilton 3216, New Zealand.
[2] National Institute of Water and Atmospheric Research (NIWA), Instrument Systems, 10 Kyle Street, Riccarton, Christchurch 8011, New Zealand.

daniel.clements@niwa.co.nz

Early detection of an invasive species enables early intervention, and along with prevention, early detection provides the best (most cost-effective) opportunity to successfully manage invasive species that pose a biosecurity risk. Typically, aquatic weed invasions that go unnoticed or are overlooked, or where management interventions are delayed, become problematic resulting in a decline in the values and functions of aquatic ecosystems. When aquatic weeds establish and are left to proliferate, they compete with and displace native species. This can cause significant habitat alteration, impact adversely on recreation and cultural values, hydroelectric generation, and compromise agricultural productivity by impeding water delivery. Surveillance methods that can be efficiently deployed are required to detect and locate incursions at an early stage of invasion, so that control strategies can be implemented. Current surveillance methods are limited and rely heavily on divers to detect incursions. The development of new detection methods that operate at larger spatial scales and can be deployed readily by management agencies, will improve detection capability, leading to reduced management response times and better outcomes. NIWA researchers have developed a method for remote detection of invasive aquatic weeds utilising advances in remote sensing, recognition software and machine learning, initially targeting two of New Zealand's worst submerged aquatic weeds, *Lagarosiphon major* and *Ceratophyllum demersum*. This presentation outlines the development of NIWA's portable invasive species detector module, that can be deployed from manned or unmanned surface vessels. The project has applied an Artificial Intelligence (AI) Deep Learning (DL) approach to detect submerged target species. A prototype module contains a software 'detector' that has been trained to identify targets in live stream video imagery. When it identifies a target is present within a video frame, the GPS location, the time and the total number of instances detected within that video frame are recorded. The resulting GPS detection file can then be projected in mapping applications (e.g., ArcGIS), so that control or eradication can be undertaken. The prototype module has been trialled in NIWA's flume facility to determine its ability to detect lagarosiphon and subsequently initial field testing has been conducted at Lake Wakatipu and the upper Kawarau River (Queenstown, South Island). Whilst the project has primarily developed a detection tool to target invasive species in New Zealand waterways, in principle there is little to prevent global use if the detector was trained to recognise geographically relevant target species (e.g., localised invasive weeds, fish, invertebrates).

Developing the evidence base for effective biosecurity of aquatic invaders within raw water transfers

Zoe Cole [1], Martin Tillotson [2], Polina Nikova [1], Alexander Donovan [1] and Alison Dunn [1]

[1] School of Biology, University of Leeds, Leeds, United Kingdom
[2] School of Civil Engineering, University of Leeds, Leeds, United Kingdom

bs16zkc@leeds.ac.uk

The introduction and secondary spread of invasive alien species (IAS) negatively impact the environment, the economy and human health. The spread of aquatic IAS is primarily due to human facilitated pathways, including transport, trade, recreation. A further key pathway that has been identified is that of raw (untreated) water transfers (RWT). RWT refers to movement of large volumes (1-5 Mega litres) of water from between different water sources (reservoir, lake or river), or from a source to a Water Treatment Works. RWT are essential to ensure that water companies can provide a consistent supply of water to domestic and industry customers. In the UK, The National Infrastructure Commission (NIC) has identified the need for a national transfer network in response to climate change, which will lead to an increase of investment into new RWT networks. However, RWT pose a high risk of spreading IAS as water may be moved between different sources (e.g. reservoir chains) spanning different catchments, with RWT often peaking during summer drought periods. In the UK, The Environment Agency (EA) are working with UK water companies to prevent spread of IAS within both current and new RWT. Water companies have clear evidence based biosecurity protocols in place to prevent IAS spread via contamination of equipment and PPE. However, there is a need for research into biosecurity protocols that can be incorporated into RWT. We present evidence for the effectiveness of physical (hydrocyclone and screens) and chemical biosecurity protocols for RWT in reduction the risk of IAS spread.

Towards passive traps for marine pest species using novel acoustic methods

Serena Cox and Giacomo Giorli

National Institute of Water and Atmospheric Research, 301 Evans Bay Parade, Haitaitai, Wellington 6021

serena.cox@niwa.co.nz

Acoustic or sound-baited traps that attract pest species are highly effective in detecting incursions of pest species, even at low densities. Such traps have proven highly effective in monitoring and eliminating terrestrial arthropods such as fruit flies and crickets. The use of electronic sound synthesisers to reproduce the sound of conspecifics or hosts has proven highly successful; however, this technique has not been utilised in a marine setting as a novel acoustic method for pest control. Here we explore sound production by an invasive marine arthropod, the Asian paddle crab *Charybdis japonica*. Sound production in crustaceans is widely documented and accepted as a means of communication. However, the mechanisms and behavioural function of sound production has never been described in *C. japonica*. The sound produced by *C. japonica* may provide a mechanism to produce sound traps which mimic the sound made by conspecifics and attract these pest species. We describe two distinct sounds being produced by *C. japonica* (a click and a rasp) and suggest two potential methods of sound production based on external shell morphology and the structures of the gastric mill. We also provide some evidence of behaviours that may be used in the generation of these sounds, consisting of leg flicks and clicks, and feeding (gastric mill processing). We explore the possibilities of using acoustic technology such as hydrophones as sound traps for the detection and attraction of these and similar species.

Contribution of garden societies and gardeners to biosecurity: The Royal Horticultural Society

Sara Redstone, Fryni Drizou, Kirsty Wright, Josie Stuart, Matthew Cromey

Royal Horticultural Society, RHS Garden Wisley, Woking, Surrey, GU23 6QB, United Kingdom

Imported plants and plant products are the main pathway of entry for invasive pests. Plants for planting are the highest risk material. By changing the way we buy and move plants, the UK's 30 million gardeners could make a massive difference to reduce the risks of introducing or spreading destructive plant pests. The Royal Horticultural Society (RHS), founded in 1804 is the UK's leading gardening charity. Our aim is to enrich everyone's life through plants, and make the UK a greener and more beautiful place – we are committed to inspiring everyone to grow. Gardeners can minimize the risk of entry of invasive pests through following good practices and garden societies such as the RHS can provide the resources and education to help enable such practices. Gardeners, being very familiar with how a healthy plant looks and with its current range of pests, are often the first to notice when something different appears. The RHS Members Advisory Service is where RHS members report unusual findings. New records and new to science organisms are regularly reported through this service.

An abstract for a presentation at the pre-Congress workshop on the Value of Botanic Gardens to Biosecurity

Enhancing biosecurity to sustain eradication outcomes in Palau

Loyola Darius [(1)], Richard Griffiths [(2)] and Monica Gruber [(3)]

[(1)] Island Conservation Palau, P.O Box 1292 Koror Palau 96940
[(2)] Island Conservation New Zealand, 561 Woodcocks Rd, RD 1, Warkworth 0981, New Zealand
[(3)] Pacific Biosecurity ,PO Box 1762, Wellington, New Zealand

loyola.darius@islandconservation.org

Managing invasive species to enhance climate resilience is a major initiative across the Pacific, including Palau. Several successful rat eradications have been conducted in Palau and more are planned. A key requirement to sustain these expensive interventions is that the target species does not re-invade. After an eradication from one key island, rats re-established by an unknown pathway. Island Conservation, in partnership with the Palau national and state governments is implementing a practical, comprehensive framework for national Early Detection and Rapid Response and inter-state/inter-island biosecurity. The goals are to ensure the sustainability of eradications and enhance the resilience of communities to the "double-edged sword" of invasive species and climate change. Our talk discusses developing the Palau framework for invasive species biosecurity, and some of the challenges in implementing such a framework in island nations like Palau.

Implementing molecular surveys for marine pests: addressing doubt

Kathryn Wiltshire [(1)], Danièle Giblot-Ducray [(2)], Kelly Hill [(2)] and Marty Deveney [(1)]

[(1)] South Australian Research and Development Institute, SARDI Aquatic Sciences, West Beach, SA 5024, Australia
[(2)] South Australian Research and Development Institute, SARDI Molecular Diagnostics, Plant Research Centre, Urrbrae, SA 5064, Australia

marty.deveney@sa.gov.au

Surveillance is critical for understanding risk, triggering responses and optimising biosecurity activities. Molecular surveys using environmental DNA (eDNA) save time and cost, but have challenges that differ from traditional surveillance. Operational validation requires internal controls, confirmatory tests and approaches to assess the likelihood of false negatives and false positives. We have developed a qPCR detection system targeting 19 priority marine pests. The detection system uses three internal controls to assure sample integrity and understand extraction efficiency and PCR inhibition from samples. The testing framework is implemented using assays that have been operationally validated using field or constructed samples. Bayesian latent class and occupancy modelling provide an understanding of assay diagnostic sensitivity (DSe) and specificity (DSp) and the field performance of the molecular survey system. DSe and DSp facilitate robust survey design and models provide confidence in outputs by supporting interpretation of survey results, particularly new detections. The framework enables the application of the eDNA surveillance system to risk-based ballast water management in Australian ports.

Pests and pathogens of native plants from the Pacific: what risks for New Zealand taonga?

Kiryn Dobbie[1], Julia Soewarto[1, 3], Alby Marsh[2, 3], Te Whaeoranga Smallman[1, 3], Matt Buys[1], Andrew Pugh[1], Stephanie Sopow[1] and Belinda Gresham [1]

[1] Scion, PO Box 3020, Rotorua, New Zealand
[2] The New Zealand Institute for Plant & Food Research Ltd, Private Bag 11600, Palmerston North 4474, New Zealand
[3] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

kiryn.dobbie@scionresearch.com

Pacific Islands plant biodiversity, including in Aotearoa-New Zealand, is one of the world's most precious resource and yet, one of the most fragile. Global trade, travel and tourism have increased, accelerating the intentional and unintentional movement of harmful arthropod pests and pathogens beyond natural biogeographical barriers (e.g. fruit flies, *Phytophthora* spp.). Other pests are also spreading by natural means, but rapidly expanding their global distribution either due to changes in land uses or other consequences of global climatic changes such as changes in transoceanic air currents or more favourable climate in areas of introduction (e.g. fall armyworm, myrtle rust). Movement of plant pests and pathogens through the Pacific pose a significant risk to Aotearoa, as the surrounding island nations may provide an incursion pathway (either natural or human-aided) of future biosecurity threats. Arthropod pests and plant diseases in natural or native plant populations are underprioritized by environmental policies and regulatory management, yet the environmental and cultural importance are of significant value to indigenous people who hold an intrinsic role of responsibility to the wellbeing of their taonga (treasures) and are often the most affected by this damage or in the worst cases by the local or complete disappearance of a species. A database of potential biosecurity threats (fungi and arthropods) to Aotearoa native plant populations, with the potential to come from neighbouring Pacific countries, has been developed from the available literature and will be presented. This work was the first phase of a multiyear project aiming at providing tools and resources to Māori, Pasifika partners and other biosecurity stakeholders so they can best fulfil their kaitiaki role and prepare for potential new biosecurity challenges threatening native species.

Genomic basis of adaptation in an invasive sea squirt (*Styela clava*)

Jiankai Wei and Bo Dong

Laboratory of Morphogenesis and Evolution, Fang Zongxi Center for Marine EvoDevo, College of Marine Life Sciences, Ocean University of China, Qingdao 266003, China

bodong@ouc.edu.cnhasna

Tunicates occupy an evolutionary position at the boundary of invertebrates and vertebrates. They exhibit adaptation to a wide range of environmental conditions across the globe. Despite hundreds of years of embryogenesis studies, the genetic basis of the invasive habits of ascidians remains largely unknown. The leathery sea squirt, *Styela clava*, is an important invasive species. We used the chromosomal-level genome and transcriptome of *S. clava* to explore its genomic- and molecular-network-based mechanisms of adaptation to environments. Compared with *Ciona intestinalis* type A (*C. robusta*), the size of the *S. clava* genome was expanded by 2-fold, although the gene number was comparable. An increase in transposon number and variation in dominant types were identified as potential expansion mechanisms. In the *S. clava* genome, the number of genes encoding the heat-shock protein 70 family and members of the complement system was expanded significantly, and cold-shock protein genes were transferred horizontally into the *S. clava* genome from bacteria. The expanded gene families potentially play roles in the adaptation of *S. clava* to its environments. The loss of key genes in the galactan synthesis pathway might explain the distinct tunic structure and hardness compared with the ascidian Ciona species. We demonstrated further that the integrated thyroid hormone pathway participated in the regulation of larval metamorphosis that provides *S. clava* with two opportunities for adapting to their environment. Thus, our report of the chromosomal-level leathery sea squirt genome provides a comprehensive genomic basis for the understanding of environmental adaptation in tunicates. In addition, we found that defense and energy-associated metabolites derived from ascidian gut microbiome may provide an adaptive interplay between gut microbiome and ascidian host that maintains a beneficial metabolic system across season and starvation stress. The diversity-generating metabolisms from both microbiota and host might lead to the co-evolution and environmental adaptation.

**** 1080 – Whanganui Pig Hunters and their thoughts about the use of 1080

Claire Dowsett, Anna Carr and Brent Lovelock

Department of Tourism, Otago Business School, University of Otago, Dunedin, New Zealand

claire.dowsett@postgrad.otago.ac.nz

Ute drivers in Whanganui and other areas around Aotearoa, New Zealand, are infamous for their graphic and confronting signage plastered to their rear windscreens "**** 1080". This paper focuses deeply on the discourse of Whanganui pig hunters and their experiences with, observations of, and position within a spectrum of pro- or anti-1080 arguments. In this research, which investigated the community values associated with wild pigs, discussion around the use of 1080 (Sodium fluoroacetate) for pest control formed a significant part of the narratives from the research contributors. Aside from the animal ethics surrounding 1080 use, pig hunters in this study were concerned about losing access to hunting grounds utilised for gathering wild food during poisoning operations and fearing 1080 interfering with the surrounding environment and food chain. There was recognition, however, that 1080 is currently the only suitable tool for controlling pests in rugged and inaccessible terrain; however, more humane solutions should be actively sought, including optimising the effective use of hunting for conservation.

The threat of *Ceratocystis* species to the New Zealand kiwifruit industry

Matt Dyck and Erin Lane

Kiwifruit Vine Health, 25 Miro Street, Mount Maunganui, New Zealand

matt.dyck@kvh.org.nz

Ceratocystis fimbriata represents a fungal species complex of multiple strains, each with a distinct host range and geographic distribution. Many of these strains, particularly those of the Latin American Clade, cause wilt and canker diseases of economically important plants, including kiwifruit, mango, coffee, cacao and lemon. The first reports of *C. fimbriata* strains causing wilt disease in kiwifruit were reported in Southern Brazil, with some growers reporting vine losses of 20–40% as a result of this pathogen. Pathogenicity studies indicate that strains from some other hosts and geographic locations are also highly pathogenic to kiwifruit, and therefore biosecurity efforts must have a broader focus than only those pathways from Southern Brazil. Kiwifruit Vine Health (KVH) is a small organisation dedicated to protecting the biosecurity interests of New Zealand kiwifruit growers, an industry worth $3B in annual export returns. KVH's pest and disease Risk Matrix ranks *C. fimbriata* as one of the most significant biosecurity threats to the New Zealand kiwifruit industry and therefore readiness work is being prioritised to improve our state of industry preparedness for incursion and response to this pathogen. This readiness work includes activities undertaken in partnership with Biosecurity New Zealand and research funded by Zespri Innovation.

One Biosecurity approach to research prioritisation

Cassandra Edmunds and Philip Hulme

The Centre for One Biosecurity Research, Analysis and Synthesis (COBRAS), Department of Pest Management and Conservation, Burns Building, PO Box 85084, Lincoln University, Lincoln 7647, Canterbury, New Zealand

Cassandra.Edmunds@lincoln.ac.nz

Created in 2016, Biosecurity 2025 is a partnership between people, organisations, Māori, and government in New Zealand, with the aim of making our biosecurity system more resilient and future-focused. One of the major outputs of Biosecurity 2025 was the production of a stocktake of desired outcomes. Stocktake of Biosecurity Research, Science and Technology Priorities was published by Ministry for Primary Industries Manatu Ahu Matua in 2021. This collated the existing priorities identified in other documents and processes. The stocktake was designed to support investment choices in research, inform science capability and capacity planning, and support local and international research collaborations. The stocktake identified over 60 priority areas that require further research. A list of this length would be challenging if not unrealistic to fund in New Zealand. The Centre for One Biosecurity Research Analysis and Synthesis (COBRAS), based at Lincoln University, aimed to address this disparity between resource and intent by identifying the most crucial priorities from the original stocktake. Aiming to gain a consensus-driven shortlist through breaking down the traditional biosecurity sectoral siloes of Industry, Science and Policy, COBRAS has surveyed widely the New Zealand biosecurity community asking which of the stocktake priorities they consider to be among the top 10 most important. The purpose of the survey is to ascertain if policymakers, biosecurity practitioners, people working in industry, Māori stakeholders and scientists share similar views on the strategic priorities identified as underpinning the New Zealand biosecurity system. Results of the national survey will be presented and will highlight the extent to which different sectors prioritise similar biosecurity issues and the extent to which it is possible to develop a homogenous short-list of national priorities. In addition, at a broader scale, the results point to where in the biosecurity system future investment is most expected particularly in relation the following aspects: emerging future risks, risk pathways, detection and diagnostics, pest management, impact assessment, system resilience, indigenous culture, and biosecurity governance. This research will contribute to improving global biosecurity prevention and management through breaking down silo working and fostering a single approach across the main stakeholder groups and driving future research in directions that are beneficial to achieving ‘One Biosecurity’ aims.

Heat stress responses of insects and their life stages: Implications for quarantine treatments and predictive models

Kambiz Esfandi, Amanda Hawthorne, Cristian Baldassarre and Samuel Brown

The New Zealand Institute for Plant & Food Research Limited,
Private Bag 92169, Auckland Mail Centre, Auckland 1142, New Zealand

kambiz.esfandi@plantandfood.co.nz

Heat treatment has been widely used as a quarantine treatment to control insect infestations in international trade. However, the efficacy of heat treatment can vary depending on the species and life stages of insects. Little is known about the generalisability of insect response to heat stress, particularly in different insect species and their life stages. In this study, we conducted an extensive experiment to investigate the response of different insects and their life stages to heat stress to identify possible generalisability in the response that could be useful in developing quarantine treatments and predictive models. The experiment involved exposing different species of insects and their life stages to varying levels of heat stress and monitoring their survival and developmental. We found that the efficacy of heat treatment varied widely between species and life stages, with some species and life stages being highly susceptible to heat stress while others showed relatively high tolerance. However, we also found some commonalities in response to heat stress across different species and life stages, which could potentially be used to develop more effective quarantine treatments and predictive models. Our results suggest that the variation in physiological differences between different species and life stages of insects plays a significant role in determining their response to heat stress. By understanding these differences, we may be able to develop more targeted and effective quarantine treatments and predictive models for controlling insect infestations in international trade. This study provides a valuable contribution to insect pest management and has important implications for developing sustainable and effective quarantine treatments.

Mapping pan-Pacific distributions of *Metrosideros* species as potential *Ceratocystis* hosts: a fuzzy geographic approach given occurrence data uncertainty

Thomas Etherington, Murray Dawson and James McCarthy

Manaaki Whenua – Landcare Research, Lincoln, New Zealand

etheringtont@landcareresearch.co.nz

Information about the pan-Pacific distribution of *Metrosideros* species that could act as potential hosts for two *Ceratocystis* pathogens that cause Rapid 'Ōhi'a Death in Hawai'i, is critical information for developing surveillance and management plans that could prevent wider impacts across the Pacific region. Well-resolved distributional information requires reliable data on species' occurrence. Unfortunately, we discovered within the Global Biodiversity Information Facility, the world's biggest aggregator of open access occurrence data, extremely limited data availability for some regions and species. Some Pacific nations had only tens of occurrences for all *Metrosideros* species, and similarly some *Metrosideros* species had only tens of occurrences throughout the whole Pacific region. Data quality is another issue, especially as most of the species occurrence data comes from the iNaturalist citizen science platform. We discovered and corrected numerous and widespread species misidentifications that had achieved 'research grade' status, and incorrect reporting of observations as cultivated rather than wild. Such errors are problematic in themselves, but misidentifications have the potential to bias the underlying species identification algorithms of iNaturalist to create compounding errors. While errors can be corrected, another data quality issue is that of geographical sampling bias. Much of the data is concentrated into certain areas of the Pacific due to differences in survey effort and data mobilisation resources. If ignored such bias can lead to misleading distributional analyses, so care must be taken to use approaches that are insensitive to the inevitable presence of biased data. While more data can be collected or mobilised and errors in existing data can be addressed, the urgency of the *Ceratocystis* disease issue requires at least an initial mapping of *Metrosideros* species across the Pacific region. We describe an approach to map pan-Pacific distributions of *Metrosideros* species using a fuzzy geography approach that is flexible enough to work within the current data limitations and, critically, can quantify and communicate the underlying uncertainty of any distribution mapping. A fuzzy framework enables us to use a data driven approach where we are data rich, and a rule-based approach where we are data poor, integrating both approaches to provide what we feel is the most appropriate way to provide distributional information currently. Our aspiration is that by making this distributional information openly available, and by updating the information as new and better occurrence data becomes available, we can support the development of pan-Pacific surveillance and management plans for *Ceratocystis* diseases.

Predation by invasive portunid crabs on functionally and culturally important bivalves in New Zealand

Michal Ferries [1], Michael Townsend [2] and Drew Lohrer [1]

[1] National Institute of Water and Atmospheric Research, Hamilton, New Zealand
[2] Waikato Regional Council, Hamilton, New Zealand

michal.ferries@niwa.co.nz

Charybdis japonica (Portunidae), a predatory crab native to Asia, was first reported in Auckland in 2000. *C. japonica* populations have subsequently spread throughout much of northern New Zealand (both east and west coasts). Although most common in submerged habitats, *C. japonica* also occurs in intertidal areas, raising questions about its impact on intertidal prey species. Therefore, an experimental study was designed to evaluate its impact on intertidal sandflat assemblages, specifically those dominated by ecologically and culturally important bivalve species *Macomona liliana* (Tellinidae) and *Austrovenus stutchburyi* (Veneridae). To understand feeding patterns and impacts on soft-sediment assemblages, we exposed twenty-five 0.30m^2 patches of sediment to predation by large adult *C. japonica* for 48 hours. Bivalve densities were increased in some treatments to see if prey availability affected predation rate. We analysed final densities of bivalves in cages with and without *C. japonica* and used gut content analysis to determine the prey consumed during this time. The proportional contribution of prey species to the diet of *C. japonica* was calculated using stomach fullness as a weighing factor. A total of 45 crabs were dissected for gut content analysis, with only 18 of these containing food material at 5–30% capacity. The consumption of *A. stutchburyi* and *M. liliana* represented approximately 70% of the gut contents, with the remainder consisting of gastropod species *Diloma subrostratum*, *Cominella glandiformis* and other unidentified soft-bodied macrofauna. At present, *Charybdis japonica* appears to have little to no broad-scale impact on bivalve populations within the intertidal area. However, with a continuing increase in *C. japonica* populations, these invasive crabs may add pressure to already stressed habitats. Further research on the consumption of key prey species by *C. japonica* is critical to effective management and planning.

The team of 4.7 million? Biosecurity perceptions and practices in and around the Port of Tauranga

Susanna Finlay-Smits [1,4], Penny Payne [2,4] and John Kean [3,4]

[1] Manaaki Whenua Landcare Research
[2] The University of Waikato
[3] AgResearch
[4] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

Finlay-SmitsS@landcareresearch.co.nz

The Port of Tauranga is Aotearoa New Zealand's largest and fastest growing port, processing a large volume of goods and containers from diverse origins. This presents a significant risk to Aotearoa as these goods may contain biosecurity threats. As the 'biosecurity capital' of Aotearoa, Tauranga is looked to as an example of how biosecurity in such a complex environment can be managed, and how diverse groups in the port and surrounding communities can be enlisted as biosecurity risk managers within the Team of 4.7 Million – a government initiative to engage all New Zealanders in biosecurity surveillance and prevention. This paper presents the findings of the B3-funded Biosecurity Excellence in Port Communities project, which employed interviews and surveys to explore the biosecurity understandings, perceptions, and practices of port staff, transitional facilities staff, industry participants, local community, and primary school children in and around the Port of Tauranga. The understandings of biosecurity held by these diverse groups will be discussed as will their perceptions regarding who holds responsibility for biosecurity, and what enables and inhibits their uptake of biosecure behaviours.

Automatic detection of contaminants on sea container exteriors to improve detection of unwanted exotic organisms

Rhys Fitzgerald [1], Jason Sun [2, 5], Taylor Welsh [3, 5], Damen Rajkumar [2, 5], Mark McNeill [1, 5] and James Atlas [4]

[1] AgResearch, Private Bag 4749, Christchurch 8140, New Zealand
[2] The New Zealand Institute for Plant & Food Research Limited, Private Bag 3230, Waikato Mail Centre, Hamilton 3240, New Zealand
[3] Scion, 10 Kyle Street, Riccarton, Christchurch 8011, New Zealand
[4] University of Canterbury Computer Science & Software Engineering, University of Canterbury, New Zealand
[5] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

rhys.fitzgerald@agresearch.co.nz

The global movement of sea freight provides a significant pathway for the movement of and introduction of unwanted exotic organisms. Along with the potential economic and environmental impacts, there is loss of biodiversity for the receiving country. While risk analysis and profiling; offshore cleaning stations; and visual inspection at the border during unloading mitigate the risk of introduction, it is time and labour intensive, with a high risk of slippage. The ability to rapidly survey a larger proportion of sea containers for external contaminants to both improve detection of unwanted organisms and reduce biosecurity risk is being addressed with research to develop semi-automated container scanning tools for seaports. This is based on two key technologies: a scanning system using cameras in conjunction with edge-applied neural networks, and laser-based topology scanning. Two pilot studies using cameras demonstrated that a deep-learning neural network could be used to successfully identify externally contaminated sea containers. Current research aims to extend the pilot studies to improve the robustness of detection systems, whilst also developing an imaging and computing system that would allow for the system to be deployed in a port environment. The laser-based topology scanning technology will lead to an anomaly detection system, based on the identification of deviation from the expected smooth and largely uniform surface topography of a shipping container. Deviation may indicate the presence of a contaminant. By selecting suitable wavelengths, the system can also use spectral information to maximum the reflectance difference between contamination and container surface. The advantage of topography scanning laser approach is that it is much less computation intensive as a simple threshold can be used to identify the possible contamination based on roughness, reflectivity, and protrusion in real time. Results to date show that there are consistent spectral differences between container and contaminations, particularly around 1450 nm where contaminations such as insects and soil have a lower reflectance due to absorbance caused by the presence of water. Results from studies using the two technologies will be presented, along with an examination of potential challenges to the application and suitability of these systems in a seaport environment. The need to improve detection of unwanted organisms in a sea port environment makes the use of these technologies vital if biosecurity risk is to be reduced.

An extension program to protect forest health in Hawai‘i

James B. Friday

University of Hawai'i Cooperative Extension Service, 875 Komohana St., Hilo, Hawai'i 96720, USA

jbfriday@hawaii.edu

A new disease called Rapid ‘Ōhi‘a Death is decimating forests of Hawai‘i’s most important native tree, ‘ōhi‘a (*Metrosideros polymorpha*). We designed an extension program to 1) make forest landowners aware of the disease, 2) decrease human movement of the pathogens, and 3) increase public support for agency measures taken to protect forests and limit spread of the disease. In addition to forest landowners, we targeted groups who would be most likely to inadvertently move the pathogens, including eco-tour operators. Because the disease, along with weed seeds and pests such as invasive ants, may be moved with soil, we taught decontamination techniques to clean vehicles and gear before traveling to native forests. We conducted eight workshops for eco-tour operators, but the operators themselves subsequently have reached thousands of tourists and island residents. Evidence exists that high populations of feral game animals such as pigs, goats, and sheep in native forests create wounds on trees where the pathogens can enter. While fencing and feral animal removal has been shown to be effective in protecting forests from disease, these actions reduce hunting opportunities for local communities. We reached out to hunting groups to discuss common values and what compromises can be made between protecting the most pristine forest areas and providing access for hunting. Because the ‘ōhi‘a is revered in Native Hawaiian cultural traditions, we worked with Native Hawaiians to incorporate cultural values into our extension programs. A half-hour documentary featured Native Hawaiian cultural practitioners describing the importance of the tree to them. With the onset of COVID-19, we moved our programs online and conducted webinars, virtual field days, and virtual workshops. We found that we were able to reach some new audiences with online programs but lost contact with others, particularly in local communities. A recent survey demonstrated that we have been successful in raising awareness of the disease, with 89% of the population of Hawai‘i now knowing what ‘ōhi‘a trees are and 80% aware of the threat of Rapid ‘Ōhi‘a Death.

Diagnostic test performance of visual assessment and soil bioassay for *Phytophthora agathidicida* to improve survey design and interpretation for the causal pathogen of kauri dieback in *Agathis australis* using Bayesian latent class analysis

Emilie Vallee [1], Karyn Froud [2], John Kean [3], Yue Chin Chew [4], Edward Ashby [5], Alastair Jamieson [4], Lee Hill [6], Fredrik Hjelm [6] and Lisa Tolich [4]

[1] WOAH Collaborating Centre for Diagnostic Test Validation Science in the Asia-Pacific Region, Massey University, Palmerston North, New Zealand
[2] Biosecurity Research, Auckland, New Zealand
[3] AgResearch, Hamilton, New Zealand
[4] Auckland Council, Auckland, New Zealand
[5] Te Kawerau ā Maki, Auckland, New Zealand
[6] BioSense Limited, Auckland, New Zealand

karyn.froud@biosecurityresearch.co.nz

Accurate and precise estimations of the performance of diagnostic tests is needed to design and interpret surveillance for biological invasions. Kauri (Agathis australis), a keystone forest species, is threatened by kauri dieback, caused by Phytophthora agathidicida. There is no gold standard (perfect) test to determine the true P. agathidicida status of a kauri tree. Test performance is measured by the diagnostic sensitivity (probability a tree that does have P. agathidicida returns a positive test result) and diagnostic specificity (probability a tree that does not have P. agathidicida returns a negative test result). Bayesian latent class analysis (BLCA), used in animal and human health, is an innovative approach in plant health diagnostic test performance evaluation. A cross-sectional study of the baseline prevalence of P. agathidicida in randomly selected kauri trees in the Waitākere Ranges was undertaken. Visual assessment of symptoms and soil bioassay using baiting, culture, and morphological identification were used as 'tests' to infer the presence of P. agathidicida. A BLCA model was built using prior expert opinion from collaborators on the tests' performance, and on high versus low pathogen prevalence areas within the study area. Data were collected in 2021 from 159 and 572 trees within estimated high and low prevalence areas respectively. For visual assessment, the estimated sensitivity was 41.0% (95% PI 29.8-53.3) and the estimated specificity was 87.0% (95% PI 84.0-89.8). For the soil bioassay, the estimated sensitivity was 63.2% (95% PI 42.6-88.1) and the estimated specificity was 98.7% (95% PI 96.8-99.8). Soil bioassay performance values were used to estimate the true prevalence of P. agathidicida calculated from the apparent prevalence results of the survey. The apparent prevalence was 30.2% and 3.3% in the high versus low prevalence areas. Whereas, the true prevalence estimate, based on the "latent" infection status of the BLCA model, was 46.4% (95% CI 31.5-67.5), and 3.8% (95% CI 1.16-7.1%) for the high versus low prevalence areas. Historical surveillance used visual assessment then soil bioassay tests in series to delimit P. agathidicida. These sensitivity and specificity estimates calculate that the true prevalence of P. agathidicida will have been underestimated by around 3.9 times in these historical surveys. Knowing these values allows us to account for low test sensitivity when designing surveillance programmes and calculating sample sizes. Innovative methods for evaluating diagnostic tests are useful to validate all tests targeting any type of pathogen or pest and allow for better readiness to biological invasions.

Māori inclusive research programmes lead to greater science outcomes.

Beccy Ganley [1], Nick Waipara [1], Aaron McGlinchy [2] and Daniel Patrick [2]

[1] Ngā Rākau Taketake, Plant & Food Research, New Zealand
[2] Biological Heritage National Science Challenge, Maanaki Whenua Landcare Research, New Zealand

Beccy.Ganley@plantandfood.co.nz

Forest ecosystems in Aotearoa New Zealand are threatened by two invasive pathogens; *Phytophthora agthadicida*, which causes kauri dieback symptoms in *Agathis australis* (kauri) and *Austropuccinia psidii*, myrtle rust, which infects members of the Myrtaceae family. The New Zealand Government allocated funding for urgent research into these pathogens, and in 2019 contracted the NZ Biological Heritage National Science Challenge to develop a research plan and manage the funds. An innovative research programme was established, Ngā Rākau Taketake – Saving our Iconic Trees from Kauri Dieback and Myrtle Rust, to undertake crucial research underpinning long-term management strategies for both diseases. This programme used a radically different structure and approach to ensure involvement of Māori throughout the programme and research. This included commitment to Te Tiriti o Waitangi (agreement signed between the British Crown and Māori chiefs), co-leadership models, use of cultural authority and research disclosure agreements, supporting mātauranga (knowledge) Māori-led research and direct inclusion of mana whenua (Māori with territorial rights over tribal lands) in the research. We discuss the benefits, opportunities, and challenges from using this model, as well as the science gains and contributions to biosecurity and management of these diseases from a dual knowledge approach.

RNAi prospects to control invasive ant species in Australia

Amol Bharat Ghodke [(1)], Elizabeth Cash [(3)], Thomas Walsh [(2)], Neil Tsutsui [(3)], Kumaran Nagalingam [(1)] and Benjamin Hoffmann [(1)]

[(1)] Commonwealth Scientific and Industrial Research Organisation (CSIRO), Health & Biosecurity, Australia;
[(2)] Commonwealth Scientific and Industrial Research Organisation (CSIRO), Land & Water, Australia;
[(3)] Department of Environmental Science, Policy, & Management, The University of California, Berkeley, USA

amol.ghodke@csiro.au

Invasive ants are significant biosecurity threats, causing US$51.93 billion loss worldwide. Management tactics available for invasive ant species rely heavily on chemical pesticides that are often not species-specific and are harmful to the environment. RNA interference (RNAi) technology shows promising prospects to develop environmentally friendly tools for invasive species management. It uses a gene silencing approach to knock down specific genes mediating functional traits in target species, therefore it is unlikely to have off-target effects on other species. Further, RNAi-mediated gene knockdown is sequence-specific and can be manipulated easily to evolving species to counter resistance development. Our study focused on testing the effectiveness of RNAi technology for gene silencing in *Solenopsis invicta* and *Anoplolepis gracilipes* to develop control tools for practical field application. In this talk, we will discuss the results from our bioassays that showed significant gene silencing of multiple gene targets in *Solenopsis invicta* and *Anoplolepis gracilipes*. We highlight the biological and technical challenges we encountered in our studies and discuss the potential to integrate existing ant bait systems and RNAi for field application.

Strengthening phytosanitary research programming and collaboration: from European to global phytosanitary research coordination

Baldissera Giovani

Euphresco, 21 Bd Richard Lenoir, 75011 Paris, France

bgiovani@euphresco.net

It is not possible to avoid all the challenges to plant health posed by global trade, increasing travel activities and climate change. However, it is possible to optimise strategies to address these challenges with effective cooperation and coordination. Research plays a key role in underpinning phytosanitary activities, ranging from pest risk analysis, regulation, surveillance, taxonomy, diagnostics and mitigation measures. Research also helps to maintain and develop scientific expertise and infrastructure that support plant health. The success of Euphresco as a primarily European network for phytosanitary research coordination has set the ground for discussions on the development of initiative(s) to address the needs of other regions of the world and global phytosanitary research coordination. While Euphresco has been effective in Europe and has attracted non-European members, its current structure and operation limit their full engagement; moreover, there are research areas that are under-represented. A reflection that will consider the global plant health research context in order to clarify the role of Euphresco and to adapt its structure and operation to better serve a wider and more diverse membership is then needed. In September 2022, the international workshop 'Shaping global plant health research coordination' was held in London (GB). Representatives of national, regional and international plant health networks attended from around the world. The workshop participants agreed that there is a need for global phytosanitary research coordination to enhance international collaboration and to enable greater efficiency in research investment in plant health. The presentation will provide an overview on how Euphresco has supported research coordination and international collaboration until now and will allow to discuss future actions to set the foundations for global phytosanitary research coordination.

Enabling large scale community surveillance and action on invasive species

Andreas Glanznig [1], Peter West [2], Hanwen Wu [2], Alexander Schmidt-Lebuhn [3]

[1]Centre for Invasive Species Solutions, c/- University of Canberra Innovation Centre, Building 22, University Drive South, Bruce ACT 2617
[2]NSW Department of Primary Industries
[3]CSIRO

andreas.glanznig@invasives.com.au

Citizen science and community action is integral to effective biosecurity and invasive species management. This talk will provide strategic insights on the national Centre for Invasive Species Solutions approach in working with communities around Australia to build platforms to enable collaborative and community led action. This includes the application of behavioural science and community based social marketing approaches in program design, and development of easy-to-use digital surveillance and management tools (FeralScan and WeedScan) supported by accessible toolkits on best practice management (PestSmart and WeedsAustralia). The talk will specifically outline the key features of our community digital surveillance and management tools to foster regional scale, cooperative action on priority invasive species. * FeralScan is a nation-wide digital community monitoring, recording communication and management web site and purpose-built App, now used by over 620 organisations and communities to enable monitoring and management of vertebrate pests. Hosting over 319,000 records, and 30,000 photos, the platform empowers and drives adaptive management programs through dash boards, and community alerts to enable real-time rapid responses.

* WeedScan is a soon to be released nation-wide artificial intelligence based weed ID and notification App and web site to enable rapid and more strategic action on about 300 priority weed species.

Cockroaches in the coalmine: bioindicators of lost ecological resiliency

Scott Goetz [1], Levi Gray [1], Patrick Barnhart [2], Diane Vice [3] and Melia Nafus [1]

[1] United States Geological Survey, Pacific Island Ecosystems Research Center, Hawaii National Park, Hawai'i, United States of America
[2] United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, Guam State Office, Barrigada, Guam, United States of America
[3] Guam Department of Agriculture, Division of Aquatic and Wildlife Resources, Barrigada, Guam, United States of America

sgoetz@usgs.gov

Species within ecosystems are connected by food webs such that major perturbations can induce trophic cascades that alter flora and fauna community structure, often in unexpected ways. Invasive species, a major source of ecological disturbance, have been postulated to have negative effects on ecosystem services and cause declines in biodiversity that are speculated to reduce ecological resiliency, although field examples of these conceptual relationships are uncommon. The simplified food webs and high rates of species endemism of oceanic islands may be particularly sensitive to community-level effects of bioinvasion. Here, we opportunistically used a system in which a nonnative predator, brown treesnakes (*Boiga irregularis*), was recently introduced to an insular ecological community to determine if we could quantify whether there was evidence to support a trophic cascade that provided evidence for decreased ecological resiliency in the face of local species extirpations. We found that in areas in which snakes were more commonly captured, observations of a large gecko, presumably favored prey of the snake, decreased while counts of smaller lizards did not change. Cockroach, likely a prey source of the large gecko, sightings also increased with decreased sightings of the large gecko. In sum, the introduction of an invasive snake to a small oceanic island supported that an immediate tri-trophic interaction, including the invertebrate community, which supports a hypothesis for lost ecological resiliency and identifies a potentially valuable bioindicator of invasion by an infamous cryptic predator.

Forest biosecurity in New Zealand – A plantation forestry perspective

Brendan Gould [1], Bill Dyck [1], John Simmons [2] and Paul Adams [1]

[1] Forest Owners Association, PO Box 10986, Wellington, 6140, New Zealand
[2] New Zealand Farm Forestry Association, Wellington New Zealand, PO Box 10349, The Terrace, Wellington 6143

brendan.gould@nzfoa.org.nz

Forest health and forest biosecurity have long been important areas of focus for New Zealand's plantation forestry industry. With the plantation forestry sector transitioning from largely public ownership to private ownership over the last few decades, the industry has had to adapt and implement funding, governance, and delivery structures for a range of plantation forest sector good initiatives including, inter alia, biosecurity and research and development. The Forest Biosecurity Committee (FBC) was formed to provide industry with strategic leadership and oversight for all aspects of forest biosecurity, and to foster cohesion across industry, government, and the science community to improve forest biosecurity outcomes. The FBC oversees and implements the industry's biosecurity work programme, which is funded by the Forest Growers Levy Trust, with a small contribution from government, including risk reduction, surveillance, readiness and response activities. Biosecurity surveillance forms a major component of the industry's work and includes a range of surveillance programmes spanning risk based targeted surveillance through to general surveillance and awareness raising. The Industry is also increasingly focusing on readiness and research initiatives, some in partnership with government, to improve New Zealand's preparedness to detect and respond to forest biosecurity risks. The industry has developed a Forest Biosecurity Strategy and a Forest Biosecurity Research Strategy to inform, guide, and prioritise its work programme and research focus into the future.

Co-designing UAV technologies and operational protocols for biosecurity: transdisciplinary approaches in biosecurity technology design

Andrea Grant [1], Will Allen [2] and Simon Lambert [3]

[1] Scion, 10 Kyle St, Riccarton, PO Box 29237, Riccarton, 8011, Aotearoa New Zealand
[2] Will Allen and Associates, Learning for Sustainability, Christchurch, Aotearoa New Zealand
[3] University of Saskatchewan, College of Arts, Kirk Hall 137, 91 Campus Drive, Saskatoon, SK, SK S7N 5e8, Canada

andrea.grant@scionresearch.com

As part of keeping countries free from invading insect pests that damage our native forests, urban trees, forestry plantations and other horticulture crops, researchers are continually exploring the design and use of new technologies. Sterile insect release, CRISPR-Cas technologies and use of unmanned aerial vehicles (UAVs) for surveillance and control are recent examples of technical innovations in biosecurity, many of them promoted as socially acceptable innovations. However, new technologies can introduce novel issues of acceptability that may be overlooked. Consideration of technologies and design of their use is an important interface in which acceptability and other social and cultural issues can be explored. Recently Scion, New Zealand's Crown Forestry Research Institute, has been exploring the use of UAVs as one potential option for treating individual tall trees infested with unwanted pests (insects or pathogens). UAVs have potential advantages over other spray delivery technologies such as helicopters for this type of operation, particularly in urban/suburban environments where new incursions are often found. However, there are few examples of developing technologies where different groups with an interest in biosecurity tools and their operation have been asked about their views and perspectives of the technology and operational design process. This presentation reports on a pilot research project that has been developed to offer a way to include such views and perspectives in the development and design of UAV and their operational protocols. Findings from transdisciplinary focus groups with researchers, social scientists, Māori researchers and practitioners, and forestry managers and workshops with researchers (technical, social and cultural), agencies and their advisors identify and make recommendations on how to include multiple perspectives in novel technologies and operation design through policy, practice and research.

Exploring pest mitigation research and management associated with wood packaging in the international supply chain: what and where are the weak links?

Leigh F. Greenwood [1], Miguel A. Avila [2], David R. Coyle [3], María E. Guerrero [2], Gustavo Hernández [2], Chris J.K. MacQuarrie [4], Oscar Trejo [2] and Meghan K. Noseworthy [5]

[1] Forest Health Program, The Nature Conservancy, Missoula, MT, USA
[2] Dirección General de Gestión Forestal y de Suelos, Secretaría de Medio Ambiente y Recursos Naturales – SEMARNAT, México City, México
[3] Department of Forestry and Environmental Conservation, Clemson University, Clemson, SC, USA
[4] Natural Resources Canada Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, ON, Canada
[5] Natural Resources Canada Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada

lgreenwood@tnc.org

Global trade continues to increase in volume, speed, geographic scope, diversity of goods, and types of conveyances, which has resulted in a parallel increase in both quantity and types of pathways available for plant pests to move via trade. Wood packaging material (WPM) such as dunnage, pallets, crates, and spools, is an integral part of the global supply chain due to its function in containing, protecting, and supporting the movement of traded commodities. The use of untreated solid wood for WPM introduces the risk of wood boring and wood-infesting organisms into the supply chain, while the handling and storage conditions of treated WPM presents risk of post-treatment contamination by surface-adhering or sheltering pests. The wood-boring and -infesting pest risks intrinsic to the solid wood packaging pathway were addressed in the 2002 adoption and 2009 revision of ISPM 15, which was first implemented in 2005–2006 in North America. Although this global initiative has been widely implemented, some pest movement still occurs due to a combination of factors, including: fraud, use of untreated material, insufficient or incomplete treatment, and post-treatment contamination. Here we examine the forest-to-recycling production and utilization chain for wood packaging material with respect to the dynamics of wood-infesting and contaminating pest incidence within the environments of the international supply chain and provide opportunities for improvements in pest risk reduction. We detail and discuss each step of the chain, the current systems in place, and regulatory environments. We discuss knowledge gaps, research opportunities and recommendations for improvements for each step. This big picture perspective allows for a full system review of where new or improved pest risk management strategies could be explored to improve our current knowledge, global regulations, and biosecurity.

Addressing the threat of invasive species to deliver a resilient Pacific

Richard Griffiths, Patty Baio, Loyola Darius and Paul Jacques

Island Conservation, 630 Water St, Santa Cruz 95060, CA, USA

rgriffiths@islandconservation.org

The presence of invasive alien species (IAS) and the arrival of new IAS are undermining attempts within the Pacific Region to adapt to the impacts of climate change. IAS impact biodiversity, disrupt ecosystems, affect agriculture, spread disease and diminish the availability of critical natural resources. Their presence leads to intensely modified islands with low diversity that have a reduced capacity to adapt and recover from the negative effects of climate change. Disrupted forests and resource-starved reefs, for example, are more vulnerable to storm damage and bleaching events. The good news is that some of the most damaging IAS present in the Pacific can be removed from islands and new species prevented from establishing with significant and sustained benefits to biodiversity, ecosystem recovery and livelihoods. Resourcing interventions to prevent new IAS arriving and eradicate those IAS already established needs to be prioritised by multi-lateral funding mechanisms if we are to tackle the threat of IAS at the scale required and ensure Pacific communities remain resilient into the future.

Detection of *Xylella fastidiosa* in New Zealand indigenous plant species growing overseas

Sandra B. Visnovsky [1, 6], Fernanda Nieto-Jacobo [1], Preeti Panda [1, 6], Sarah Thompson [1], Isabel Bojanini Molina [2], Alexandra Kahn [2], Ronny Groenteman [3, 6], Luciano Rigano [4, 6], Robert Taylor [4, 6], Holly Forbes [5] and Rodrigo Almeida [2]

[1] The New Zealand Institute for Plant & Food Research Limited, Private Bag 4704, Christchurch 8140, New Zealand
[2] University of California, Berkeley, CA, United States of America
[3] Manaaki Whenua – Landcare Research, PO Box 69040, Lincoln 7640, New Zealand
[4] Plant Health and Environment Laboratory, Ministry for Primary Industries, P.O. Box 2095, Auckland 1140, New Zealand
[5] University of California Botanical Garden, CA, United States of America
[6] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

groentemanr@landcareresearch.co.nz

Xylella fastidiosa (Xf) is a xylem-limited bacterial plant pathogen that is transmitted by insect vectors. It infects a wide range of plant species and causes devastating diseases. The pathogen is not present in New Zealand (NZ). A survey of NZ indigenous woody plants species growing in Southern California in 2012 revealed that several were susceptible to *Xf*. The current project used diagnostics of *Xf* as part of a biosecurity aim to predict the risks and impacts of *Xf* if it were introduced into NZ. Specifically, we are investigating methods to detect the pathogen at the sequence-type level directly from plant material, without an isolation step. Using a sentinel plant network, over 140 NZ indigenous plants growing in the University of California Botanical Garden at Berkeley were screened for *Xf*. Eight plants tested positive by at least two methods. All eight were identified as *Xylella fastidiosa* subsp. *multiplex* sequence-type ST6 or ST7. Most of the positive samples came from shrub-like species, unlike the woody species sampled in Southern California in 2012. Bacterial isolates from three plant species were isolated in California and their genomes were sequenced. In addition, we recently received dried samples from some of the plants sampled in 2012 in Southern California. These samples will: enable a follow-up on the disease progression 10 years on; provide material for DNA extraction for developing diagnostics tools; and help assess the risk of *Xf* sequence-types to indigenous flora and their potential transfer to crops.

An abstract for a presentation at the pre-Congress workshop on the Value of Botanic Gardens to Biosecurity

Celebrating 20-years of a national marine pest surveillance programme

Abraham Growcott [1] and Chris Woods [2]

[1] Biosecurity New Zealand, Wellington
[2] National Institute of Water and Atmospheric Research, Christchurch

abraham.growcott@mpi.govt.nz

An effective surveillance system is a vital component of any biosecurity system. Biosecurity New Zealand in partnership with the National Institute of Water and Atmospheric Research conceived, developed, and implemented the National Marine High Risk Site Surveillance (NMHRSS) programme, which celebrated its 20th anniversary in 2022. The NMHRSS programme commenced in 2002 with ongoing six-monthly survey of eight ports with the highest likelihood of entry of marine NIS and was designed to facilitate the early detection of seven high-risk species which at that time were not known to be present in New Zealand waters. Water current and habitat modelling were used to determine high risk zones of establishment in each port and to focus where each of the five survey methods should be deployed to maximise early detection of founding populations. The NMHRSS programme has two secondary objectives which are: 1) to detect incursions of marine non-indigenous species (NIS) not previously recorded in New Zealand; and 2) to detect range extensions by marine NIS that are already established in New Zealand waters. Continuous improvement of the programme has occurred since, for example, by adding new port survey locations (Ōpua and Marlborough 2007, New Plymouth 2009, and Napier 2021), testing of emerging detection methods (e.g., molecular methods), refining of survey effort allocation at ports and assessing the change in propagule pressure in relation to international vessel traffic patterns. Outside of its primary purpose of early detection of marine NIS, the NMHRSS programme has supported the biosecurity system by raising the awareness among risk managers, policy makers and wider partners and stakeholders as to the continued entry and risk of marine NIS to New Zealand's marine values (environmental, socio-cultural, and economic). This has led to the implementation of vessel biofouling border standard and domestic pathway approaches to prevent further spread and establishment of marine NIS. This highlights the importance of long-term datasets that can be used to support policy development. Since the inception of the NMHRSS programme a total of 26 new-to-New Zealand species and 195 range extensions have been detected via this programme. Finally, all marine surveillance data from these surveys and public submissions are freely available through an online GIS mapping platform supporting the New Zealand's Government's open data policies.

Enhanced Pacific Biosecurity Partnership: A programme to protect plants from invasive pests and diseases

Disna Gunawardana, Merje Toome-Heller and Lalith Kumarasinghe

Plant Health and Environment Laboratory, Ministry for Primary Industries, Auckland, New Zealand

disna.gunawardana@mpi.govt.nz

New Zealand's Ministry for Primary Industries (MPI) has been strengthening the Pacific Island Countries' (PICs) biosecurity systems since 2011. Most of this work has been delivered through the Aid projects funded by New Zealand's Ministry of Foreign Affairs & Trade (MFAT). The current MFAT funded 5-year project – Enhanced Pacific Biosecurity Partnership Programme (EPBP) – started in 2021 and supports Cook Islands, Fiji, Niue, Samoa, Tonga, and Vanuatu. The main project partners are the NPPOs of the mentioned countries, but we also collaborate with other institutions in the Pacific to maximise the benefits to the PICs. MPI's Plant Health and Environment Laboratory (PHEL) delivers the plant health component of the programme, improving diagnostic laboratory set ups, delivering pest and disease diagnostic trainings, and assisting with developing diagnostic tools and techniques for early diagnosis of invasive species. This is achieved through laboratory and field-based workshops in PICs and in New Zealand, as well as through delivering virtual trainings and preparing diagnostic resources tailored for PICs. Examples of some of the most significant exotic pests that PHEL has provided training on include fruit flies, fall armyworm, Giant African snail, Khapra beetle, fire ants, Pierce's disease, citrus canker, and papaya ringspot virus. As part of the previous and current projects, diagnostic laboratories are set up with essential laboratory equipment. To date, the Biosecurity Authority Fiji Plant Health Laboratory has been fully equipped to carry out morphological and molecular diagnostics of plant pests and diseases, and work has started to upgrade the laboratories in other countries. In addition to being able to identify exotic organisms accurately and quickly, it is vital to find them early and have effective response systems in place for successful eradication. Therefore, PHEL collaborates with other MPI teams to establish new and/or improve the existing surveillance programmes in PICs and support their risk assessment and response management processes. Some examples include the fruit fly, invasive ant, and fall armyworm surveillance programmes. To further target the different layers of the biosecurity system, the programme builds capability in border clearance processes by providing training and support to PIC biosecurity officers. We also focus on the PIC partners' laboratory quality management systems to ensure that all required data is captured and recoded following the international standards and requirements.

Development of RPA based advanced molecular diagnostics assays with potential for in-field applications

Sandeep K. Gupta [1], Nicola Richards [2], Tyler Regtien [1], Mitchell Weston [2], Jeanne Jacobs [2], Trevor Jackson [2], D. Neil Wedlock [1] and Sean Marshall [2]

[1] Animal Health Solutions, Ethical Agriculture, Hopkirk Research institute, AgResearch, Palmerston North, New Zealand
[2] Resilient Agriculture, Lincoln Science Centre, AgResearch, Christchurch, New Zealand

sandeep.gupta@agresearch.co.nz

Recent advancements in nucleic acid detection have revolutionised diagnostics for various microorganisms. Several isothermal amplification methods such as loop-mediated isothermal amplification (LAMP) and recombinase polymerase amplification (RPA) combined with lateral flow dip stick or fluorescence-based detection have been developed as diagnostic methods for detection of various pathogens, including viruses. RPA has become a powerful tool for 'point of care' molecular diagnostics due to its simple set-up and shortened timeframes to obtain results. Similar to PCR, RPA amplifies DNA but operates at a constant temperature (between 25°C to 42°C). RPA has the advantage of being relatively tolerant to numerous PCR-inhibitory substances, which reduces the time and cost involved in obtaining purified DNA from test samples. Additionally, RPA requires minimal instrumentation (e.g., a simple heating block and/or a portable fluorometer) with results obtained within 30-40 min, making it suitable for use under field conditions. Previously, we developed a specific RPA assay using lateral flow dip stick technology to detect *Mycoplasma ovipneumoniae*, the causative agent of pneumonia infection in sheep. The RPA assay detected *M. ovipneumoniae* in nasal swab secretions as well as lung lavage samples, and the results obtained using this approach correlated with *M. ovipneumoniae* culture-based detection methods. More recently, we have developed an RPA assay to rapidly detect Oryctes rhinoceros nudivirus (OrNV) using fluorescence-based chemistry. OrNV is used as a biocontrol agent to suppress populations of coconut rhinoceros beetle (CRB), an important invasive pest of palm trees across the Pacific. RPA-based re-assessment of the viral status of DNA from beetle populations previously assessed by PCR, demonstrated a high correlation between both methods. In addition, the results from testing crude lysates prepared from the gut tissues of CRB with the OrNV-RPA assay revealed a high correlation with the PCR-based method. These findings verified that RPA could be a useful tool for rapid in-field assessment of the presence of OrNV virus within invading CRB populations. Currently, we are developing an RPA assay with a CRISPR/Cas-based extension to differentiate between different CRB populations invading the Pacific. Such an assay could potentially be used in in-field settings to improve CRB management in the Pacific Islands.

Anthropogenic risk pathways for marine disease in New Zealand

Ian Davidson [(1)], Oli Floerl [(1)], Ed Peeler [(2)], Louisa Wood [(3)], Andrew Robinson [(4)] and Anca Hanea [(4)]

[(1)] Cawthron Institute,Private Bag 2, Nelson 7040, New Zealand
[(2)] Centre for Environment, Fisheries and Aquaculture Science, Pakefield Road, Lowestoft, Suffolk NR33 0HT , United Kingdom
[(3)] The University of Portsmouth, Winston Churchill Avenue Portsmouth, Hampshire, PO1 2UP, United Kingdom
[(4)] Centre of Excellence for Biosecurity Risk Analysis, School of Biosciences, The University of Melbourne, VIC 3010, Australia

anca.hanea@unimelb.edu.au

The spread of marine disease is consequential for economic and ecological resources worldwide, including aquaculture systems. In New Zealand (NZ), novel pathogens have had major impacts on the shellfish aquaculture industry over the last decade. As a result, environmental managers require decision tools and resources to implement policies to reduce risk of disease incursions and manage disease outbreaks. We model the spread of pathogens through anthropogenic pathways (e.g., ship biofouling, imported ornamental species) using two example pathogens and four vector pathways from international sources to NZ as the overall model system. The classic stepwise invasion model of source, entrainment, transport, and discharge is used, together with an existing model for establishment likelihood. We considered the biogeography, biology, and life-history of model pathogens and provided an expert panel with summary information from a review of these organisms. Because data on the quantities and trajectory of pathogens in marine vectors is scarce or non-existent, the expert panel was asked to provide numerical estimates and degrees of uncertainty around model components. The expert elicited estimates were complemented with vector data (e.g., vessel traffic), and informed the risk of incursion of the model pathogens to NZ ports or other places. The results provide a testable hypothesis (for model validation) on the likelihood of encountering particular pathogens within four vector pathways of international importance for marine disease transmission. This can inform subsequent risk analysis and resource allocation for national biosecurity systems to protect valuable primary industries and biodiversity.

A cooperative response to fall armyworm in New Zealand: Government and Industry working together.

Scott Hardwick[1,2], Nicholas Davies[1,2], Anthony Harmer[3], Antony Heywood[4], Ivan Lawrie,[5] Richard Palmer[6], Craig Phillips[1,2], Andrew Pitman[4] Graham Walker[7,2]

[1] AgResearch, Private Bag 4749, Christchurch 8140, New Zealand
[2] Better Border Biosecurity (B3) (https://www.b3nz.org.nz/)
[3] Biosecurity New Zealand – Tiakitanga Pūtaiao Aotearoa, Ministry for Primary Industries – Manatū Ahu Matua, PO Box 2526, Wellington 6140 New Zealand
[4] Vegetables New Zealand, PO Box 10232, The Terrace, Wellington 6143
[5] Foundation for Arable Research Inc, PO Box 23133, Hornby, Christchurch 8441
[6] Process Vegetables NZ, PO Box 10232, The Terrace, Wellington 6140
[7] Plant & Food Research Private Bag 92169, Auckland Mail Centre, Auckland 1142, New Zealand

Scott.hardwick@agresearch.co.nz

Fall armyworm (FAW), *Spodoptera frugiperda* (Lepidoptera: Noctuidae), is a pest of corn/maize and other crops. It is native to the Americas and has recently spread to Africa, India, China, Japan, SE Asia, Indonesia, Australia and New Zealand (NZ). In NZ it was first found at Tauranga in March 2022 and by April 2022 it had been recorded at numerous locations in the upper North Island. An incursion response was initiated that was jointly funded by government and some industries via a prearranged Government Industry Agreement (GIA). The response included monitoring, modelling, and education. Monitoring involved establishing approximately 118 pheromone trapping sites throughout the maize and sweetcorn growing areas of the North and South Islands, including 28 sites where FAW had been observed in autumn 2022. Traps were maintained and checked weekly throughout the 2022-23 growing season and crop scouting was also encouraged. Modelling was conducted to identify NZ locations where FAW could survive winter, predict its phenology and estimate its annual generations. To assist maize/corn growers to identify FAW infestations, identification guides were produced and distributed via the internet, industry representatives and eight face-to-face workshops.
During early to mid-season 2022-23, more FAW infestations were found by crop scouting than by pheromone trapping, except perhaps in Northland where numerous individuals likely survived winter. The monitoring results suggested there was probably under reporting of FAW during 2021-22. FAW may have survived winter 2022 in Northland, Auckland, parts of the Waikato, Hawke's Bay and perhaps also in parts of Westland in the South Island. By the end of the 2022-23 growing season, FAW had been observed in the North Island in Northland, Auckland, Waikato, Hawke's Bay, Bay of Plenty and in the South Island in Golden Bay, Canterbury and Westland. There have been no observations of FAW in the South Island in Marlborough, Otago or Southland to date.

Assessing the risk of establishment of rapid ‘ōhi ‘a death: using knowledge of *Ceratocystis* species already in New Zealand

Luna Hasna [(1)], Robert Beresford [(1)], Virginia Marroni [(2)], Rebecca Campbell [(3)] and George Perry [(4)]

[(1)] The New Zealand Institute for Plant & Food Research Limited, Private Bag 92169, Mt Albert, Auckland 1142, New Zealand
[(2)] The New Zealand Institute for Plant & Food Research Limited, 74 Gerald Street, Lincoln 7608, New Zealand
[(3)] The New Zealand Institute for Plant & Food Research Limited, 55 Old Mill Rd, Motueka 7198, New Zealand
[(4)] University of Auckland, School of Environment, 23 Symonds Street, Auckland 1010, New Zealand

luna.hasna@plantandfood.co.nz

The fungal genus *Ceratocystis* includes plant pathogens that affect a wide range of hosts in more than 22 plant families. Aggressive wilt pathogens *C. lukuohia* and *C. huliohia* cause rapid ‘ōhi ‘a death (ROD) on the Hawaiian forest tree *Metrosideros polymorpha* (‘ōhi ‘a), which is resulting in severe ecological damage. Ohi’a is an important component of forest ecosystems in Hawaii and is related to the New Zealand (NZ) native species pōhutukawa, *Metrosideros excelsa*. If these *Ceratocystis* species become established in NZ, pōhutukawa and other native myrtle species could be at risk. Previous work shows that NZ pōhutukawa is susceptible to ROD disease when artificially inoculated in the laboratory.
In NZ, *Ceratocystis fimbriata* was reported on kūmara (*Ipomoea batatas*) in Kaitaia in 1960 and was also recorded from the Bay of Islands, Helensville, Great Barrier Island, Auckland, Matakana Island (Bay of Plenty) and Gisborne. However, no information is available about whether any *Ceratocystis* species are already present on woody plants in NZ. Determining this will contribute to baseline information to inform biosecurity and to understand future changes. Biogeographic evidence from other areas suggests that members of the *Ceratocystis* Asian-Australian clade are highly likely to occur in our forests. Recent published studies from Australia and South Africa have used a targeted baiting method to successfully detect *Ceratocystis* spp. in their forests for the first time. In our study, a preliminary survey in the Auckland area did not find any *Ceratocystis* spp. However, a detailed survey is underway focusing on the primary risk areas. We are conducting in vitro experiments on mycelial growth, spore germination, and pathogenticity for *C. fimbriata* from kūmara in NZ to compare this species with the Hawaiian species *C. lukuohia* and *C. huliohia*. This work will contribute to an analysis of the potential climatic risk for NZ native species if other pathogenic *Ceratocystis* species were to arrive in this country.

Risk analysis of alien fishes invasion in inland waters of Guangxi, China

Jiayang He

College of Environmental Science and Engineering, Guilin University of Technology Guilin, Guangxi, China

HJY2022WSRY@163.com

In order to provide scientific basis for the prevention and control of alien fishes invasion and aquatic ecological environment protection in Guangxi, the risk assessment and suitable area prediction of alien fishes invasion in inland waters of Guangxi were carried out. Using the alien fishes invasion risk assessment system and the aquatic biological invasion capability screening system (aquatic species invasiveness screening kit, AS-ISK), fish species at risk of invasion in the inland waters of Guangxi were screened, using the maximum entropy model (Maximum Entropy, MaxEnt) to predict fish at high risk of invasion in the inland waters of Guangxi. There were 18 species of alien fishes were naturally distributed in the inland waters of Guangxi. Thirteen species of fish, including Clarias gariepinus Burchell, Oreochromis niloticus Linnaeus, Oreochromis mossambicus Peters, Oreochromis aureus Steindachner, Pterygoplichhtys pardails Castelnau, Coptodon zillii Gervais, Micropterus salmoides Lacepède, Ietalurus punetaus Rafinesque, Piaractus brachypomus Cuvier, Labeo rohita Hamilton, Prochilodus lineatus Valenciennes, Cirrhinus mrigala Hamilton and Gambusia affinis Baird & Girard have high invasion risk; and Tinca tinca Linnaeus and Neosalanx taihuensis Chen have medium invasion risk. The prediction results of fish with high invasion risk shows that Qianjiang River, Yujiang River and Nanliu River are vulnerable to fish invasion. Both medium and high risk fish should be monitored, and continuous monitoring and early screening should be carried out in waters with high risk of invasion.

Proteomic profiling of small extracellular vesicles isolated from an in vitro cell culture bioreactor simulating Mycoplasma bovis infection

Mallory Crookenden [(1)], Joel Pratt [(1)], Ancy Thomas [(2)], Charles Hefer [(3)], Alice Lake [(1)], Axel Heiser [(1)] and Evelyne Maes [(2)]

[(1)] Animal Health Solutions, AgResearch Ltd. Palmerston North, New Zealand

[(2)] Proteins & metabolites, AgResearch Ltd., Lincoln, New Zealand

[(3)] Data Science South, AgResearch Ltd., Lincoln, New Zealand

axel.heiser@agresearch.co.nz

Mycoplasma bovis (*M. bovis*) is a pathogenic bacterium causing untreatable mastitis, abortions, swollen joints, and severe arthritis in cattle. The disease was first detected in New Zealand in 2017 and has since spread to farms throughout the country. The New Zealand government has implemented a comprehensive plan to control and eradicate *M. bovis*. This work aims to develop a diagnostic tool for the detection of "hidden" *M. bovis* infection that is undetectable via direct detection of the pathogen, e.g. by PCR, or by serology. It focuses on the detection of biomarkers of infection from circulating small extracellular vehicles (sEVs), secreted in response to *M. bovis* infection. In recent years, sEVs, and exosomes in particular, have gained significant interest in the field of diagnostics. Exosomes are small extracellular vesicles of 30-150 nm known to have important functions in cellular communication, signal transduction, and immunomodulation. As these nanoparticles contain proteins, lipids, and metabolites, representative of their cell of origin, their content may have potential to carry biomarkers for diagnosis of early or hidden infections. In this work, we want to unlock the diagnostic potential of sEVs using an *in vitro* infection model. We hypothesize that the exosomal proteome of *M. bovis* infected cells may contain information representative of infection compared with control cells. To this end, a control culture of a bovine endometrial epithelial cell line (bEEL cells) (n = 5) and a co–culture of bEEL cells and *M. bovis* (n = 5) were established within bioreactor flasks. From each bioreactor harvest, sEVs were isolated using Size Exclusion Chromatography qEV10 columns (IZON, New Zealand). The isolated exosomal fraction was further heat treated for 5 min to inactivate *M. bovis* before proteins were extracted, digested, and analysed by proteomics. In total, over 4100 proteins representing 2816 protein groups were identified across the samples. As expected, hundreds of mycoplasma proteins have been identified in the sEVs of the co-cultures, but not in the control samples. Additional comparative proteomics profiling of the altered bovine proteome of sEVs in response to infection by *M. bovis* indicated separate grouping. Specific exosomal proteins were detected using ExoCarta. In conclusion, our data provides preliminary evidence that exosomal protein profiles are altered in the presence of *M. bovis* infection and can thus play a crucial role in early diagnosis of the disease.

Funding biosecurity systems efficiently, fairly and sustainably

Gary Stoneham [1], Susan Hester [2, 3] and Arthur Campbell [4]

[1] The Centre for Market Design, The University of Melbourne, Parkville, Victoria, Australia
[2] Centre of Excellence for Biosecurity Risk Analysis, The University of Melbourne, Parkville, Victoria, Australia
[3] UNE Business School, University of New England, Armidale, New South Wales, Australia.
[4] Department of Economics, Monash University, Caulfield East, Victoria, Australia

shester@une.edu.au

Despite the central role that humans play in moving pests and diseases across the globe, governments tasked with protecting communities and economies from invasive species typically only focus on the science of pest and disease spread when developing biosecurity regulations. Regulations are usually developed with little thought as to how the risk creators — the individuals and organisations involved in the activities that impose biosecurity risks — will respond. Biosecurity regulations that do not carefully consider stakeholder responses can deliver unintended and counterproductive policy consequences. Objectives around protecting the economy and community from the impacts of invasive species are unlikely to be met, or worse, behaviour may be the opposite to what the regulation was intending to trigger, resulting in significant costs incurred managing incursions, checking compliance, or in managing trade relationships. The importance of considering the human dimension in biosecurity policy design cannot be overstated — each biosecurity regulation creates an inducement (an incentive) for individuals to take actions that they would otherwise not consider. Because both scientific and human elements are important in pest and disease spread, efficient and effective management of threats can only be achieved by integrating both our knowledge of pest and disease behaviour (epidemiology) and our understanding of how humans respond to incentives inherent in regulations (economics – specifically, market-design economics). Technology can also assist in this process. We explore the design of incentive-compatible biosecurity policy using examples from the Australian biosecurity system where the importance of considering incentives has been recognised, and steps are underway to embed an 'incentive-approach' into biosecurity policy design.

Shared responsibility for biosecurity: Organisational challenges and opportunities

Vaughan Higgins [1], Melanie Bryant [2], Marta Hernandez-Jover [3] and Russell Warman [4]

[1] School of Social Sciences, University of Tasmania, Hobart, Tasmania, Australia
[2] College of Business and Economics, University of Tasmania, Hobart, Tasmania, Australia
[3] School of Agricultural, Environmental and Veterinary Sciences, Charles Sturt University, Wagga Wagga, New South Wales, Australia
[4] Tasmanian Institute of Agriculture, University of Tasmania, Hobart, Tasmania, Australia

vaughan.higgins@utas.edu.au

Shared responsibility is an increasingly prominent approach to managing biosecurity risk in countries such as Australia, Aotearoa/New Zealand and the United Kingdom. However, finding ways to improve its efficacy through better governance arrangements has been under-researched. This paper reports on a recently completed research project in Australia that aimed to investigate the inter- and intra-organisational relationships and interactions that influence efforts to implement a shared responsibility approach to agricultural biosecurity. Drawing from 89 semi-structured interviews conducted with Australian federal, state, and regional biosecurity stakeholders, the paper applies the theoretical lens of 'institutional logics' to tease out how different biosecurity stakeholders approach shared responsibility. Applying this approach to our data, we show that three logics are evident in Australian biosecurity – a risk-shifting logic, a scale and efficiency logic, and a bureaucracy logic. Of these three logics, a bureaucracy logic continues to remain dominant. We argue that this poses challenges for shared responsibility by reinforcing siloed approaches to dealing with biosecurity matters, creating tensions with efforts to build relationships with those who need to be more engaged with biosecurity, and undermining efforts to build trust among diverse biosecurity stakeholders. We outline three broad principles from our project data – leading, learning and leveraging – that may assist those involved in biosecurity governance to engage with other logics and enable the effectiveness of a shared responsibility approach to be improved.

Integrated Landscape Management for sustainable control of invasive non-native plants

Hariet L. Hinz [1], René Eschen [1], Urs Schaffner [1] and Arne Witt [2]

[1] CABI, 2800 Delémont, Switzerland
[2] CABI, Nairobi, Kenya

h.hinz@cabi.org

Invasive species can have impacts across several different dimensions, from ecological to economical to social, and can affect multiple sectors, from agriculture, to pastures and grasslands, to forests and conservation areas. In addition, invasive non-native plants (INNP) may be perceived as negative or positive depending on their density and geographic location, and the stakeholder group in question. Their management should therefore ideally include the different stakeholder groups impacted to resolve potential conflicts of interest. One approach, which has been used for this purpose is Integrated Landscape Management (ILM), which aims to consolidate the land use needs of the different stakeholder groups affected by the INNP. CABI has been active in INNP management, especially their biological control since over 60 years on a global level, and in ILM since 2016, namely with its projects on the invasive tree *Prosopis juliflora* in Eastern Africa (Woody Weeds and WW Plus). *Prosopis juliflora* has invaded several million hectares of grassland, cropland, wetland and settlements in Eastern Africa, including the drylands of the Afar region in Ethiopia, where it consumes more than 50% of the annual rainfall in the invaded area, with serious negative consequences. On the other hand, Prosopis is also being used as firewood, fodder or to produce charcoal and is thereby contributing to the livelihood of some stakeholders. However, its overall impact has been shown to be negative above a certain density. CABI has worked with local and county level implementation groups to co-develop sustainable land management practices for *Prosopis* and to integrate *Prosopis* management into existing county level land use plans. The aim is to stop the further spread of *Prosopis* and to remove it from high-value areas, such as dry-season grazing areas or cropland to help supporting livelihoods and reduce conflicts over land use, while also offering biodiversity and climate benefits. We are currently exploring options to scale up the approach to different geographic areas and/or to other INNPs. Our vision is to build and preserve resilient landscapes that sustain livelihoods, withstand shocks such as climate change and at the same time regenerate and protect the environment and its biodiversity.

Development of the Comet Assay for diagnosis of irradiated insects and fruit in the phytosanitary treatments used to prevent establishment of exotic invasive species

Ela Hiszczynska-Sawicka [1, 4], Solomon Balagawi [2] and Karen F. Armstrong [3, 4]

[1] AgResearch Ltd., Private Bag 4749, Christchurch, New Zealand
[2] NSW Department of Primary Industries, Central Coast Primary Industries Centre, Locked Bag 26, Gosford, NSW, 2250, Australia
[3] Bio-Protection Research Centre, Lincoln University, Canterbury, New Zealand
[4] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

ela.sawicka@agresearch.co.nz

Phytosanitary irradiation treatment makes insect pests reproductively sterile and prevents their spread into non-endemic regions. Irradiation damages an insect's DNA and makes it incapable of performing normal biological functions. However, as a phytosanitary treatment, irradiation may not result in complete mortality, but live, non-viable insects may be found during the biosecurity inspection process. Under the current export inspection and phytosanitary certification protocol for ionisation irradiation (ISPM 18), verification of the irradiated status of a live insect is undertaken through audit checks including laboratory analysis. For internal feeders such as fruit flies, this involves rearing the immature insect to adult, taking at least 2-3 weeks, before its sterility or reproductive status is confirmed while the commodity is detained. The current irradiated commodity market access pathway lacks a technology or tool that can quickly (within hours) confirm that an appropriate level of irradiation treatment has been applied. We adopted the Comet Assay technique to detect post-irradiation changes in the DNA of insects as a marker of irradiation treatment. The comet assay is a universal, easy-to-implement tool that can overcome the species limitations of alternative immunochemical methods designed for detecting irradiation. Persistent single-strand DNA breaks caused by the irradiation dose are used as post-irradiation stage markers and are easily observed as comet-like 'tails' using standard electrophoresis and microscope equipment. Here we subjected different insects to irradiation at various doses and assessed the level of DNA damage using the comet assay. Further, we tested comet assay under export fruit conditions using 2nd/3rd instar Queensland fruit fly (Qfly) infested mangoes irradiated with the minimal dose of 150 Gy that is typically used commercially. Our results have proved that for insects irradiated with doses of 150 Gy and higher (250, 400 Gy), the damage on DNA level is still persistent, even after 7 days post-irradiation, and can be detected by comet assay. Based on irradiation of Clover Root Weevil, we also showed that comet detection is dose-dependent, with the persistence of comets increasing with increased dose. Results on the irradiation of Qfly also showed that post-irradiation changes in DNA were still confidently detected 10 days after irradiation, well within the time of export shipping. Irradiation-induced comets were also detectable at the pupal stage of Qfly. These results suggest that comet assay could be a useful tool to detect the level of DNA breaks in irradiated insect pests to minimise biosecurity risks and facilitate market access continuity.

The tunnel trap: Aerodynamic design principles for improved brown marmorated stink bug trapping

Rachael Horner [1, 7], Gerardo Roselli [2, 3, 4], Raffaele Sasso [5], Massimo Cristofaro [3], Shuying Chen [6] and Mark Jermy [6]

[1] The New Zealand Institute for Plant & Food Research Limited, Private Bag 4704, Christchurch Mail Centre, Christchurch 8140, New Zealand
[2] Fondazione Edmund Mach, I-38010 San Michele all'Adige (TN), Italy
[3] Biotechnology and Biological Control Agency, 00123 Rome, Italy
[4] Center of Agriculture, Food and Environment (C3A), University of Trento, I-38010 San Michele all'Adige (TN), Italy
[5] ENEA C.R. Casaccia, Laboratory SSPT-BIOAG-SOQUAS, Rome, Italy.
[6] Department of Mechanical Engineering, University of Canterbury, 10 Kyle Street, Riccarton, Christchurch 8140, New Zealand
[7] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

rachael.horner@plantandfood.co.nz

The Brown Marmorated Stink Bug (BMSB) *Halyomorpha halys* is an invasive insect species that poses significant economic and environmental threats to New Zealand, Australia, and other countries. To prevent its establishment, and to evaluate the efficacy of the control methods to manage its invasiveness, effective tools for detection and delimitation of BMSB are essential during an incursion. Pheromone trapping is an important surveillance and eradication tool, and a wind-orienting live-catch, pheromone-baited cylinder trap with solid walls has been developed, the tunnel trap. Computational fluid dynamics modelling has shown that the tunnel trap produces a higher-integrity and higher-concentration pheromone plume with a high air speed when compared with the sticky panel trap. The tunnel trap design has been refined to make it robust in wind, rain, and sun; easily transportable and stored; smaller and more discrete; and cost-effective to manufacture. In field trials conducted in Italy between 2020 and 2022, several tunnel trap prototypes have consistently caught significantly more adult stink bugs than sticky panel and pyramid traps, making them an effective tool for surveillance, and delimitation in the case of an incursion.

Comparative biochemical and transcriptome analyses in tomato and eggplant reveal their differential responses to *Tuta absoluta* infestation determines the host fitness of pests

Youming Hou [1], Limin Chen [1, 2, 3], Xiaowei Li [2] and Yaobin Lu [2]

[1] State Key Laboratory of Ecological Pest Control for Fujian and Taiwan Crops, Key Lab of Biopesticide and Chemical Biology, Ministerial and Provincial Joint Innovation Centre for Safety Production of Cross-Strait Crops, College of Plant Protection, Fujian Agricultural and Forestry University, Fuzhou 350002, P. R. China
[2] State Key Laboratory for managing Biotic and Chemical Threats to Quality and Safety of Agro-products, Key Laboratory of Biotechnology in Plant Protection, Ministry of Agriculture and Rural Affairs, Institute of Plant Protection and Microbiology, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China
[3] Lishui Academy of Agricultural and Forestry Sciences, Lishui, Zhejiang 323000, China
Funding: This work was supported by the Joint Funds of the National Natural Science Foundation of China (No. U22A20489)

ymhou@fafu.edu.cn

South American tomato pinworm, *Tuta absoluta*, is one of the most destructive insect pests in Solanaceae crops, particularly tomato. Tomato is more prone to *T. absoluta* invasion and damages than other host plants, but the mechanism behind this preference has not been elucidated. Here, two contrasting host preference plants, tomato and eggplant, were used to investigate biochemical and transcriptomic modifications induced by *T. absoluta* infestation. And we performed widely targeted comparative metabolome and volatilome profiling using the UPLC-MS/MS and HS-SPME/GC-MS, respectively on eggplant and tomato under control and *T. absoluta* infestation conditions. Overall, 141 VOCs and 797 primary/secondary metabolites were identified, largely dominated by aldehyde, alcohols, alkanes, amine, aromatics, heterocyclic compound, ketone, olefin, phenol and terpenes. Eggplant emitted a number of compounds that were lower or completely absent in tomato either under control condition or after *T. absoluta* infestation. The results from electroantennogram and Y-tub showed that 35 differentially accumulated volatile organic compounds could elicit female *T. absoluta* response, implying that these volatiles significantly affect the behavior of this pest. Biochemical analysis at 0–72 h post *T. absoluta* infestation revealed significantly reduced concentrations of amino acid, fructose, sucrose, jasmonic acid, salicylic acid, and total phenols in tomato compared to eggplant, mainly at 48 h post *T. absoluta* infestation. Transcriptome analysis showed higher transcript changes in infested eggplant than tomato. Signaling genes had significant contributions to mediate plant immunity against *T. absoluta*, specifically genes associated with salicylic acid in eggplant. Genes from PR1b1, NPR1, NPR3, MAPKs, and ANP1 families play important roles to mitigate *T. absoluta* infestation. This study through comparison of biochemical and transcriptomic data revealed why the suitability of tomato as a host to *T. absoluta* invasion is much higher than eggplant. Further, important signaling genes critical to modulate *T. absoluta* damage in tomato were identified and will the targets of future studies. Briefly, this study provides a unique perspective about *T. absoluta* infestation in tomato. It will allow us to implement efficient biological control programs against *T. absoluta* in cultivated tomato.

Establishing a health baseline of the culturally significant bivalve pipi (*Paphies australis*) from Aotearoa New Zealand to improve disease investigations.

Joanne Howells [1, 2], Lisa Maria [3], Taryn Shirkey [4], Ari Carrington [4], Phil Ross [2] and Henry Lane [5]

[1] Animal Health Laboratory, Biosecurity New Zealand, Ministry for Primary Industries, PO Box 40742, Upper Hutt 5140, New Zealand
[2] Environmental Research Institute, University of Waikato, Tauranga 3110, New Zealand
[3] Aquatic and Environmental Health, Ministry for Primary Industries, PO Box 40742, Upper Hutt 5140, New Zealand
[4] Patuharakeke Te Iwi Trust Board, PO Box 557, Whangārei
[5] National Institute for Water and Atmosphere, Wellington, New Zealand

Joanne.Howells@mpi.govt.nz

Disease is a major threat to the economic, ecological and cultural services provided by wild bivalve populations. Over the past decade there have been anecdotal reports on declining health of native bivalve populations around New Zealand, which is supported by increasing observations and reports of mass die-offs. Causes of declining health and mass die offs of wild bivalves are not clear and could be due to a number of interactive and cumulative factors, including declining water quality, climate change, or disease. Pipi/kōkota (*Paphies australis*) within the Whangārei region (northern New Zealand) have suffered repeated die-offs and declining health since at least 2009. Exotic disease was ruled out by Biosecurity New Zealand during disease investigations, although several bacteria (e.g., *Vibrio* spp., *Endozoicomonas* spp., *Pseudomonas* spp.) were identified. Baseline health data for wild native shellfish populations are absent, making it difficult to contextualise pathogens observed during die-offs in terms of their importance to host health. This research aimed to examine and document the health of pipi in the Whangārei region with the objective of identifying factors that have contributed to declining heath. We sampled pipi from four sites within Whangārei region, eight times across two years (total *n*= 640), to establish a health baseline using histopathology, bacteriology, and qPCR. Three pipi die-offs occurred during the sampling window that were opportunistically sampled to compare moribund pipi with healthy pipi. Differences in bacterial growth, community, and pathology were observed between pipi collected during normal health and die-offs. Establishing a health baseline for pipi from the Whangārei region provided a benchmark to assess any anomalies in pipi population experiencing mortality events compared with healthy populations, identify factors contributing to die-offs and to help inform management decisions in affected populations.

Exploring the behavioral mechanism for successful cryptic invasion of the black cocoa ant, *Dolichoderus thoracicus* (Smith, 1860), in Taiwan

Feng-Chuan Hsu [1], Ming-Chung Chiu [2], Lan-Wei Yeh [3], Wei-Jiun Lin [1], Ching-Chen Lee [4], Shu-Ping Tseng [2], Chin-Cheng Scotty Yang [5], Chung-Chi Lin [4] and Chuan-Kai Ho [1]

[1] Institute of Ecology and Evolutionary Biology, National Taiwan University, Taipei 10617, Taiwan
[2] Department of Entomology, National Taiwan University, Taipei 10617, Taiwan
[3] Department of Life Science and Center for Ecology and Environment, Tunghai University, Taichung 40704, Taiwan
[4] Department of Biology, National Changhua University of Education, Changhua 50007, Taiwan
[5] Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA

hsufengchuan@gmail.com

Cryptic invasions, the introduction of non-native lineages, can threaten biodiversity through hybridization and introgression. Understanding the underlying mechanisms for successful cryptic invasions will benefit ecosystem management and conservation. Ants are among the most widespread and notorious invasive insects, but studies on cryptic invasions of ants are limited. To explore if exotic ant populations exhibit different behaviors that link to their colonization success (e.g., forming supercolonies and small colonies in exotic and native populations, respectively), we examined the black cocoa ant, *Dolichoderus thoracicus*, mainly in Taiwan. Specifically, we 1) conducted mitochondrial phylogenetic analysis with samples across the species range to confirm whether a cryptic invasion has occurred in this species in Taiwan, 2) examined intraspecific aggressive behavior among individuals collected from 35 field sites in Taiwan in order to reveal a behavior difference between native and exotic populations, and 3) analyzed the cuticular hydrocarbons (CHCs) of subsamples from the behavioral assay, since CHCs may explain ant colony identification. The phylogenetic analysis revealed that *D*. *thoracicus* populations in central Taiwan were composed of two major clades: native Clade I (N = 7, three haplotypes) and exotic Clade II (N = 28, one haplotype). The behavioral assays showed that Clade I *D*. *thoracicus* were divided into two small groups, but Clade II *D*. *thoracicus* formed a large group as a supercolony covering an area of approximately 128,000 ha. Furthermore, the concentration and diversity of CHCs on workers in the exotic populations (supercolony) were lower than those of the native populations, consistent with the less aggressive behavior and larger population size (supercolony) among exotic populations. In other words, the CHCs results help explain the behavioral mechanism for the successful cryptic invasion in *D*. *thoracicus*. Overall, this study demonstrates that exotic *D*. *thoracicus* populations in invaded habitats can form a supercolony through behavior plasticity, which may not only explain the mechanism for their successful invasion but also provide insights into future management strategies.

Rapid and accurate diagnostics of invasive species using CRISPR/Cas12a technology

Xiaoping Hu and Qiang Wang

Taicheng Road#3, NWAFU South Campus, Northwest A&F University, China

xphu@163.com

With increasing international and national trade, invasive species could be spread across countries and adversely affect local agriculture, forestry and even human health. The estimated loss by invasive species accounts for ~5% of the global economy. From morphology, it is difficult to identify some agricultural and clinical pests rapidly. Development of accurate and sensitive detection techniques will be required for inhibiting the harmful pests for long-distance transmission. The recent CRISPR/Cas12a technology contained two components, an endonuclease (Cas12a) and a 41~44nt single crispr RNA (crRNA), and has been considered a new generation of rapid and accurate nucleotide acid detection methods. CRISPR/Cas12a(Cpf1) with crRNA cleaves specific double-stranded DNA and a random reporter probe, generating fluorescent or immunoreactive signals for detection. Combined with CRISPR/Cas12a and recombinant polymerase amplification (RPA) technologies, we established rapid, accurate and sensitive detection tools for specific detection of several important pathogenic fungi including *Magnaporthe oryzae* pathotype *Triticum* (MoT), *Verticillium dahliae* and *Leptosphaeria lindquistii*. The RPA-CRISPR/Cas12a detection system had a lower detection limit of ~10 copies of genomic DNA per reaction, and was able to successfully detect target species from complex samples. The detections have a strong specificity and could be completed within 1 h under 37ºC without complicated lab equipment, which is suitable for use in customs and field. In summary, the field-deployable CRISPR/Cas12a-based detection system will allow for more accurate, specific, and sensitive detection of invasive species, and contributed to early warning of destructively invasive species.

One Biosecurity: Building better responses to biological invasions in the wake of a global pandemic

Philip Hulme

Centre for One Biosecurity Research, Analysis and Synthesis, Lincoln University, PO Box 85084 Christchurch, Canterbury, New Zealand

philip.hulme@lincoln.ac.nz

In the wake of the SARS-CoV-2 pandemic, the world has woken up to the importance of biosecurity and the need to manage international borders. Invasive weeds, animals and pathogens cause multiple impacts to animal, plant, and environmental health with important societal implications. These biosecurity threats often have impacts across sectors: as hosts of zoonotic parasites, vectors of pathogens, pests of agriculture or forestry, as well as threats to biodiversity and ecosystem function. Yet strong sectorial identities exist within biosecurity, associated with specific international standards, individual economic interests, specific research communities and unique stakeholder involvement. One Biosecurity aims to address this at global, national and local scales. It is an interdisciplinary approach to policy and research that builds on cross-sector connections to effectively prevent and mitigate the impacts of biosecurity risks that transcend the traditional boundaries of health, agriculture and the environment. One Biosecurity will require the bringing together of taxonomists, population biologists, modellers, economists, chemists, engineers, and social scientists to engage in a new agenda that is shaped by politics, legislation, and public perceptions. The world is facing major sociological, political, and environmental predicaments that require interdisciplinary biosecurity strategies and responses. Greater international movement of people and goods from areas that present high biosecurity risks will heighten the threat of incursions, and these incursions will spread more rapidly due to increased intensification of agricultural and urban landscapes, while shifts in social licence will constrain management options. These new threats will occur within a context of a rapidly changing climate and a progressive decline in key taxonomic skills. An integrated perspective is essential to address several major sociological and environmental challenges to biosecurity: climate change, increasing urbanisation, agricultural intensification and human global mobility, as well as public resistance to pesticides and vaccines. One Biosecurity underpins three initiatives essential to deal with the pandemic risks from biological invasions: new risk assessment tools that look beyond national borders toward biosecurity risks of international concern, a stronger regulatory instrument to address biosecurity threats at a worldwide scale, and the establishment of a multilateral biosecurity convention responsible for biosecurity governance. Together, these initiatives will drive a new science and policy agenda to deliver evidence-based governance of global biosecurity.

Biosecurity and Antarctica – an overview of an international effort to protect a critical environment with global significance

Rachel Innes, Ceisha Poirot

Antarctica New Zealand, 38 Orchard Road, Christchurch 8053, New Zealand

r.innes@antarcticanz.govt.nz

Despite Antarctica's isolation and harsh climatic conditions, the introduction of non-native species is a serious threat to the region. Antarctica is no longer considered too cold or too far away for non-native species to establish, with several species already established on the Antarctic Peninsula and offshore islands. Logistics, including the transport of people and cargo to the continent and out to ever increasing new field locations in support of science, and increasing pressures from tourism in the region, have increased the risk of non-native species establishment, and with it, the associated challenges of managing that risk. Furthermore, changing climatic conditions such as warming ocean temperatures and increasing ice-free areas are opening up new potential habitats increasing the likelihood that non-native species could become established.

The Protocol on Environmental Protection to the Antarctic Treaty (the Protocol) provides for the comprehensive protection of the Antarctic environment and its dependent and associated ecosystems, prohibiting the intentional introduction of non-native species to the Antarctic Treaty area except in accordance with a permit (which can only be issued under prescribed circumstances). Managing non-native species introductions is one of the highest priorities of the Committee for Environmental Protection (CEP) who in 2011 adopted the Non-native species manual.

An overview of biological invasions into Antarctica, the history of management within the Antarctic governance fora, and the role of science in reducing the risks of non-natives species establishment in Antarctica and the Southern Ocean are explored.

The long history of *Oryctes rhinoceros* (CRB) invasion into the Pacific

Trevor Jackson

AgResearch, Lincoln Research Centre, Private Bag 4749, Christchurch 8140, New Zealand

trevor.jackson@agresearch.co.nz

Oryctes rhinoceros (L.) (Coleoptera: Scarabaeidae: Dynastinae) (coconut rhinoceros beetle; CRB) is endemic to South/South East Asia, but was accidentally introduced to the Pacific and spread across the islands through the 20th century. In the absence of natural enemies the beetle flourished and high densities of beetles caused severe damage to coconut palms. Management centred on collection of beetles, destruction of breeding sites, and quarantine measures to try to limit spread the beetle. Biological control was attempted, but it was not until the 1960s that the Oryctes rhinoceros nudivirus (OrNV) was discovered in Malaysia and introduced in a managesd programme (FAO/UNDP) into the Pacific islands infested by CRB. OrNV spread and caused a decline in beetle populations to manageable levels throughout region. The virus was incorporated in CRB management plans and for ~40 years after adoption of this biocontrol strategy, no new outbreaks of CRB were reported from uninfested palm growing islands in the Pacific allowing continuity of palm-based village economies. However, the situation has changed again in the last 20 years with a new wave of CRB invasions, which are the focus of this symposium.

X-ray technology as a biosecurity treatment for New Zealand: current use, prospects & potential

Lisa Jamieson [1], Jack Armstrong [2], Helen Gear [3], Jung Cho [1], Barbara Waddell [1], Samuel Brown [1], Peter Follett [4], Mark Seelye [1] and Allan Woolf [1]

[1] The New Zealand Institute for Plant & Food Research Limited, PO Box 92169, Auckland 1142, New Zealand
[2] Quarantine Scientific Limited, 63 Stanners Road, RD2, Kerikeri 0295, New Zealand
[3] In Gear Global Limited, 53 Coroglen Rise, Pukerua Bay, Wellington 5026, New Zealand
[4] USDA-ARS, 64 Nowelo Street, Hilo, Hawaii 96720, United States of America

Lisa.Jamieson@plantandfood.co.nz

High dose X-ray is an internationally accepted phytosanitary treatment used to reduce the risk of establishments of biosecurity organisms on trade pathways. It is a form of ionizing radiation (or irradiation) produced by electron accelerators, or more recently, high dose X-ray tubes that generate higher doses of X-rays than standard medical X-ray units. Unlike radioactive isotope gamma irradiation, high dose X-ray does not use a radioactive source, and therefore, is a more environmentally acceptable form of biosecurity treatment. Here we review high dose X-ray technologies for biosecurity purposes, including the prospects and opportunities for New Zealand biosecurity system; efficacy against major biosecurity threats; impact on commodities; social license to operate; and the international effort to accelerate the adoption of e-beam/X-ray technologies in Asia and the Pacific.

A systems approach to biosecurity pays off: a case study investigating introduction pathways and interceptions of non-indigenous species at a biosecurity border

Barbara Kachigunda [1], Grey Coupland [1], Devindri Perera [2], Kerrie Mengersen [3], Johann van der Merwe [1] and Simon McKirdy [1]

[1] Harry Butler Institute, Murdoch University, Murdoch, WA 6150, Australia
[2] Faculty of Computing and Technology, University of Kelaniya, Sri Lanka
[3] School of Mathematical Sciences, Queensland University of Technology, 2 George St, Brisbane QLD, 4001, Australia

b.kachigunda@murdoch.edu.au

The Quarantine Management System (QMS) in place on Barrow Island (BWI), a remote island off the western coast of Australia, is a fully integrated biosecurity system across the biosecurity continuum. The QMS aims to minimize the impact on the environment during the development and subsequent operation of the Gorgon Liquified Natural Gas project. The island is a "Class A" nature reserve with high-biodiversity value and is surrounded by extensive reserves of gas and oil. It is imperative to balance the exploitation of natural resources while conserving the biodiversity on the island. The biosecurity continuum involves the implementation of pre-border, border, and post-border activities to minimize the likelihood of pests and diseases arriving and establishing on BWI. Biosecurity focus was predominantly on pre-border activities where quarantine measures were embedded within the procurement, contracting, and logistics processes. A systems approach was implemented to reduce the risk of non-indigenous species (NIS) being present on cargo, vessels, aircraft, and people during preparation for shipment, in storage, during loading, and in transit and to minimize detection at BWI border. In this study, multiple pathways of NIS introduction were investigated during the development of the project. Introduction pathway studies generally describe the diverse routes by which non-indigenous species (NIS) can be introduced but rarely consider multiple introduction pathways occurring simultaneously. Fifteen introduction pathways were categorized in association with importing locality and the type of cargo they transported. The number and types of detection events for each introduction pathway were recorded during biosecurity inspections, cargo clearances, and surveillance conducted between 2009 and 2015. In total, more than 600,000 biosecurity inspections were completed, with 5,328 border detection events recorded constituting less than 1% of the biosecurity inspections. The border inspection events were classified as animals, plant material, soil, and organic matter, with 60% identified as dead or non-viable and 40% as alive. Of those detections, 2,153 were classified as NIS with only 2% live detections and 659 identified species. Cargo vessel and inward-bound passenger numbers peaked during the major construction period and were associated with an increase in the number of live NIS detections. All introduction pathways have complexities, unique structural aspects, and niche areas that supported NIS in surviving the effects of treatment and evading detection during the mandatory compliance inspection. This study highlights that biosecurity incursions can be minimized if a systems approach is adopted in addition to other traditional biosecurity surveillance measures.

Working together to address invasive species on islands

Salit Kark

The Biodiversity Research Group, The University Of Queensland

s.kark@uq.edu.au

Islands hold some of Earth's most precious and unique natural environments, yet islands are also prone to many threats, including biotic invasions. Ambitious projects, including the removal of invasive species from large islands, have achieved significant conservation wins for diverse island landscapes and stakeholder groups. Because different islands often share similar challenges, national legislation and frameworks to support collaborations to address both human and biodiversity needs, joint research, and information sharing across islands become an important opportunity to address the diverse and often complex environmental challenges facing islands and their people. Frameworks that can be applied across multiple islands are required and include knowledge sharing, data sharing, and experience sharing to ensure that pan-State and Territory coordination can disseminate the lessons learned from island projects to island stakeholders across Australia. To address this, we discuss a need for a platform in Australia and the region that provides a multi-disciplinary platform for island solutions and for sharing knowledge on invasive species and other island challenges. This will aim to bring together island managers, communities and researchers working on environmental island solutions, drawing together policy-makers, Indigenous communities, natural and social scientists to lead innovative collaborations and novel partnerships. Such a platform can help create, evaluate, deliver and share innovative solutions for jointly addressing environmental challenges facing people and biodiversity on islands nationally, and share solutions for islands globally in the face of global change. We provide examples from our work in Norfolk Island and other islands across Australia.

Strengthening Biosecurity in Hawaii and the Pacific

Leyla V Kaufman and Chelsea Arnott

Hawaii Invasive Species Council

Pacific Cooperative Studies Unit, University of Hawaii
Department of Land and Natural Resources, Honolulu, Hawaii

leyla.v.kaufman@hawaii.gov

Globalization has increased and intensified the chances for invasive species movement worldwide. Hawaii's role as a hub for travel, commerce, and military transport is a major contributor to its vulnerability to species incursions. In 2017, the State of Hawaii adopted the Hawaii Interagency Biosecurity Plan. This plan is a 10-year path forward to increase biosecurity in the state. The plan is multidisciplinary and lays out multiple actions to address gaps and weaknesses in our current biosecurity system. This presentation will provide a brief overview of the plan and will describe the framework of a Port of Entry Pest Monitoring Program in Hawaii. The Port of Entry/Exit Pest Monitoring Program brings together multiple State agencies, such as the Hawaii Department of Transportation (HDOT), Hawaii Department of Health (HDOH), Hawaii Department of Agriculture (HDOA), Department of Land and Natural Resources (DLNR), and the University of Hawai'i. The program partners with the Invasive Species Committees (ISCs) statewide and the Hawai'i Ant Lab (HAL) to conduct the monitoring activities. The first phase of this program was funded by the HDOT as a 5-year pilot project. The pilot period focused on the following invasive targets: coconut rhinoceros beetle (*Oryctes rhinoceros*), Africanized Honeybees (*Apis mellifera scutellata*), mosquitoes and ants. Target species were selected due to the threat they present, they can be easily missed during inspections, as well as the ability to set up feasible and time efficient monitoring protocols. The program is currently phasing out of the pilot period. State and federal funds have been secured to continue current monitoring activities at airports as well expanding activities to seaports and also expand the list of targets.

Darwin and the exploding trousers: assessing an existential risk after two centuries of biological invasions in New Zealand

John Kean

AgResearch Limited, Hamilton 3240, New Zealand

john.kean@agresearch.co.nz

On 13 June 1863, a letter appeared in The Press, a daily broadsheet newspaper published in Christchurch, New Zealand. The letter was addressed to The Editor and contained a grave warning about an impending crisis: an invasion of a specific new type of organism arising by natural selection, a concept elucidated by Charles Darwin just 4 years earlier. The letter's author, "Cellarius", was later revealed to be a sheep farmer from a high-country station inland from Christchurch. He predicted the nature of these new organisms and that they would come to dominate and subjugate mankind, urging that "war to the death should be instantly proclaimed against them". Unsurprisingly, these words went unheeded at the time, though they did go on to influence philosophers such as Karl Popper (father of the scientific method) and novelists CS Lewis, Aldous Huxley and Agatha Christie. But now we are just starting to appreciate the veracity and magnitude of the coming risk. This talk will revisit and contextualise the invasion predicted by Cellarius within a framework of biosecurity risk assessment. Drawing on two centuries of biological invasions in New Zealand, we will look at how biological HAZARDS can be identified and characterised, starting with Charles Darwin's visit in December 1835 and possibly his worst observation about species fitness. From there we'll consider EXPOSURE to biological threats as we visit the acclimatisation societies of the late 19th century, the failure of the earliest biosecurity legislation, and the importance of some early eradications. Finally we'll consider our VULNERABILITY to impacts of invasive species, including unforeseen outcomes like New Zealand's 1931 epidemic of exploding trousers. The general framing of risk as the intersection of hazards, exposure and vulnerability helps us to understand and manage biological invasions. And it helps explain why the dire warnings of a New Zealand sheep farmer are only now, 160 years later, being debated by technologists, governments, philosophers and scientists as one of the greatest looming existential threats to civilisation.

Rapid ʻŌhiʻa Death: Ongoing research to protect native forests in Hawaiʻi and the Pacific

Lisa Keith, Eva Brill, Blaine Luiz and Lionel Sugiyama

USDA Agricultural Research Service, Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center, Hilo, Hawaiʻi, USA

lisa.keith@usda.gov

ʻŌhiʻa, *Metrosideros polymorpha*, is Hawaiʻi's most common and widespread native tree, ranging from sea level to 2,500 m elevation in both dry and wet forests. It is the most ecologically important native tree, defining ecosystem function and providing critical habitat to many endemic and endangered flora and fauna. Rapid ʻŌhiʻa Death (ROD) is a phenomenon causing widespread mortality of ʻōhiʻa on Hawaiʻi Island and Kauaʻi. A novel molecular assay was developed for diagnostic testing of *Ceratocystis lukuohia* and *C. huliohia* in wood, frass, insects, soil, and water. Since 2014, more than 15,000 samples have been collected and tested, with results used to help characterize the biology of the fungal pathogens, understand the role of insects and their boring dust in disease spread, aid in the development of remote sensing technologies, map the distribution and spread of ROD, screen *Metrosideros* spp. for resistance, and support ROD management efforts. The Hawaiʻi Department of Agriculture relies solely upon the results of the qPCR detection assay for releasing interisland shipments of ʻōhiʻa products and any plants cultivated in soil, which would otherwise be rejected for shipment due to an existing quarantine. ROD poses a serious threat to Hawaiʻi's flagship native tree species. Various aspects of ongoing ROD research to help safeguard Hawaiʻi's irreplaceable forest ecosystems and watersheds will be discussed.

Biosecurity research portal: connecting key questions to research

Les Kneebone and Andrew Robinson

Centre of Excellent for Biosecurity & Risk Analysis, University of Melbourne, Parkville, Australia

les.kneebone@unimelb.edu.au

Centre of Excellence for Biosecurity & Risk Analysis (CEBRA) plans to implement a research portal, or digital library, that captures biosecurity resource from a range of content sources. CEBRA is targeting grey literature – that is, research that bypasses traditional publishing workflows and business models. CEBRA is already working with research repositories sourced from research, government and industry organisations. Grey literature sources are many – we discuss our approach to eliciting content sources and managing content 'pipelines' sustainably. We take the opportunity to encourage interest from potential content providers in the project, with a view to ensuring a rich and robust content flow into the digital library. We also demonstrate innovative designs for accessing and analysing the harvested content. Taxonomy-driven search and browse features address the inherent problems of language ambiguity for biosecurity concepts (names of pests, pathways, commodities, controls, etc.). The same metadata structures can be used to build graphical representations of the key concepts in documents. Graphical and analytical tools can be developed by the project team and external parties to answer key biosecurity questions, elicited during the project. The research portal can be used to not only discover information that addresses key questions, but also to measure and report gaps and overlaps in the biosecurity research endeavour. The portal should be a useful reference for informing research and policy design and priorities. Taxonomies developed as part of the project are also available in standard vocabulary formats for reuse in other biosecurity management and information systems.

Optimal post-border surveillance against invasive pests to protect a valuable nature reserve and island asset

Tom Kompas [1], Long Chu [2], Simon McKirdy [3], Melissa Thomas [3] and Johann Van Der Merwe [4]

[1] Centre of Excellence for Biosecurity Analysis, School of Biosciences and School of Ecosystem and Forest Sciences, University of Melbourne, Melbourne, VIC 3010
[2] Crawford School of Public Policy, Australian National University, Canberra, ACT 2600
[3] Harry Butler Institute, Murdoch University, Murdoch, WA
[4] Chevron Australia, Perth, WA

tom.kompas@unimelb.edu.au

Harmful and often catastrophic damages from the introduction of non-indigenous species (NIS) are widely acknowledged. While preventing the introduction of NIS through border and pre-border measures has been the first line of defence, post-border surveillance has recently attracted considerable attention as it increases the likelihood that small invasive populations will be found and eradicated quickly before they become widespread. We develop a novel and practical optimal surveillance model across space and a number of surveillance techniques for four different invasive pests, determining where and how to best allocate resources to detect and eradicate these pests. Our focus is on Barrow Island, a Class A Nature Reserve in Australia, home to thousands of native plants and animals, many endemic to the island, where limited industrial activity and environmental protection coexist. It is also home to the world's largest non-government quarantine and surveillance system. Our results provide a unique platform that finds the maximum net benefit from post-border surveillance expenditures across species, locations, and surveillance methods, thus protecting a key environmental asset.

The incursion of the Coconut Rhinoceros Beetle (CRB) into the Pacific Region and its management efforts

Mark Ero and Sarlesh Kumar

Pacific Community (SPC), Land Resources Division, Private Mail Bag, Narere Campus, Suva, Fiji

sarleshk@spc.int

The Coconut Rhinoceros Beetle, *Oryctes rhinoceros* Linnaeus is native to the Southeast Asia region but has spread to many other parts of the world including the Pacific. The early incursions of the beetle were brought under control through the introduction of the effective strain of Oryctes NudiVirus (OrNV) from its native range in Malaysia. However, the detection and spread of the virus resistant haplotype (CRB-G) of the beetle in the region has posed greater management challenges. Since first detected from Guam in 2007, the new CRB haplotype has been confirmed from Hawaii, Northern Marianas, Palau, Papua New Guinea, Solomon Islands, New Caledonia, and Vanuatu in the last decade, decimating coconuts in its path of spread. The damage to coconuts has impacted the livelihoods of Pacific Islanders that depend on the crop as source of food, water, and income. The Pacific Awareness and Response to the Coconut Rhinoceros Beetle (PARC) project funded by the New Zealand Ministry of Foreign Affairs and Trade (MFAT) and managed by the Pacific Community (SPC) is providing technical support with the awareness and management efforts in Solomon Islands, Papua New Guinea, and Vanuatu in partnership with local stakeholders, and AgResearch New Zealand. This presentation provides an overview of the activities supported by SPC in the partner countries.

Parasites as lost baggage and unwelcome hitch hikers

Kevin Lafferty

United States Geological Survey, Western Ecological Research Center, Marine Science Institute, UC Santa Barbara, Santa Barbara, CA 93106, United States

lafferty@ucsb.edu

Whether an invader brings parasites is constrained by the diversity and prevalence of parasites in the home range. On average a host has about 16 documented parasite species in its native range. Although invaders may bring some of these parasites with them, parasite establishment depends on suitability for transmission. For instance, the invasion of the tiger mosquito to Pacific islands depends on a suitable mammalian blood supply in the form of rats, or humans. Parasite invasion also depends on the life stage that invades, and the propagule pressure. Marine species that invade as larvae in ballast water seem less likely to bring parasites than those that invade as adults. On average, two introduced parasite species are linked to an introduced species. Indicting that the global invasion count is 3x bigger than if we just count host species. Sometimes we encourage parasites to catch up with their introduced hosts. Indeed, invaders only pick up a few native parasite species on average, and the net lack of parasites in the native range is thought to give an invader an advantage. This has been the underlying basis for modern biological control – namely, find an invader's natural enemies, test them for specificity and efficacy, and introduce them. Done properly, this can provide safe, effective and inexpensive pest control for insect pests, but scientists have been leery about using biological control for other host taxa like sea stars and crabs. The few parasites that accompany invaders can cause negative economic or ecological effects. This is particularly the case when invaders bring parasites they have evolved to tolerate, then share those parasites with native species that lack tolerance, such as the California abalone that were poorly equipped to deal with two exotic parasites brought in by aquaculture. Aquaculture is a common source disease spill over. Although farmed animals suffer directly from disease, farmers can indirectly benefit from reduced market competition when diseases spill over to wild stocks. Abalone farms are permitted to export fatal pathogens into critical habitat for highly susceptible endangered wild abalone species. This has eliminated the abalone fishery, which increases the value of farmed abalone. Invasions will continue, and sometimes their parasites will follow. Sadly, few scientists are trained to diagnose novel infectious diseases and fewer regulations exist to limit disease introductions.

Indigenous perspectives and experiences of biological invasions

Simon Lambert [1], Tame Malcolm [2], Melanie Mark-Shadbolt [1], Marcus-Rongowhitiao Shadbolt [1] and Phoebe Fordyce [1]

[1] Te Tira Whakamātaki, Waimakariri, Aotearoa New Zealand
[2] Department of Conservation, Wellington, Aotearoa New Zealand

simon@ttw.nz

In this session we propose discussing Indigenous perspectives and experiences of biological invasions. Specifically, we assert that Indigenous Peoples around the globe have a long history of dealing with environmental changes and are acutely aware of the impacts of invasive species and diseases on their lands and in their waters. While invasive species can cause dramatic changes to ecosystems, including species mortality and biodiversity disturbance, little is shared about how Indigenous Peoples are and have responded to managing invasive species. This session will examine Indigenous experiences of biological invasions, how Indigenous knowledges have informed the response and management of biological invasions, and the potential impacts of future biological invasions on Indigenous Peoples and their lands and waters. A facilitated session, the Keynote Speaker is an Indigenous practitioner and researcher, and now policymaker, who will share his experience managing pests using Indigenous knowledge and tools. He will also share his view on the policy and regulatory shifts that need to happen to ensure Māori are able to participate in the management of biological invasions. The second and third speakers are Indigenous Peoples who have actively worked to protect their lands from biological invasions. They have built vital Indigenous knowledge that we can now recognize as 'biosecurity'. Indigenous territories include most of the world's biodiversity, but they are increasingly under threat from exploitative resource extraction, rapid climate change, and increased biological invasions. These speakers share lessons from their experiences, and note how traditional Indigenous ways of governance, conservation, and management are adapting to modern challenges. The fourth speaker(s) will share their perspective and experiences as Indigenous youth working in the biosecurity and biodiversity space. Specifically, they will note what they think the future holds for their generation and our environment, what tools and technologies they are interested in and nervous about. Then the speakers will form a panel to answer questions.

New Zealand's largest aquaculture export, green-lipped mussels, and an aquatic parasite *Perkinsus olseni:* An incidental or emerging relationship?

Henry S. Lane [1], Diana Jaramillo [2] and Mukul Sharma [2]

[1] National Institute of Water and Atmospheric Research Ltd, Wellington, New Zealand 6012
[2] Biosecurity New Zealand, Upper Hutt, New Zealand, 5018

henry.lane@niwa.co.nz

The emergence and spread of aquatic diseases in response to changing ocean climate poses a threat to wild and farmed populations, impacting economic, environmental, and sociocultural wellbeing. *Perkinsus olseni* (Perkinsidae) is a parasite of molluscs notifiable to the World Organisation for Animal Health (WOAH, founded as OIE) that was first reported in intertidal clams from Northland in 1999. Since then, the geographic and host range of this parasite in New Zealand has extended. In 2014, *P. olseni* was reported in green-lipped mussels, *Perna canaliculus*, for the first time. Green-lipped mussels have historically been considered disease-free based on thousands of historically negative samples. *P. olseni* has not caused mortality in any life stage of green-lipped mussels, but its report raises questions on its future potential to cause disease in an important native shellfish, especially under a changing ocean climate. Green-lipped mussels were collected from two major growing areas (n=358) and three wild populations (n=236) from northern, central, and southern New Zealand. We aimed to (i) determine the distribution and prevalence of *P. olseni* in green-lipped mussels around New Zealand and (ii) determine the performance of commonly used diagnostic test methods, including real-time PCR, conventional PCR and culture by Ray's fluid thioglycollate medium (RFTM). Prevalence and diagnostic test performance were evaluated using latent class analysis. The prevalence of *P. olseni* was between 1 and 3% for all sites, except for the wild population collected from Nelson Harbour (22%) and Lyttelton Harbour (0%), representing central and southern sites, respectively. We did not detect *P. olseni* in any location it has not been reported before. Real-time PCR showed the highest diagnostic sensitivity and was therefore considered the test best suited for surveillance of *P. olseni* in sub-clinically infected green-lipped mussel populations. From this study, we provide a benchmark against which to measure changes in prevalence of *P. olseni* and the effects of climate change on disease emergence. We also propose future avenues of research to better understand *P. olseni* in New Zealand and its relationship with green-lipped mussels.

Range reshuffling: climate change, invasive conifers, and the future of beech forests in Aotearoa New Zealand

Matthew J. Larcombe [1], Shar Mathias [1], Laura G. van Galen [1, 2] and Scott Jarvie [3]

[1] Department of Botany, University of Otago, New Zealand
[2] Department of Environmental Systems Science, ETH Zürich, Switzerland
[3] Otago Regional Council, Dunedin, New Zealand

matt.larcombe@otago.ac.nz

Climate change is altering the distribution of forest trees. This is a concern because forest trees play a vital functional role in maintaining biodiversity and ecosystem services. Research indicates that some tree species will see major declines in habitat availability while others expand their range as the climate warms. These 'winners' may be both native and/or alien invasive species. Subsequently, a reshuffling of species compositions in forests is a likely outcome of climate change. Aotearoa New Zealand provides an excellent model for examining compositional shifts in native and exotic forest cover with climate change. There has been a ~ 70% reduction in native forest cover since human arrival, which has been largely replaced by low-statured native and exotic vegetation. The most extensive native forest type remaining, beech (Nothofagaceae) forest, is slow to recover naturally and does not spread easily from remnant patches. On the other hand, Aotearoa has one of the world's most intractable invasive tree problems, with wilding conifers covering around 1.8 million ha and continuing to spread at around 90,000 ha/year. Here we used Species Distribution Models (SDM) to examine how the distribution of habitat for the native beech species and the 13 most invasive confers will change and interact by 2070. Our results indicate that habitat for both native and exotic forests in New Zealand will be substantially redistributed under future climates. Potential habitat for the native beech species, and to a lesser extent wilding conifers, is likely to decrease overall in response to climate change, but losses in some areas will be partially offset by gains in other areas. A major finding was that much of the new suitable habitat for native beech species in 2070 is also predicted to be suitable for at least one wilding conifer species. Key conflict zones where native beech will be competing for habitat with multiple wilding conifer species were extensive, especially in the South Island. These conflict zones, combined with the superior dispersal and establishment capacity of conifers, indicate that competition for habitat between native and exotic forests will be a serious conservation challenge in the coming decades. However, for all five native beech species, we also identify areas of suitable habitat that are outside the current and future habitat envelope of the wilding conifers, providing hope that refugial habitats may persist.

Is this “low risk” pathway truly low risk? A risk-based sampling approach

Thao P. Le [1, 2], Thomas K. Waring [1, 2], Andrew Robinson [1] and Christopher M. Baker [1, 2]

[1] The Centre of Excellence for Biosecurity Risk Analysis, The University of Melbourne, Melbourne, Australia
[2] Melbourne Centre for Data Science, The University of Melbourne, Melbourne, Australia

tk.le@unimelb.edu.au

The number of goods imported into Australia has sharply risen in recent years due to online shopping and e-commerce. However, it is impractical to stop and inspect every parcel for potential noncompliance and/or biosecurity risk. One option is to classify goods as either “high risk” or “low risk” and focus inspection efforts on high-risk items. However, “low risk” is not “no risk”, and we would like to ensure that low-risk items are sufficiently low risk. Many approaches seek to estimate the risk to some precision, but the lower the risk, the more samples we need. As we are expecting a low-risk pathway, we do not want to expend a lot of sampling effort and therefore would prefer a method where the lower the risk, the less samples we would need. Here, we approach this problem by using thresholds. Our method focuses on letting us know whether the risk is below certain thresholds, rather than estimating the risk precisely. This method also allows us to detect a significant change in risk. Our approach typically requires less sampling than previous methods, while still providing evidence to regulators to help them efficiently and effectively allocate inspection effort.

Haumana Speak for ʻŌhiʻa Lehua and Manu of the Forest- Engaging Students to Participate in Hawaiʻi's Legislature to Advocate for Native Species Conservation"

Kailee Lefebvre [1], Ambyr Miyake [2] and Lukanicole Zavas [3]

[1] Pacific Studies Cooperative Unit, 3190 Maile Way, Honolulu, HI 96822-2279
[2] 3190 Maile Way, St. John 315, Honolulu, Hawaii, 96822
[3] American Bird Conservancy, 4249 Loudoun Ave., The Plains, VA 20198-2237

kaileehl@hawaii.edu

Participating in the State legislature can be daunting, confusing, and out of reach, especially for the younger generation. This presentation will provide details on a project to engage haumana (students) grades K-12 in two legislative efforts in Hawaiʻi- designating ʻōhiʻa lehua (*Metrosideros polymorpha*) the State endemic tree, and designating a Hawaiian Honeycreeper Celebration Day. Endemic to Hawaiʻi, ʻōhiʻa lehua is the most important and abundant native forest tree in the state. The arrival of a fungal disease called Rapid ʻŌhiʻa Death (ROD) put Hawaiʻi forests at risk. After internal discussions with partners from multiple organizations, realizing the desire for civics engagement in the classroom and the potential for haumana to create meaningful change, the Coordinating Group on Alien Pest Species (CGAPS) worked to engage haumana across the state in a real-life experience advocating for a bill to designate ʻōhiʻa lehua the State endemic tree. The objectives of this project were twofold; to raise awareness about the importance of ʻōhiʻa lehua and ROD, and to engage students in the legislative process. Classroom lessons focused on ʻōhiʻa and civics were conducted in the fall of 2021, and these students engaged 18 legislators and submitted 1,225 pieces of testimony during the 2022 legislative session. SB2059 was unanimously passed by the legislature and signed into law by Governor Ige. Surveys showed that 63% of students said they learned a lot about ʻōhiʻa and ROD, 83% of the students had never participated in State legislature before this project, and 36% said they are likely to participate in the legislative process in the future. 100% of kumu (teachers) said they would participate in a similar project in the future. In response to the success of the pilot program, CGAPS consulted with partners and began a follow-up project for the 2023 legislative session to educate students about native Hawaiian Honeycreepers (descendants of the Asian rose finch) and advocate for a resolution naming a Hawaiian Honeycreepers Celebration Day. Similar to the objectives of the previous project, haumana would learn about the endangered honeycreeper species, the threats they face, and conservation efforts. As of February 2023, the project has engaged 20 schools including more than 2,000 students state-wide and legislators from the Senate and the House of Representatives have committed to introducing a concurrent resolution. This talk will review the project methods, outcomes, and other data, and can serve as a template for future engagement efforts.

Brown marmorated stink bug biosurveillance, management and biological control: Progress made in managing this invasive pest and continued knowledge gaps

Tracy C. Leskey

United States Department of Agriculture, Appalachian Fruit Research Station, 2217 Wiltshire Road, Kearneysville, WV 25430 USA

tracy.leskey@usda.gov

Following the devastating outbreak of the invasive brown marmorated stink bug, *Halyomorpha halys*, in the mid-Atlantic USA in 2010, which led to catastrophic crop damage and threatened the livelihoods of affected growers in the region, an unprecedented national research project comprised of a multidisciplinary, multi-institutional team was launched to tackle this crisis. Over the past 13 years, this team has made continuous progress in understanding the basic biology, ecology and behavior of this pest, and developing effective biosurveillance and monitoring tools, and biorational management tactics. Moreover, progress toward identifying effective landscape-level biological control options including native natural enemies, adventive populations of *Trissolcus japonicus*, and the microsporidia species *Nosema maddoxi* has been made. However, gaps in knowledge still remain. Early season biology and behavior of this insect remains unclear, abiotic and biotic factors affecting relative population densities are not well understood, and methods for generating the largest impact from promising biological control agents are incomplete. While brown marmorated stink bug likely will never be eliminated from the USA, we have made tremendous progress toward sustainable management of this invasive pest, but there is still more to do.

Next-generation and highly targeted pest control: using dsRNA for varroa mite control in beehives

Phil Lester, James Baty, Mariana Bulgarella, Antoine Felden, Rose McGruddy and Zoe Smeele

Victoria University of Wellington

Phil.Lester@vuw.ac.nz

Double-stranded RNA (dsRNA) is a candidate technology with the potential to control invasive species, pests, and diseases, while minimizing non-target effects. This pest management approach involves designing short strands of dsRNA that silence or stop a gene essential to the life history of the pest species. We have been testing the potential of using dsRNA to control parasitic varroa mites in honey bee hives. Varroa are the leading cause of bee colony deaths by their direct parasitism and via spreading viral diseases. Our experiments have ranged in scale from small laboratory bee colonies to large field trials. Laboratory trials have shown the dsRNA targeting the varroa gene calmodulin does not kill the mites, but instead inhibits the parasites' reproduction. Mites exposed to the dsRNA were unable to produce eggs when parasitising the bee pupae. Our field trials showed the dsRNA could significantly reduce mite populations, but this reduction was dependent on initial mite numbers and bee colony size. Trends in viral disease in the bees followed trends in mite population abundance. When the mite populations were reduced, so were infections of the Deformed wing virus in the bees. We have also examined honey from these hives for dsRNA residues and used genomic assessments to predict potential non-target effects. As with any pesticide treatment for varroa, residues were observed in honey. These residues were initially high soon after dsRNA treatment, but by the time of honey harvest, they had dropped substantially. RNA from a range of other sources was also observed in honey samples. Our genomic assessment indicated very few non-target effects are likely from this dsRNA treatment. Further work is ongoing to understand stake-holder acceptance and refine application of this approach. However, our results indicate that this dsRNA treatment has considerable potential as a next-generation and highly-targeted pest control option, for varroa and potentially many other pests.

Temperature adaptation of the South American tomato pinworm, *Tuta absoluta*, a newly invaded pest in China

Xiao-Wei Li [1], Dong Li [1], Wen-Chao Guo [2] and Yao-Bin Lu [1]

[1] State Key Laboratory for Managing Biotic and Chemical Threats to the Quality and Safety of Agro-products, Institute of Plant Protection and Microbiology, Zhejiang Academy of Agricultural Sciences, Hangzhou, China
[2] Institute of Plant Protection, Xinjiang Academy of Agricultural Sciences, Urumqi

lixiaowei1005@163.com

Tuta absoluta is a devastating invasive pest worldwide, causing severe damage to the global tomato industry. It has been recorded recently in the northwestern border areas of China, posing a significant threat to tomato production. To provide the basic information for the prediction of its potential distribution and population dynamics in newly invaded areas, the developmental duration, survival rate and population growth parameters of *T. absoluta* under laboratory conditions were investigated, and the effective accumulative temperature and occurrence generation were determined using models. In addition, the supercooling capacity and low temperature tolerance of this pest were examined under laboratory conditions and its overwintering potential in Xinjiang was estimated. The results showed that within the constant temperatures ranging from 15 to 30ºC , the duration of different developmental stages of *T. absoluta* shortened as the temperature rose. 25ºC was the most suitable temperature for *T. absoluta*. At 35ºC , the survival rate of eggs decreased sharply to 11%, and the larvae could not finish development. The effective accumulative temperatures of egg, larval, pupal, entire immature stages and the whole generation were 104.17, 232.59, 129.87, 434.78 and 526.32 degree-days, respectively. *T. absoluta* could have four to five generations per year in Yining County and Qapqal Xibe Autonomous County, Xinjiang. The supercooling points of pupae and adults were not influenced by gender. The LT50 and LT90 of female and male adults were the lowest when exposed to cold for 2 h. However, when the duration of exposure extended from 4 to 10 h, the LT50 and LT90 of female and male pupae were the lowest. Comparison of the lowest LT50 and LT90 with temperatures in January indicated that *T. absoluta* might not be able to overwinter in most of the northern and central regions of Xinjiang. However, in the southern regions, the extremely low temperature was higher than the LT90, suggesting that *T. absoluta* has a higher overwintering potential in these regions. In conclusion, the range of adaptive temperature for the invasive *T. absoluta* population in Xinjiang is wide, suggesting that it has a high diffusion threat to most parts of China. These results form a basis for predicting the dispersal potential and possible geographic range of this pest in Xinjiang. In addition, our findings provide guidance for the control of this pest by reducing overwintering shelters.

Evaluation of the likelihood of establishing false codling moth (*Thaumatotibia leucotreta*) in Australia via the international cut flower market

Xingyu Li, Robert Emery, Grey Coupland, Yonglin Ren and Simon McKirdy

Harry Butler Institute, Level 4, Building 390 West Wing, Murdoch University, Perth, WA 6150, Australia

20210609@murdoch.edu.au

Kenya and some other African countries are threatened by a serious pest, *Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), the false codling moth. Detection of *T. leucotreta* in products prior to transportation is difficult due to the cryptic nature of the larvae and this is of biosecurity concern for Australia. *T. leucotreta* is a known polyphagous pest of agriculturally important crops and may cause considerable economic loss. To assess the biosecurity threat of *T. leucotreta* to Australia, Maxent was employed to predict likely establishment regions of this pest in Australia. Habitat suitability and risk assessment of *T. leucotreta* in Australia were identified based on areas with suitable climatic conditions and the presence of hosts in a given habitat. Modeling indicated that Australia is vulnerable to invasion and establishment by *T. leucotreta* in some states and territories, particularly near-ocean areas of western and southern Australia. Within these locations, the risk is associated with specific cropping areas. As such, invasion and establishment by *T. leucotreta* may have serious implications for Australia's agricultural and horticultural, including cut flowers industries. This study will be used to inform government and industry of the threat posed by *T. leucotreta* imported via the cut flower industry. Targeted preventative measures and trade policy could be introduced to protect Australia from invasion by this pest. In addition to predictions for Australia, part of this research focus was on creating a prediction map of *T. leucotreta* in Europe (unpublished) and this work has been cited as personal communication by Pest Risk Assessment (PRA) on the FCM of the European Food Safety Authority (EFSA).

From studies to applications: the development of invasion mechanism and key phytosanitary technology on agricultural insect pests in China

Zhihong Li, Yujia Qin, Zihua Zhao, Lijun Liu and Shaokun Guo

Key Laboratory of Surveillance and Management for Plant Quarantine Pests, Ministry of Agriculture and Rural Affairs, College of Plant Protection, China Agricultural University, Beijing, PR China

lizh@cau.edu.cn

Agricultural insect pests are regarded as one of the most important kinds of pest for crops, fruits and vegetables in the world. Storage beetles, tephritids and fire ants spread more widely under the background of globalization and global climate change. According to current regulations in China, some genera and species of storage beetles, tephritids and fire ants are listed as quarantine species, e.g., *Trogoderma*, *Ceratitis*, *Bactrocera*, and *Solenopsis,* which gained more attention to the studies and applications of prevention and control. This review focused on the development of studies and applications on invasion mechanism and key phytosanitary technology of agricultural insect pests in recent years in China. We reviewed the related studies of invasion history and stress adaptation mechanism, establishment probability and potential geographical distribution and economic loss, species detection and identification, phytosanitary treatment, monitoring and invasion tracing of storage beetles, fruit flies and fire ants, such as *Trogoderma granarium*, *Ceratitis capitata*, *Bactrocera dorsalis* and *Solenopsis invicta*. Meanwhile, we analyzed the related applications of key phytosanitary techniques based on above studies including entry/exit plant quarantine and national agriculture plant quarantine in China. The perspectives and suggestions of further studies and applications of invasion biology and phytosanitary measures on economically important plant pests based on global community are illustrated for reference.

Global macroecology of historical insect invasions

Andrew Liebhold [1, 2], Rebecca Turner [3], Cleo Bertelsmeier [4], Eckehard Brockerhoff [5], Helen Nahrung [6], Deepa Pureswaran [7], Alain Roques [8], Hanno Seebens [9], Takehiko Yamanaka [10]

[1] USDA Forest Service Northern Research Station, Morgantown, WV, 26505, USA
[2] Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, 165 00 Praha 6 – Suchdol, Czech Republic
[3] Scion (New Zealand Forest Research Institute), Christchurch 8440, PO Box 29237, New Zealand
[4] University of Lausanne, 1015 Lausanne, Switzerland
[5] Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland
[6] University of the Sunshine Coast, Brisbane, Australia
[7] Canadian Forest Service, Québec, Canada
[8] INRAE, UR 0633, Zoologie Forestière, 45075-Orléans, France
[9] Senckenberg Biodiversity and Climate Research Center, Frankfurt, Germany
[10] Research Center for Agricultural Information Technology, National Agriculture and Food Research Organization, Tsukuba, Japan

aliebhold@gmail.com

Biological invasions are largely an unintended consequence of globalization. With increasing mobility, humans have accidentally transported organisms around the world, breaking the geographical boundaries that separated species ranges that persisted for millions of years of evolution. Among animals, insects are the most numerous group of species, with thousands of insect species having been established outside of their native ranges and many of these species causing immense impacts on agriculture, human health and conservation of native ecosystems. Here, we report on an analysis of historical insect invasions in 11 world regions. We use these data to compare frequencies of invasions among different insect orders and among different insect families. Certain groups, such as the Hemiptera, Formicidae and the Staphylinidae are generally over-represented in non-native insect assemblages, while other taxa are under-represented. These patterns generally reflect characteristics of these insects that cause them to enter important invasion pathways and biological characteristics that facilitate invasions. These results ultimately can be of use when conducting invasive pest risk analysis. We also investigated environmental drivers that explain geographical variation in numbers of species in various insect taxa. Results indicate a strong species-area relationship for both native and non-native insects. However, we found that this appears to be driven by an indirect effect of land area affecting plant diversity and that the strongest drivers of insect species richness are native and non-native plant species richness. The substantial effect of non-native plant richness on non-native insect richness suggests that plant invasions create new ecological niches that promote insect invasions.

Giant African snail genomes provide insights into molluscan whole genome duplication (WGD) and aquatic-terrestrial transition

Conghui Liu, Yuwei Ren, Zaiyuan Li, Lijuan Yin, Xi Qiao, Fan Jiang, Sen Wang, Bo Liu, Hangwei Liu, Fanghao Wan and Wanqiang Qian

No 7, Pengfei Road, Dapeng District, Shenzhen, Guangdong, China

liuconghui@caas.cn

What is known as the giant African snail, is in fact a group of Achatina snails, which together form a worldwide invasive species of agricultural crops. At present, most studies are mainly based on *Achatina fulica*. However, in recent years, *Achatina immaculata*, a more invasive African snail with its larger size and stronger environmental adaptability, appears to be displacing *A. Fulica*. We compared the invasiveness of these two snails, assembled a chromosome-level reference genome for the Giant African snail *A. immaculata*, and compared the genomes of two Giant African snails (*A. immaculata* and *Achatina fulica*) with the other available mollusc genomes. The chromosome-level macrosynteny, colinearity blocks, Ks peak and Hox gene clusters, collectively suggested a WGD event shared by *A. immaculata* and *A. fulica*. The estimated timing of this WGD event (~70 Mya) was close to speciation age of Sigmurethra-Orthurethra (within Stylommatophora) lineage and Cretaceous-Tertiary (K-T) mass extinction, indicating the WGD reported in this article maybe a common event shared by all Sigmurethra-Orthurethra species and may have provided ecological adaptability and genome plasticity to survive the K-T extinction. Based on the macrosynteny, we deduced an ancestor karyotype containing 8 conserved clusters for Gastropoda-Bivalvia lineage. To reveal the mechanism of WGD in shaping the adaptability to terrestrial ecosystem, we investigated gene families related to respiratory, aestivation and immune defense of giant African snails. Several mucus related gene families were expanded in the early age of Stylommatophora lineage, functioning in water retention, immune defense and wound healing. Hemocyanins, PCK and FBP were doubled and retained after WGD, enhancing the capacity of gas exchange and glucose homeostasis in aestivation. After WGD, zinc metalloproteinase genes were highly tandem duplicated to protect the tissue against the ROS damage. This evidence collectively suggests that although the WGD may not be the direct driver for A-T transition, it provides an important legacy for the terrestrial adaptation of the giant African snail.

Species and distribution of exotic fishes invasion in inland waters of Guangxi

Hao Liu [1], Jiayang He [1], Zhiqiang Wu [1, 2], Liangliang Huang [1, 2, 3], Zhongbin Chen [4], Dongjie Wang [5], Yangyan Sun [1], Hao Wen [1] and Qiliang Song [1]

[1] College of Environmental Science and Engineering, Guilin University of Technology, Guilin, Guangxi, China
[2] Innovation Center for Water Pollution Control and Water Safety Guarantee in Karst Areas, Guilin University of Technology, Guilin, China
[3] Guangxi Key Laboratory of Environmental Pollution Control Theory and Technology, Guilin University of Technology, Guilin, China
[4] Department of Applied Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic
[5] College of Marine Sciences, South China Agricultural University, Guangzhou, Guangdong, China

1069057284@qq.com

With its well-developed karst topography and rivers, Guangxi is an important freshwater fishery production base and gene pool of aquatic biological resources in China. Its warm climate and dense river network promote the culture of exotic fish while also facilitating the survival, reproduction and spread of exotic fish after escape. In this study, the species and distribution of exotic fishes in Guangxi's inland waters are analysed by collating and summarising relevant information on these fishes. A total of 18 species of exotic fishes have been recorded in Guangxi's inland waters, belonging to 6 orders, 12 families and 16 genera, with the largest number of Perciformes (6 species), Carps (5 species) and Catfishes (3 species). At the family level, the Lepidopteridae and Cyprinidae have the highest number of species, both with 4; at the genus level, the only genus with more than two species is *Tilapia*. In terms of introduction routes, 18 exotic fish species were introduced for aquaculture, ornamental fish trade and biological control purposes. Of these, the *Pterygoplichhtys pardails* was introduced for the ornamental fish trade; the *Gambusia affinis* was introduced for biological control purposes; and the remaining 16 species were introduced for aquaculture purposes.

Changing gut bacteria diversity using antibiotic suppressed the reproduction of *Bactrocera dorsalis*

Lijun Liu, Linyu Zheng, Ge Shi, Zhenzhen Bai and Zhihong Li

Key Laboratory of Surveillance and Management for Plant Quarantine Pests, Ministry of Agriculture and Rural Affairs, College of Plant Protection, China Agricultural University, Beijing, PR China

ljliu@cau.edu.cn

The oriental fruit fly *Bactrocera dorsalis* (Hendel) is a destructive insect pest of a wide range of fruit crops. Because of the importance of gut bacteria in the development, reproduction and fitness of their host fruit fly, uncovering their function has become a worldwide question. Using antibiotics to remove gut bacteria is a common method to investigate gut bacteria function. In our previous study, the combination of three types of antibiotics (tetracycline, ampicillin and streptomycin) can significantly change the gut bacteria diversity of laboratory-reared *Bactrocera dorsalis*. However, the function of special gut bacteria is still not clear. In this study, we detected the infection of gut bacteria on the reproduction of *B. dorsalis* through feeding back experiment. The result showed that gut bacteria diversity changes caused by antibiotics prolonged the preoviposition period, suppressed the development of ovary and reduced the egg production significantly. RT-qPCR showed that the changes also resulted in different expression of the key genes in the Insulin pathway (*Akt*, *InR*, *IRS*, *FoxO*), JH pathway (*JHAMT*, *JHEH*, *Kr-h1*) and 20E pathway (*EcR*, *USP*, *E75*). Feedback of one strain of bacteria named *Enterobacter cloacae*, which was isolated from the gut of *B. dorsalis,* can eliminate these effects. This study forms a basis for deciphering the molecular mechanisms underlying how gut bacteria regulate reproduction via three important pathways in the oriental fruit fly. It also provides valuable resources for future studies on the correlation between insects and their gut bacteria.

Development of an integrated island biosecurity framework

Yang Liu, Melissa Thomas, Chad Hewitt and Simon McKirdy

Harry Butler Institute, Murdoch University, Perth, WA 6150, Australia

Y.Liu@murdoch.edu.au

Due to geographic isolation, islands are often the last refuge for many threatened and endemic species. Human activities such as tourism, fishery and industrial development, along with climate change, facilitate the introduction of invasive alien species and disease (hereafter, IAS). Over the last decades, there has been an increasing number of biosecurity plans developed, with the aim of protecting the interests of agriculture, production and fisheries converted to the inclusion of environmental and socio-cultural concerns. These plans encompass biosecurity activities (pre-border, border and post-border) to varying degree and types of related strategies employed. They further differ in the targeted ecosystems (terrestrial and marine), taxonomic groups, methods implemented for risk assessments (quantitative and qualitative). Such diversity could ensure that the limited resources are applied cost-effectively and efficiently, while resulting in unintentional gaps in the development of plans. Currently, there exists no objective biosecurity framework to guide the development of island biosecurity plans. The new plans tend to be a sub-set of existing plans developed through neighboring states or foreign aid. The omission of island-specific biosecurity considerations may cause inadvertent introduction of IAS and waste of limited resources. We undertook systematic review and meta-analysis of the island biosecurity management plans cross the globe. Through the contribution of knowledge from and collaboration among global biosecurity experts and managers from government, academia and industry, we identified gaps in island biosecurity knowledge (e.g. area-specific and industry-specific) and isolated key areas for further research and capacity building. A heat map will be further developed to enable us to understand usage patterns of the different biosecurity categories and visualize the research outcomes. By the end of this project, an integrated, objective and systematic island biosecurity framework, which incorporates all island biosecurity elements, will have been developed to facilitate consistency and transparency in creating island-specific plans.

The nectar resource plant buckwheat enhances the potential of the parasitoid *Eretmocerus hayati* in the augmentative biological control of the whitefly *Bemisia tabaci*

Xue-Qian Wang, Yu-Wei Zhong, Shu-Sheng Liu and Yin-Quan Liu

Ministry of Agriculture Key Lab of Molecular Biology of Crop Pathogens and Insects, Institute of Insect Sciences, Zhejiang University, Hangzhou 310058, China

yqliu@zju.edu.cn

Nectar resource plants provide pollen, nectar, shelter and alternative prey for natural enemies and play an important role in agriculture habitat management. The wasp *Eretmocerus hayati* is a predominant parasitoid of the whitefly *Bemisia tabaci* and has been used in augmentative biological control of this insect pest. However, the short lifespan of this parasitoid after release constrains its control efficacy in the field. In this study, we tested the effects of buckwheat, a commonly used nectar resource plant, on the lifespan, egg load and parasitism rate of *E. hayati*. The lifespan of adult wasps extended up to 6.7 times after feeding of buckwheat nectar, and their egg loads increased significantly. Buckwheat enabled *E. hayati* to replenish more mature eggs following egg deposition in parasitization and parasitize more whitefly nymphs. Additionally, in the presence of buckwheat the survival and fecundity of the host whiteflies did not change significantly. In population tests conducted using cages, parasitoids with the provision of buckwheat were able to suppress whitefly populations to a significantly lower level than the control. Our results indicate that buckwheat can be used to enhance the control efficacy of *E. hayati* in the augmentative biological control of the whitefly.

Bacterial community structure in *Spodoptera frugiperda* and the prevalence of the endosymbiont *Wolbachia*

Yuan Liu [1, 2, 3], Li-Na Zhang [1, 2, 3] and You-Ming Hou [1, 2, 3]

[1] State Key Laboratory of Ecological Pest Control for Fujian and Taiwan Crops, Fujian Agriculture and Forestry University, Fuzhou 350002, China
[2] Fujian Province Key Laboratory of Insect Ecology, College of Plant Protection, Fujian Agriculture and Forestry University, Fuzhou 350002, China
[3] Ministerial and Provincial Joint Innovation Centre for Safety Production of Cross-Strait Crops, Fujian Agriculture and Forestry University, Fuzhou 350002, China

lyuan@stu.scau.edu.cn

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) is a polyphagous invasive pest that causes widespread damage particularly to maize and wheat. The bacterial microbiota associated with *S. frugiperda* could play a crucial role in the insects' development and reproduction. However, bacterial endosymbionts in *S. frugiperda* remain poorly studied, particularly *Wolbachia*. Here we investigated the composition, abundance and diversity of microbiomes associated with different adult tissues of *S. frugiperda*. And the infection prevalence frequencies of endosymbionts in five provinces, including Yunnan, Guangxi, Hainan, Guangdong and Fujian were assessed. We identified Proteobacteria, Firmicutes, and Bacteroidetes as the three most dominant bacterial Phyla in different tissues of *S. frugiperda*. The most abundant bacterial taxa were Enterobacter and Enterococcus, which were different in abundance. And for the first time, we described that *S. frugiperda* was infected with *Wolbachia*, which was only present in Yunnan, Guangxi, and Hainan, and *Wolbachia* infection rates were 33.33%, 23.33%, and 12.97% respectively. Phylogenetic analyses revealed that *Wolbachia* from different *S. frugiperda* populations belonged to the *wPip* strain within Supergroup B. Given that *Wolbachia wPip* may induce cytoplasmic incompatibility, our findings lay a foundation for the development of potential biocontrol techniques against *S. frugiperda*. Keywords: *Spodoptera frugiperda*; tissues; bacterial endosymbionts; *Wolbachia*; infection rates. Funding: This research was funded by the National Key R&D Program of China (2022YFC2601400), the National Key Research and Development Programme of China (2017YFC1200605), and the Science and Technology major project of Fujian (2017NZ0003-1-6)

Russell lupin – a beautiful but harmful species; Harnessing the power of the tourism industry in the management of invasive weeds

Brent Lovelock, Stu Hayes, Anna Carr and Matthias Spall

Department of Tourism, University of Otago, PO Box 56 Dunedin, New Zealand

brent.lovelock@otago.ac.nz

Tourism is a vector for the spread of invasive species, but can also be impacted, both positively and negatively, by invasive species. Russell lupin (*Lupinus polyphyllus*) provides an example of an invasive weed that has historically been spread through the actions of tourists, and whose current distribution is strongly linked with the tourism industry. Russell lupin spreads quickly, smothering the braided riverbeds of the central South Island, and providing cover for predators of riverine birds including the threatened Black stilt/kakī (*Himantopus novaezelandiae*). While normally an invasive with such profound impacts would be subject to intense management and control measures, Russell lupin, because of its attractive flowers, is instead celebrated as a beautiful natural feature and as a tourist attraction. Its status as a visitor attraction is further cemented in social media postings that proclaim its beauty. In this paper, we present research that speaks to the ambiguous status of this charismatic invasive weed. We report on a survey of 238 domestic and international tourists visiting the south of New Zealand, with a focus on their knowledge of, and attitudes to Russell lupins and their management. We also present a parallel analysis of how Russell lupin is represented – visually and textually within social media, focusing on the Instagram communications of Regional Tourism Organisations, and the reactions on the part of audiences to such communications. In both the survey data and the Instagram analysis we found overwhelming evidence of Russell lupin being represented by tourism organisations as a desirable landscape feature and seasonal destination attraction that adds aesthetic value to the places where it grows (e.g., Lake Tekapo). Tourists' attitudes to Russell lupin are similarly accepting, and their awareness of Russell lupin as an ecological problem is low, this differing starkly from their awareness of and attitudes toward other invasive weeds such as wilding conifers. Collectively, these findings suggest that there may be challenges in gaining the support of tourists and the tourism industry for the eradication of Russell lupin. There is a need to re-socialise Russell lupins as a serious invasive species; however, this would entail the collaboration of the tourism industry and significant changes to how the species is perceived and portrayed.

Vector ecology and management to combat disease spread in aquaculture

Bailey Lovett, Lauren Fletcher, Shaun Cunningham, Patrick Cahill and Ian Davidson

Cawthron Institute, Nelson, New Zealand

Bailey.Lovett@cawthron.org.nz

Aquatic disease is a significant risk to aquaculture globally, and emerging diseases in a changing climate threaten to repeat and exacerbate previous crises. Movements of vectors – the physical entities that entrain and transport pathogenic agents – greatly facilitate the introduction and spread of aquatic disease in marine farming regions. Preventing or interrupting pathogen transfers associated with movements of vectors such as stock, vessels, vehicles, equipment, and people is therefore key to ensuring the ongoing productivity and profitability of aquaculture operations. We conducted a vector analysis to identify disease risks and management gaps associated with aquaculture vectors, using New Zealand's aquaculture industry as case study. We created an exhaustive list of anthropogenic vector movements in the industry to characterise their size, frequency, and geographic scale. We then reviewed the literature on pathogen entrainment in aquaculture vectors (worldwide) to identify their contribution to previous disease introductions and outbreaks. These combined data allowed us to compare the relative risk of different vector movements for disease transmission, and subsequently conduct a gap analysis for treatments and other management actions that could reduce risk. Our findings highlighted that large movements of live and dead stock and vectors that can entrain dead, remnant, or fragments of stock (i.e., tissues and fluids), such as processing discharge, farm servicing vessels, and grow-out and harvest equipment, occur frequently in New Zealand as part of normal farming operations. For example, industry-wide production of green-lipped mussels (*Perna canaliculus*) is facilitated by more than 10 million metres of rope that are in constant flux among farms throughout the year. Several of these vector movements have previously been implicated in disease spread in aquaculture, both in New Zealand and overseas. For instance, international and domestic movements of infected live oyster stock have been overwhelmingly responsible for the introduction and spread of ostreid herpesvirus type 1 (OsHV-1) in Pacific oysters (*Crassostrea gigas*), while movements of harvest vessels, processing discharge and live and dead salmon have been directly implicated in outbreaks of infectious salmon anaemia (ISA) virus in several countries. Increased vigilance and treatment development for management should therefore target these vectors and their movements. Our findings also demonstrate that vector analyses can provide a rapid means of prioritising domestic vector movements for management, and can inform the development and implementation of cost-effective management actions to ensure operational imperatives—like stock, equipment, and people transfers—can occur without elevated disease risk to cultured species.

Host plant adaptation mechanisms of the South American tomato pinworm, *Tuta absoluta*

Yaobin Lu, Xiaowei Li, Liming Chen and Tingting Chen

State Key Laboratory for Managing Biotic and Chemical Threats to the Quality and Safety of Agro-products, Institute of Plant Protection and Microbiology, Zhejiang Academy of Agricultural Sciences, Hangzhou, China

luybcn@163.com

The South American tomato pinworm, *Tuta absoluta*, is a newly invasive devastating pest in China, posing a significant threat to tomato production. Understanding the interactions between pests and host plants and the underlying mechanisms could help reveal the outbreak dynamics of this pest. In this study, host plant suitability of *T. absoluta* on four solanaceous plants, tomato, potato, eggplant and pepper, was first investigated. Then, the role of host plant volatiles and plant secondary metabolites in the preferences of *T. absoluta* for different host plants was determined. Finally, differential biochemical and molecular responses to *T. absoluta* infestation between the preferred host (tomato) and non-preferred host (eggplant) were analyzed. The results showed that among the four host plants, tomato was the most preferred plant for this pest. The differentially accumulated volatile organic compounds between tomato and eggplant played important roles in oviposition preferences of female adults, with four highly accumulated compounds in tomato being attractive to *T. absoluta* females, while five highly accumulated compounds in eggplant were repellent to *T. absoluta* females. Metabolome analysis showed that flavonoids and alkaloids were the most differentially accumulated second metabolites between tomato and eggplant leaves. Further bioassays showed that alkaloids from eggplant leaves had higher toxicity to *T. absoluta* larvae than alkaloids from tomato leaves, indicating that alkaloids played important roles in the survival differences of *T. absoluta* on different hosts. Biochemical analysis showed that *T. absoluta* infestation revealed significantly reduced concentrations of jasmonic acid, salicylic acid, and total phenols in tomato compared with eggplant. Transcriptome analysis showed that lower numbers of signaling genes that involved in plant immunity pathways were identified in tomato than in eggplant. These differentially expressed signaling genes between the two host plants might be involved in the molecular mechanisms of host preference differences in *T. absoluta*.

Protected agriculture matters: Year-round persistence of *Tuta absoluta* in China where it should not

Xiao-xian Liu [1, 2], Minglu Yang [3], Judit Arnó [4], Darren J. Kriticos [5, 6], Nicolas Desneux [7], Myron P. Zalucki [6] and Zhaozhi Lu [1, 2]

[1] College of Plant Health & Medicine of Qingdao Agricultural University, Qingdao 266100, China.
[2] Shandong Engineering Research Center for Environment-Friendly Agricultural Pest Management, College of Plant Health and Medicine, Qingdao Agricultural University, Qingdao 266109, China;
[3] Agriculture College of Tarim University, Aler 843300, China.
[4] IRTA, Sustainable Plant Protection Program, 08348 Cabrils, Institute of Agrifood Research and Technology, Barcelona, Spain.
[5] Cervantes Agritech Pty Limited, 7 Plummer Street, Weetangera, ACT 2614, Australia.
[6] School of Biological Sciences, The University of Queensland, Brisbane, QLD 4072, Australia.
[7] French National Institute for Agricultural Research (INRA), UMR1355, 400 Route des Chappes, 06903, Sophia-Antipolis, France.

zhaozhi@qau.edu.cn

Tuta absoluta (Lepidoptera: Gelechiidae) originates from the South American tropics but has become a major invasive pest of tomato and other Solanaceae crops worldwide. Agricultural protected facilities (APFs) such as greenhouses and plastic tunnels may provide thermal conditions that allow the survival of *T. absoluta* in temperate zones with cold winters. In this study, a CLIMEX model was used to investigate the dual effects of increasing use of APFs and climate warming on the potential distribution and seasonal dynamics of *T. absoluta* in China. Our model showed that the northern boundary for year-round population persistence in China, ignoring APFs, was approximately 30°N, covering about 21% of China's area suitable under current climate. The modelled suitable area increased to 31% and the northern boundary for year-round population persistence shifted to 40°N in 2080 under global warming. When APF refuges are included, the potential suitable area was 78% under the current climate and 79% under global warming. This suggests that, in the future, the increasing use of APFs will increase the areas at risk of *T. absoluta* invasion significantly more than global warming because APFs effectively protect *T. absoluta* from harsh northern winters. In addition, vegetable production in surrounding open fields will be at risk of invasion during milder seasons when APFs are opened and *T. absoluta* can disperse. Therefore, the micro-climatic of APFs should be considered as part of the invasion process, and Integrated Pest Management should be simultaneously implemented inside and outside APFs for the rational management of *T. absoluta*.

Population genomics of invasive lantana and implications for improved biological control

Patricia Lu-Irving [1], Francisco Encinas-Viso [2], Jason Callander [3], Michael Day [3] and Johannes Le Roux [4]

[1] Research Centre for Ecosystem Resilience, Botanic Gardens of Sydney, Sydney, NSW, Australia
[2] Centre of National Australian Biodiversity Research, CSIRO, Canberra, ACT, Australia
[3] Department of Agriculture and Fisheries, GPO 267, Brisbane, QLD, Australia
[4] School of Natural Sciences, Macquarie University, Sydney, NSW, Australia

patricia.lu-irving@botanicgardens.nsw.gov.au

The *Lantana camara* species complex is one of the world's worst weeds, affecting over 100 countries and causing substantial economic and ecological impacts globally. The management of invasive lantana is hindered by its wide range of morphological variation, which has confounded effective taxonomic characterisation and obscured the origins of the invasive complex. Biological control efforts spanning over a century have yielded mainly limited success, in part due to the diverse nature of the complex, with several agents failing to establish on some or all lantana varieties where they have been introduced. There is a clear need to characterise the variation within invasive lantana and to unravel the genetic and biogeographic patterns which underlie it. Using genome-wide marker sequencing across a geographically extensive sampling effort spanning multiple continents, this study reveals unprecedented insight into the genetic composition and ancestry of invasive lantana. Several divergent sub-lineages are present across Australia, South Africa, Hawai'i and New Zealand, with some sub-lineages being region-specific, and others found across multiple countries. Little to no gene flow occurs among sub-lineages found growing in sympatry, consistent with the notion that multiple species and hybrids make up the invasive complex. It is thus counterproductive to refer to the complex as a single species "*Lantana camara*", with the accurate identification of specific populations expected to facilitate better management. For example, revised taxonomic concepts will improve the efficiency of biological control programs by enabling predictive matching of specific agents to lantana populations identified as susceptible. Comparing the taxonomic diversity of invasive lantana among countries can forecast the potential success of agents that are effective in some countries, to other countries where they have not yet been imported. Finally, our findings can be used to reconstruct the most likely wild progenitors of invasive lantana, and thus pinpoint optimal native-range taxa and localities to explore for new, host-specific biological control agents.

Biosecurity and the Australian citrus industry: working across stakeholders to plant seeds of resilience.

Jessica Lye

Citrus Australia Ltd

Jessica.Lye@citrusaustralia.com.au

The Australian citrus industry faces significant challenges ahead in relation to limiting and stopping the spread of exotic pest and pathogen species to production areas. Notable threats include illegal importation of citrus seed, scions, and popular culinary ingredients of the *Citrus* genus and related genera, unrestricted selling of *Citrus* sp. on major online platforms, such as Ebay, Facebook Marketplace, and Gumtree, and the close proximity of the Asiatic citrus psyllid/huanglongbing disease complex in the Asia-Pacific region.

Detection of *Xanthomonus citri* subsp. *citri*, causal agent of citrus canker, in the Northern Territory during 2018, and the subsequent response and eradication of the pathogen (2018-2021) highlighted the need for citrus growing operations to become better informed about biosecurity, particularly in relation to pathway risks. The response also highlighted areas where the Australian citrus industry requires greater activity in relation to preparedness and surveillance.

To limit our risk, constant vigilance for unusual pests or disease symptoms and achieving a strong nation-wide foundation for citrus health, through the purchase of tested and certified propagation material, is required. However, achieving buy-in from production businesses and the wider community in relation to general surveillance and adoption of propagation best practices can prove challenging.

Nonetheless, with the launch of the national biosecurity program CitrusWatch, efforts to improve coordinated industry-based surveillance for early detection of exotic species have substantially increased in recent years. A volunteer-based surveillance network, termed the 'Early Detector Network (EDN)', is now run throughout Australia across both urban and agricultural landscapes. Contributions to the network from citrus growing operations have required strong leadership and a concerted effort from industry champions to promote involvement. Expansion of surveillance activities to include residents in high-density urban areas surrounding major Ports of Entry has required creative engagement approaches. Improving the health of the national citrus crop through improving awareness and attitudes towards use of clean, disease-free rootstock seed and budwood is our next major challenge.

This presentation will describe evolution of the EDN since 2021 and will share insights into the behaviours and attitudes among stakeholders towards industry driven surveillance and the use of disease-tested propagation material. It will describe strategic engagement tactics incorporated into the recently developed industry biosecurity strategy. Finally, it will discuss the barriers and opportunities that have been encountered while attempting to achieve greater buy-in and participation across diverse stakeholder groups.

An invasive species exacerbates a plant disease through enhancing commensal interaction with local co infested vector insects under climate warming

Chun-Sen Ma [1, 2], Gang Ma [2], Liang Zhu [2], Wei Zhang [2], Qing-Cai Lin [1, 2], Xue-Jing Wang [1, 2] and Xue-Fang Yang [1]

[1] School of Life Science, Hebei University, Baoding 071002, China
[2] Institute of Plant **Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China**

machunsen@caas.cn

Climate warming is expected to increase the frequency and success of invasion events. Invasive insects together with their host plants, local insects (vectors) and pathogens in a crop system are all ectotherms, and thus their life activities and interactions are all sensitive to climate warming. In vineyards, *D. suzukii* and *D. melanogaster* both transmit pathogenic bacteria and cause an important disease: grape sour rot. *D. suzukii* create oviposition sites, i.e., wounds on the healthy fruit epidermis using their zig–zag ovipositor, whereas *D. melanogaster* can lay eggs only in wounded or rotten grapes. Importantly, the two species respond to climate warming differently in demography and thereby disease infection. However, the mechanistic links between climate warming, insect vectors' interactions, and epidemic dynamics remain largely unknown. Here we first tested the basal and plastic heat tolerance (CTmax) of virgin and mated males and females at different adult ages after different acclimation regimes. We found that mated females had higher basal heat tolerance than virgin females, while mated males had lower tolerance than virgin males. Mating could decrease the acclimation capacity during aging. Aged virgin adults had a much higher acclimation capacity than aged-mated adults. Phenotypic plasticity of heat tolerance may be a main strategy used by virgin adults to cope with heat events, which could increase the invasion success of alien species. We then hypothesized and tested if the wound-making behavior of *D. suzukii* is a temperature-dependent process and can be improved under warming. We found that *D. suzukii* promoted population growth of *D. melanogaster,* but not vice versa, showing a commensal interaction. The co-occurrence of the two vector species accelerated pathogen transmission. Warmer temperatures drive *D. suzukii* into making more wounds on grapes, resulting in more oviposition sites for *D. melanogaster*, which increased population density of *D. melanogaster*, and caused a more severe plant disease. Climate warming has implications for agriculture and horticulture through changing the distribution and performances of invasive species that can damage crops and ecosystems. Climate warming can cause invasive species to thrive and spread more quickly. They may move into new areas that were previously too cold for them, leading to new problems for farmers, such as the new pests and more rapid development of pesticide resistance. Growers may need to change their crop management practices. Our studies showed that invasive species can collaborate with native species and exacerbate plant diseases. The impacts from invasive species can be complex and far-reaching. It is important for producers, policymakers, and scientists to work together to identify and manage invasive species.

On the incorporation of insects' mitigation responses to climate change into prediction models

Gang Ma and Chun-Sen Ma

Climate Change Biology Research Group, State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China

magang@caas.cn

Climate change is facilitating biological invasions worldwide. Given insects are the most destructive invasive taxonomic group, accurate predictions of the potential distribution of invasive insects under climate change is essential for biosecurity risk assessment. The shift of insect distribution depends mainly on the interactions between insects and environments, i.e. how environments limit insects and how insects respond to changing environments to reduce the limits. Species distribution models (SDMs) are commonly used in predicting species range shifts. However, most existing studies focus mainly on the processes potentially constraining rather than facilitating insects range shifts. Those studies often omit the key processes by which insects can buffer the impacts of changing climates through 1) microhabitat use, 2) thermoregulation, 3) life history variation, and 4) evolutionary responses, thereby potentially underestimating species range shifts. Neglecting these key ecological processes may lead to underestimations in the range expansions of invasive pests. First, macroscale climate change can modify fine-scale microclimates which individuals of insects experience during their life cycles. However, SDMs often use climate data at coarse resolution, leading to a mismatch between macroclimatic variables at large spatial scales and microclimates experienced by insect at fine scales. Second, insects can use a variety of approaches for thermoregulation, such as regulating diel activity time, habitat architecture and body posture as well as microsite selection or even physiological adjustment, to limit their body temperatures within optimal ranges for normal life activities. However, to what extent the invasive insects could buffer thermal extremes via thermoregulation still remains largely unexplored. Third, insects usually have distinct development stages during life history and show stage-specific basal and plastic thermal tolerances. As such, the selection of stage-specific thermal tolerance as model parameters should be cautious. Moreover, which trait would be more reliable for modeling population persistence also deserves serious consideration. Fourth, many insects have large population sizes, short generation times and high individual variations and thereby may evolve rapidly in response to climate change. Rapid evolution can promote both dispersal tendencies and population growth and may thereby facilities range expansion. In this context, here we proposed a conceptual framework for incorporating these processes into SDMs to improve model predictions. We argue that there is a crucial need to incorporate the fine-scale microclimates experienced by invasive pests and the mitigation responses of insects to climate change into predictions.

Potential geographical distribution of the little fire ant, *Wasmannia auropunctata* (Hymenoptera: Formicidae) in China based on MaxEnt model

Qiang Xu, Yujuan Gu, Panpan Li, Mutao Wu, Shuang Wei, Haijun Liu and Jun Ma

Guangzhou Customs District Technology Center, Guangzhou 510623, China

majmail@163.com

The little fire ant, *Wasmannia auropunctata,* is an important alien invasive pest newly discovered in Mainland China, whose source of introduction and potential distribution remain unclear. This study aims to make accurate predictions of its potential suitable areas and thereby support control of its spread and damage in our country China. The maximum entropy model (MaxEnt) was used to predict and simulate the suitable areas of this species by collecting its current distribution dada worldwide, and the prediction effect was evaluated. The results showed that the potential suitable areas for the little fire ant in China are mainly in southern China. The most suitable areas were predicted in Taiwan island, Hainan island, the south border of Yunnan, southwestern Guangxi, southwestern Fujian, and southern and coastal regions of Guangdong. The prediction results are consistent with the ecological conditions of the species' existing geographical range. Annual precipitation has the greatest influence on the adaptability of the little fire ant, and the theoretical optimal annual precipitation is 2,040 mm. With global warming, there is an apparent northward shift in the distribution of the little fire ant in China.

Development of a LAMP method for the rapid detection of Hessian fly (Diptera: Cecidomyiidae) for quarantine and field application

Qi Ma [1], Yue Guo [1], Xiang-Shun Hu [1], Ping Lu [2], Ai-Mei Dai [5], Hao Zhang [1, 3] and Tong-Xian Liu [1, 3, 4]

[1] State Key Laboratory of Crop Stress Biology for Arid Areas, College of Plant Protection, Northwest A&F University, Yangling 712100, China
[2] Yining Customs Technical Center, Yining 835008, China
[3] Key Laboratory of Integrated Pest Management on Crops in Northwestern Loess Plateau, Ministry of Agriculture and Rural Affairs, China, Northwest A&F University, Yangling 712100, China
[4] Institute of Entomology, Guizhou University, Guiyang 550025, China
[5] Bortala Mongolian Autonomous Prefecture Agricultural Technology Promotion Center, Bole, 833400, China

dearmqi@nwafu.edu.cn

The Hessian fly *Mayetiola destructor* is a devastating pest of wheat, causing huge yield losses worldwide, and is classified as a quarantine pest by several countries. However, morphological identification is difficult during quarantine at points of entry. To enable a rapid quarantine/biosecurity response when incursions occur, a simple, rapid, and reliable molecular identification technique has been developed that enables on-site quarantine to prevent the introduction and spread of *M. destructor*. The loop-mediated isothermal amplification (LAMP) primer set based on the mitochondrial cytochrome oxidase I gene had good specificity and a sensitivity of 1.0×10^{-3} ng μL^{-1} for DNA concentration detection. The amplification was completed in 50 min at a constant temperature (64 ± 1°C), and in combination with the toothpick DNA extraction technique, the field test was conducted in only 52 min to obtain accurate and reliable species identification results. The proposed LAMP visual detection technique improves the speed and accuracy of detecting *M. destructor* during quarantine. The technique requires only a portable thermostatic heating device for precise visual detection, is simple to operate, and can be performed by non-specialists, facilitating field inspection and outbreak monitoring.

Assessing the effect of Amazonian catfish (*Pterygoplicthyes* sp.) on the growth of the Indian major carps: a mesocosm-based study

Suman Mallick [1], Ajmal Hassan [2], Jitendra Kumar Sundaray [3] and Ratna Ghosal [1]

[1] Biological and Life Sciences, School of Arts and Sciences, Ahmedabad University, Ahmedabad, Gujarat
[2] Regional Research Centre of Indian Council of Agricultural Research, ICAR-Central Institute of Freshwater Aquaculture, Rahara, West Bengal
[3] ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, Orissa

suman.m@ahduni.edu.in

The field of invasion biology relies upon systematic analysis of ecological interactions among exotic or invasive species, and biotic and abiotic components of an invaded ecosystem. Research in this area includes an overall assessment of economic impacts of such interactions within an ecosystem. In this study, we used a mesocosm (0.04 ha inland ponds) approach to assess ecological and economic impacts of the Amazonian catfish, a popular pet species that has been recently introduced in the Indian open waters. We tested the effect of exotic catfish on different abiotic (chlorophyll, total suspended and dissolved solids, total nitrate and phosphorous of water, and carbon:nitrogen ratio in soil) and biotic (zooplankton abundance and fish growth in terms of total body length and weight) factors of the mesocosm ponds. In particular, we assessed whether catfish has any effect on the growth of the Indian Major Carps (IMC) that includes Rohu, Catla and Mrigal. IMC contributes to about 58% of aquaculture production in India and has a high economic value of $98.63 billion (as in 2021). We maintained one of the mesocosm ponds as test, having both IMC (N=300) and catfish (Mean±SE, length: 34.21±1.02 cm; weight: 275.4±21.56g; N=80), and another as control having only IMC (N=300). We conducted two such test-control pairs, one for smaller size class (10-20 cm of total body length; weight: Mean± SE, 20.8±1.20g), and another for larger class (20-30 cm of total body length; weight: Mean± SE, 137.05±4.02g) of IMC. For both the size classes, ponds were maintained for 120 days, and were sampled at every 30 days interval (0, 30, 60, 90, 120-day) to measure and compare biotic and abiotic parameters between control and test. Our results demonstrated a significant difference (P&lt0.05) in Rohu weight from 90-days onwards in the test pond when compared to control for only the smaller size class of IMC. No significant differences were obtained between control and test for any of the other factors for both the size classes. Our findings indicate that the impact of exotics on natives can be specific for a species, as sensitive species can be less tolerant, and can be stage-specific, younger individuals (smaller size) are more vulnerable than older ones (larger size). The overarching goal is to customize management programmes to safeguard sensitive, economically important species (native), and towards identifying and protecting vulnerable developmental stage of a species in the face of a biological invasion.

A Māori perspective on new technologies for invasive species control, and their potential application on our whenua (lands)

Melanie Mark-Shadbolt, Simon Lambert, Marcus-Rongowhitiao Shadbolt, Phoebe Fordyce, Micheal Heimlick and Te Taiawatea Moko-Painting

Te Tira Whakamātaki, Waimakariri, Aotearoa New Zealand

mel@ttw.nz

In Aotearoa New Zealand, a significant threat to biodiversity, conservation efforts and Indigenous cultural identity is the unwanted introduction of invasive pests, plants, and pathogens. Recently methods to control invasive species in Aotearoa New Zealand, in particular mammalian pests (i.e. possums (*Trichosurus vulpecula*)), have had decreasing public support, and amongst Māori there is also an increasing distrust for new tools and technologies especially those that are deployed via top-down initiatives or government entities. Understanding the underlying Māori values and views of pest control is vital if we want to develop a responsible process for engagement on new technologies that empowers Māori to positively participate in conversations about, and implementation of, any new technologies for invasive species control we may want to explore. This talk discusses Māori perspectives on new technologies, the values that underpin their decision-making in the pest control space, and processes for having conversations about the application of new technologies in Aotearoa.

Taonga Māori myrtaceae threatened by Myrtle rust (*Austropuccinia psidii*)

Alby Marsh [1, 2], Waitangi Wood [3], Hone Ropata [4], Nick Waipara [5], Rose Kuru [1] and Teegan Maxwell [1]

[1] The New Zealand Institute for Plant & Food Research Limited, Food Industry Science Centre, Palmerston North
[2] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)
[3] WaiCommunications, Kaeo, Te Tairawhiti
[4] Plant & Food Research, Mt Albert Research Centre, Auckland

alby.marsh@plantandfood.co.nz

Tangata whenua/Māori have a long-standing relationship with their natural world, which has shaped who we are and the way we interact and maintain resilience with the biological diversity that has, and still exists, around us. Native myrtlaceae like mānuka (*Leptospermum scoparium*) and kānuka (*Kunzea* spp.) were already revered for their medicinal properties (rongoa), long before they became popular for the honey industry. Others like pōhutukawa and rātā (Metrosideros spp), ramarama (*Lophomyrtus* spp) and maire tawake (*Syzygium maire*) have always been recognised; not only for their beauty but also the important roles they hold in maintaining the integrity of whakapapa (geneology) in both the natural world and to people. More recently, interest groups such as avid gardeners have adopted the trends for bringing natives into their gardens. Many cultivars of our native Myrtaceae have proven very popular as ornamentals such as hedging, feature trees and groundcover. In some cases, the cultivars developed are based on natural mutations in the wild ('one-off' individuals); or small, but self-sustaining populations of very rare variants; or mutations observed during the nursery production of the main plant species. Gardening in some respects may have enhanced the conservation of rare plants, with some genera like the kaka beak (*Clianthus* spp., not a Myrtaceae), for example, effectively being saved by its popularity as a landscape plant. However, the recent myrtle rust incursion has revealed that cultivars such as ramarama are very susceptible to this disease, which may or may not suggest a greater vulnerability in their parent/source species. Images of cultivars from our more popular landscape species, like ramarama and mānuka, and species of greater significance, like rāta and pōhutukawa, are highlighted in this report for a variety of reasons. Examples being: ♣ Ramarama — are very susceptible to the myrtle rust disease ♣ Mānuka — are associated with the very lucrative mānuka honey industry which Māori are heavily involved in ♣ Pōhutukawa — there are many significant examples of this species dotted around the motu (island) with very special relevance to mana whenua (guardians of the land) ♣ Rātā — again there are significant examples of this species with the key difference being the declining numbers. Some of these species are gaining in popularity as ornamentals in small marae gardens, papakāinga (home land) and private Māori-owned residences due to their (generally) smaller stature, and the growing desire to introduce natives of some shape or form into an urban environment.

A sentry for the flock: An intelligence approach to forecasting biosecurity

Madeline Marshall

Ministry for Primary Industries, 14 Sir William Pickering Drive, Burnside 8053, Christchurch, New Zealand

madeline.marshall@mpi.govt.nz

Biosecurity operations often require quick decision making under conditions of significant uncertainty, without recourse to extensive background research and assessment. Consequently, biosecurity can benefit from combining insights from invasion biology with intelligence methodology. The Biosecurity Intelligence Team (BSI) at Aotearoa New Zealand's Ministry for Primary Industries, Manatū Ahu Matua, is pioneering this interdisciplinary fusion. In contrast to risk assessment methodologies focused on identifying unwanted organisms and their biological capability for incursion and establishment, BSI's threat intelligence continuously monitors both biological and social/human changes that could influence opportunities available for organisms to reach Aotearoa New Zealand's borders. Understanding the drivers behind species' abundance, distribution, and invasion pathway dynamics has become a pressing need as global ecosystems become more interconnected and as the economic and ecological cost of invasions becomes more evident. By integrating biology, data science, and intelligence disciplines, BSI aims to quickly identify global changes and trends that could influence Aotearoa New Zealand's biosecurity. Assessments by BSI are conducted with the help of a novel and purpose-built system named Manu Taki (sentry bird) – an indicators and warnings system based on military intelligence methodology. Manu Taki monitors offshore indicators of biosecurity threats by surveying biological, environmental, and social/human events that signal a potential change to the size or character of a threat. Threat assessment takes an integrative approach, viewing the threat as a synthesis of multiple, sometimes individually weak, signals. By cataloguing global events of varied nature and impact, the Manu Taki system facilitates a holistic view of changes that can be tailored to an organism, natural disaster, political change, and so on. This ability to monitor global trends allows BSI to evaluate how particular events influence biosecurity internationally and how similar events could, in turn, impact Aotearoa New Zealand. Fusing the disciplines of invasion biology and intelligence has resulted in a unique method for providing situational awareness and informing biosecurity decision-making that is fit for purpose in an ever-changing global biosecurity threat environment.

Progress towards improving pest management strategies against *Oryctes rhinoceros*, a re-emerging invasive pest in the Pacific

Sean D.G. Marshall

AgResearch, Lincoln Research Centre, Private Bag 4749, Christchurch 8140, New Zealand

sean.marshall@agresearch.co.nz

Coconut rhinoceros beetle (CRB), *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) invaded the Pacific during the first half of the 20th century, causing widespread severe damage to coconut palm. CRB was brought under control by managed release of Oryctes rhinoceros nudivirus (OrNV) between the 1960s to 1980s, which spread among the CRB populations and caused disease, thereby supporting successful management of populations in the Pacific Region. The virus has persisted, weaking CRB populations, and for ~40 years after adoption of this biocontrol strategy, no new outbreaks of CRB were reported from uninfested palm growing islands in the Pacific. This strategy protected essential palm crops and supported village economies. However, the situation has changed again in the last 20 years. CRB invasions into completely new areas have been observed within the Pacific – Guam (2007); New Guinea Island, Papua New Guinea (2009); Hawai'i (2013); Solomon Islands (2015); Northern Mariana Islands (2017); Vanuatu (2019); New Caledonia (2020). Common to all new outbreak areas has been the high incidence of severe palm damage not seen since the introduction of OrNV. The invasions were explained when AgResearch scientists identified the presence of a new CRB haplotype (clade I) in the majority of newly invaded areas. Based on specialist microbial biocontrol expertise and relationships developed by several NZ scientists over many years, the Pacific region requested assistance to develop improved biocontrol strategies that are effective against these newly invasive populations of *O. rhinoceros*. This presentation will discuss progress made to date towards improving management of this pest.

Across land, islands, and sea: the power of metabarcoding for multiple biosecurity industries, targets, and environments.

Francesco Martoni, Alexander M Piper, Reannon L Smith, Conrad Trollip, Brendan C. Rodoni, Paul J Cunningham and Mark J Blacket

Agriculture Victoria, Agribio Centre for AgriBio Science, Bundoora, VIC, Australia

francesco.martoni@agriculture.vic.gov.au

Molecular techniques for diagnostics and surveillance have been used for decades, complementing traditional morphological identifications, and providing precise detection of target organisms, and are now arguably an essential tool for biosecurity. More recently, the advent and rise of new high throughput molecular techniques, including metabarcoding, have been applied to biosecurity. Over the last 5 years, the Agriculture Victoria Research team have been developing, validating, and testing high throughput sequencing (HTS) metabarcoding workflows for biosecurity across a wide range of industries, targets and environments. Projects have included arthropod plant pest diagnostics and agricultural surveillance, marine surveillance in ports of entry, fungal pathogens detection for forestry, and pest and disease surveys in remote areas, such as Norfolk Island. The common thread across these biosecurity projects is the use of HTS metabarcoding to record the potential presence of invasive organisms, as well as to assess and monitor the diversity of native species present. This approach not only records biosecurity targets but can detect unexpected exotic/adventive species, as well as providing information on ecological networks, recording pests as well as parasitoids and predators, with potential for wider adoption of this technique in integrated pest management and biodiversity assessment activities. Metabarcoding records have proven to be at least semi-quantitative, providing key information not only on presence/absence of a species, but also providing an indication of population seasonal fluctuations. The use of metabarcoding as a tool for biosecurity is discussed here, disentangling its components, from sample collection and DNA preservation to laboratory analysis and bioinformatic pipelines. Investigating each step of the workflow contributes to a more complete understanding of results, highlighting advantages and limitations. Ultimately, we discuss areas that now require international cooperation and efforts in order to take full advantage of this metabarcoding approach.

Mycoplasma bovis, past, present, future

Grant Matthews

Ministry for Primary Industries, New Zealand

Grant.Matthews@mpi.govt.nz

Aotearoa New Zealand made the decision in 2018 to eradicate *Mycoplasma bovis*. The pathogen was first detected in the country six years ago (July 2017). The eradication attempt to date has been trail blazing as many countries have decided to live with the disease. Here we provide a programme update, and look at what lies ahead on the pathway to eradication. We review lessons learned and consider how these may be applied to future disease control programmes.

Prospect study for wild fishery or culture of non-native crustaceans

Yvonne Matthews [(1)], Anjali Pande [(2)] and Paula Holland [(1)]

[(1)] NIWA, Gate 10 Silverdale Road, Hamilton, New Zealand
[(2)] Biosecurity New Zealand, Charles Fergusson Building, 34 – 38 Bowen Street, Wellington, New Zealand

yvonne.matthews@niwa.co.nz

The targeted harvest of invasive species for financial gain is actively discouraged by biosecurity managers in many jurisdictions because of the perceived risk that it will incentivise deliberate spread. As doing nothing to manage invasive marine species does not mitigate impacts of natural spread, the benefits and risks of potential management strategies such as harvesting need to be evaluated against alternatives, including the 'do nothing option', to determine the optimal approach. The Asian paddle crab (*Charybdis japonica*) is considered a harmful invasive marine species, that has been present in New Zealand since 2000. It has an aggressive nature and is known to outcompete native crabs and other benthic species for habitat and food. Preliminary modelling indicates the national population of *Charybdis japonica* today to be in the range of 50,000-500,000 crabs, if the crabs observed along the coast represent either 1 or 10 per cent of the actual population. Based on this, modelling suggests that future population levels could rise as high as 0.5-5.3 million by 2036. Swimming crabs are an important seafood resource that support profitable fisheries in many parts of the world. The Asian paddle crab is fished throughout its native range and is known in Southeast Asia for its good taste. This project evaluated options to manage the impacts of *Charybdis japonica* through wild harvest and utilisation of the catch. This project particularly explores opportunities for Māori to benefit from management of the crab. The potential of four different harvest strategies – commercial fishery, subsidised fishery, bounty system or cultural fishery – to manage the Asian paddle crab, were examined to see how these activities fitted into the commercial market (e.g., whether the scale of fish down necessary was likely to be possible for a sector and whether it is feasible. Exploitation of *Charybdis japonica* for consumption purposes looked the most promising exploitation activity, but information was lacking on price and supply trends for the crab market. In 2023 we conducted a survey of crab fishers and consumers to establish the demand for crab product in New Zealand and the potential commercial and cultural benefits that might accrue from harvest. In 2022-23 we will deliver an economic assessment of the potential demand for *Charybdis japonica* for consumption purposes. The learning will be developed with Māori researchers, biosecurity and fishery managers and other interest groups to discuss possible ways forward to utilise and control *Charybdis*.

Invasive weeds can disrupt chemical communication between native plants and insects

Evans Effah, Logan Svendsen, Paul Barret and Andrea Clavijo McCormick

School of Agriculture and Environment, Massey University, Palmerston North, New Zealand

a.c.mccormick@massey.ac.nz

Plants can communicate with members of the same and other species using chemical substances released above- and below-ground. Some of the substances released above-ground are volatile (gaseous) in nature and constitute the plant's scent, which mediates important plant-plant and plant-insect interactions such as kin-recognition, pollination, herbivory and plant defence. We investigated how invasive weeds (predominantly heather, *Calluna vulgaris*) in the Central Plateau of the North Island affect the emission of volatile compounds by a native plant species (manuka, *Leptospermum scoparium*) and its interactions with a native herbivore (the manuka beetle, *Pyronota festiva*). Our findings suggest that invasive weeds affect the production of volatile compounds by native plants, which reduce their volatile emissions, possibly owing to the need to reallocate resources for competition or in response to environmental change brought by invaders. We also found that the manuka beetle is unable to locate its host plant based on smell only, when the scent of an invasive plant is presented simultaneously in a Y-tube olfactometer; and will need additional sensory input to successfully locate its host plant. This is likely to cause the native insect to land on and probe the invasive plant with yet unknown consequences. This work highlights the impact of invasive plant species on native infochemical networks and their potential to disrupt vital ecological interactions.

A new model system for investigating the key predictors of invasion success

Ang McGaughran

Te Aka Mātuatua/School of Science, University of Waikato, Hamilton, New Zealand

amcgaugh@waikato.ac.nz

Despite decades of research, a fundamental question in invasion biology is how invasive species successfully colonise new habitats despite being exposed to novel environmental and ecological challenges. We often do not know why some invasions fail, because we can rarely obtain data from all stages of the invasive sequence (i.e., introduction, establishment, spread), or from an organism's complete range of potential responses. In the Invasomics Lab (University of Waikato, New Zealand), we have established a system of differentially invasive blowflies (insects that generally spread easily and adapt rapidly to new habitats): a New Zealand endemic species (*Calliphora quadrimaculata*), two mildly invasive Australasian species (*C. stygia, C. hilli*), and three highly invasive cosmopolitan species (*C. vicina, Lucilia cuprina, L. sericata*). These species invaded New Zealand at different times and differ in their ecological niches (e.g. cooler vs warmer, urban vs rural environments), thus yielding a unique opportunity to test key predictors of invasion success along an invasiveness continuum. In this talk, I will discuss our preliminary findings, which indicate that the different species – all carrion feeders easily collected via their attraction to baited traps – show variation in thermal and desiccation tolerance, as well as differences in their population genetic structure and diversity across New Zealand. I will also discuss our recent research into the generally poor availability of genomic resources for invasive pest species, and the associated implications on our ability to advance mechanistic understanding of the drivers of invasion success.

Natural Enemies – Natural Solutions for Invasive Weeds in the Pacific

Chris McGrannachan [1], Lynley Hayes [2], Quentin Paynter [1] and Temo Talie [1]

[1] Manaaki Whenua – Landcare Research, Auckland, New Zealand
[2] Manaaki Whenua – Landcare Research, Lincoln, New Zealand

mcgrannachanc@landcareresearch.co.nz

Pacific Island Countries and Territories (PICTs) are seriously impacted by invasive species but lack the resources required to effectively manage them. This creates challenges for food security, health, and well-being in the Pacific, and for preventing further loss of native biodiversity and essential ecosystem services. As unwanted species continue to invade, these challenges are predicted to worsen over the coming decades. Established unwanted species will become more abundant over time, and climate change is expected to exacerbate their harmful impacts. In response to this pressing need the Pacific Regional Invasive Species Management Support Service (PRISMSS) was established by the Secretariat of the Pacific Regional Environment Programme (SPREP) in 2019. PRISMSS aims to provide required support to PICTS to strengthen *in situ* invasive species management. Manaaki Whenua – Landcare Research (MWLR) was invited by SPREP to join PRISMSS and lead a Natural Enemies – Natural Solutions programme for invasive weeds. In this presentation we will share highlights from a recently completed, highly successful, 5-year programme in the Cook Islands, and progress from an on-going 7-year project to tackle pasture weeds in Vanuatu. We will also outline work conducted under the Managing Invasive Species for Climate Change Adaptation in the Pacific (MISCCAP) programme, in which MWLR is working closely with SPREP and New Zealand's Department of Conservation, and related GEF-6 projects. Finally, we will reflect on key lessons learnt and future opportunities to support our Pacific neighbours.

Garden sentinels: New Zealand's contribution to future proofing UK plant species from insect pests and diseases

Mark McNeill[1,5], David AJ Teulon[2,5], Wolfgang Bopp[3], Karen Armstrong[4,5]

[1] AgResearch Ltd., Private Bag 4749, Christchurch 8140, New Zealand
[2] The New Zealand Institute for Plant & Food Research Ltd, Private Bag 4704, Christchurch, 8140, New Zealand
[3] Christchurch Botanic Gardens, Rolleston Avenue, PO Box 73036, Christchurch, 8154
[4] Department of Pest-management and Conservation**, PO Box 85084, Lincoln University, Lincoln 7647, Christchurch, New Zealand
[5] Better Border Biosecurity (B3), New Zealand [www.b3nz.org.nz/]

mark.mcneill@agresearch.co.nz

The use of sentinel (expatriate) plants, is an initiative for plant biosecurity risk assessment and surveillance, that is being adopted internationally. The concept is based on the presence of plant species in foreign locations (e.g. botanic gardens, arboreta) where they may be exposed to insect pests and pathogens they have not as yet encountered, and act as an early warning system for their native range.

The Christchurch Botanic Gardens has been a participant in a three year pilot study to test the suitability of the sentinel plants concept to detect new host-plant associations on selected plant species considered important to the UK. This involves the International Plant Sentinel Network (IPSN), Botanic Gardens Conservation International (BGCI) and Department of Environment, Food and Rural Affairs (DEFRA, UK), with remote diagnostics provided by FERA Science Ltd. The surveys at the Christchurch Botanic Gardens was supported by Better Border Biosecurity (B3) parties with appropriate links to New Zealand's National Plant Protection Organisation (NPPO), the Ministry for Primary Industries (MPI), to ensure that legal responsibilities concerning new organisms were followed.

The plants selected for surveillance were *Rosa* spp. (rose), *Fagus sylvatica* (European beech), *Quercus robur* (English oak) and *Pinus sylvestris* (Scots pine). In early (December) and late (January) summer, 2-3 plants of each taxa were inspected and assessed for insect presence, damage and plant pathogens, using protocols developed by IPSN. The survey evaluated the plants health from observations of the leaves, buds/cones and stem/trunk, along with the general environment the plants were growing in. Results were recorded either on a paper or electronic plant health checker (PHC) form, and images taken of the plant and any pests or diseases. The reports and images were then scanned and sent electronically to the UK for remote diagnostics.

This presentation will discuss the outcomes of the pilot study in Christchurch, the benefits and challenges of undertaking remote surveys involving staff from Botanic Gardens and Arboreta, and the contribution of using sentinel plants to improving biosecurity outcomes.

An abstract for a presentation at the pre-Congress workshop on the Value of Botanic Gardens to Biosecurity

25 years of invasive alien species management in the islands of French Polynesia (South Pacific): successes... and failures

Jean-Yves Hiro Meyer

Délégation à la Recherche, Government of French Polynesia, B.P. 20981, 98713 Papeete, Tahiti, French Polynesia

jean-yves.meyer@recherche.gov.pf

We present a brief assessment of some invasive alien species (IAS) control programs implemented for the conservation of threatened species and native habitats in the islands of French Polynesia (South Pacific) since the first Law on Nature Protection, including IAS management, adopted by the local government in 1995. Among the dominant IAS, the small tree *Miconia calvescens* has been partially controlled following the introduction of a biocontrol fungal pathogen in Tahiti in 2000, and by on-going manual and chemical control operations in other invaded islands of the Society (Raiatea) and the Marquesas (Nuku Hiva and Fatu Iva). No other island was newly invaded for the past 20 years. In contrast, the Little Fire Ant *Wasmannia auropunctata* has spread to five other islands of the Society and one in the Austral (Rurutu) after its first discovery in Tahiti in 2004, in spite of a rigorous prevention program and several attempts to control or eradicate it. Rats (*Rattus* spp.) and bulbuls (*Pycnonotus cafer*) eradication projects are conducted in several high volcanic islands and atolls but with mixed results. Incursions of newly recorded plants and animal species (especially invertebrates and reptiles) but also pathogens have occurred in the past decade despite strict biosecurity measures. Predatory snails and feral cats are still unchecked and continue to have drastic impacts on endemic molluscs and birds respectively, while feral pigs, sheep and goats continue to destroy native forests. Public information, prevention, surveillance, control operations, and regulation texts are necessary but appear insufficient to stop the continuous and often silent invasions. We suggest that better explanation of IAS dynamics (e.g., pathways of introduction) and their ecological, economical and socio-cultural impacts (including long-term and indirect effects) should also be delivered to the local communities and authorities in French Polynesia and in the Pacific Islands as it is successfully done with climate change issues.

Delimitation and response to a novel marine pest incursion on Aotea/Great Barrier Island, New Zealand

Irene Middleton [(1)], Kelly Carter [(1)], Roberta D'Archino [(1)], Oliver Evans [(1)], Abraham Growcott [(2)], Sarah Hailes [(1)], Richard Hughes [(1)], Drew Lohrer [(1)], Daniel Kluza [(2)] and Crispin Middleton [(1)]

[(1)] National Institute of Water and Atmospheric Research, NIWA- Taihoro nukurangi, 41 Market Place, Auckland CBD, Auckland 1010, New Zealand.
[(2)] Biosecurity New Zealand – Tiakitanga Pūtaiao Aotearoa, Ministry for Primary Industries – Manatū Ahu Matua, 25 The Terrace, PO Box 2526, Wellington 6140, New Zealand

irene.middleton@niwa.co.nz

A novel incursion by a non-indigenous alga in the genus *Caulerpa* was notified to Biosecurity NZ (BNZ) from Aotea/Great Barrier Island (Aotea/GBI) in July 2021. It was subsequently identified as two, morphologically similar species: *Caulerpa brachypus* and *C. parvifolia* (hereafter referred to collectively as 'exotic Caulerpa'). Although *C. brachypus* has not previously been reported outside its native range, *C. parvifolia* and several other species in the genus *Caulerpa* have extra-limital distributions and well-documented impacts on the abundance and diversity of native organisms. Surveillance activities identified that the alga was well established in the initial incursion site at Okupu/Blind Bay and localised populations of exotic Caulerpa were found in both Rangitawhiri/Tryphena Harbour (~0.01 m^2) and Whangaparapara Harbours (~10 m^2) in September 2021. Given the limited extent of the populations and the potential risk to the local ecosystems and fisheries from the spread of these species, BNZ initiated Organism Management Activities to eliminate the localised populations of exotic Caulerpa from Rangitawhiri/Tryphena Harbour and Whangaparapara Harbour. Based on existing research regarding the management of *Caulerpa* sp. overseas, advice from tangata whenua and evaluation of the long-term impacts of treatment, the use of coarse salt and benthic lining materials were proposed to eliminate exotic Caulerpa from the two locations at Aotea/GBI. The methods were highly effective at removing exotic Caulerpa from the treated areas; however, complete elimination in the two harbours was not achievable because of the rapid expansion of the infested areas. Here, I will outline the treatment methods, logistical challenges, and efficacy of the treatment, including limitations in its use and impacts of the treatment on non-target species.

Integrating biosecurity into the tourist experience: Prospects and issues

Kevin Moore [1], Mark McNeill [2, 3] and Lloyd Carpenter [4]

[1] Department of Tourism, Sport & Society, PO Box 85084, Lincoln University, Lincoln 7647, Christchurch, New Zealand
[2] AgResearch, Lincoln Research Centre, Christchurch 8140, New Zealand
[3] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)
[4] Te Whatu Ora Health New Zealand

Kevin.Moore@lincoln.ac.nz

Human-mediated dispersal of exotic species is a major contributor to biological invasion and biodiversity loss worldwide. International tourism as a subset of the global anthropogenic movement is recognised as a pathway for the–sometimes rapid–movement of invasive alien species. Biosecurity failures can have a significant impact on the tourism industry itself, for example, in curtailment of activities once in the country, reducing the value of a country's image to prospective tourists, and a potential reduction in the number of visitors. International tourism dominates human movement into Aotearoa New Zealand, and prior to the pandemic, there were c. 3.9M visitor arrivals in 2019, with numbers forecast to return to these levels post 2024 once air routes and flight capacity are re-established. While information and inspection at the ports of arrival are designed to mitigate biosecurity risk, the relationship between biosecurity measures and the tourism experience has often been assumed to be antagonistic. In Aotearoa New Zealand, for example, border biosecurity measures have been said to be "costly and time-consuming" and "unpopular with visitors". Despite these assumptions, there is also evidence that in certain special-interest forms of tourism–such as nature tourism to the Galapagos Islands–biosecurity-oriented tourism can enhance the tourist experience and even attract a premium. In this presentation, we consider the prospects for a broader integration of biosecurity measures, protocols, and awareness into the generic tourist experience, in ways that might increase the value of the experience to the tourist. Specifically, we consider opportunities that include the cultural, social, and value dimensions of the tourist experience. Examples of such types of opportunity include indigenous practices and rituals of encounter suggestive of guest obligations to respect the local society and environment; the use of practice theory to guide incorporation of socially enacted 'bundles' of tourist practices that are supportive of sustainability and relevant to biosecurity; and the possibility of leveraging tourist values of authenticity and sincerity to create 'buy-in' to biosecurity measures and awareness. Finally, we critique these potential ways of integrating biosecurity into the tourist experience and draw conclusions about their likelihood of being successful and the challenges of implementing such possible integrative approaches in tourism.

Employing horizon scanning to prioritize invasive alien pests with the potential to threaten agriculture, biodiversity, and forestry in Africa

Joseph Mulema [1], Lucinda Charles [2], Roger Day [1], Steve Edgington [3], Fernadis Makale [1], MaryLucy Oronje [1], Ivan Rwomushana [1] and Marc Kenis [4]

[1] CABI, Canary Bird, 673 Limuru Road, Muthaiga, PO Box 633-00621, Nairobi, Kenya
[2] CABI, Nosworthy Way, Wallingford, Oxfordshire, OX10 8DE, United Kingdom
[3] CABI, Bakeham Lane, Egham, Surrey, TW20 9TY, United Kingdom
[4] CABI, Rue des Grillons 1, CH-2800 Delemont, Switzerland

j.mulema@cabi.org

Invasive alien species have become one of the biggest challenges to agricultural production, especially in Sub-Saharan Africa (SSA). The region has recorded a multitude only in the last decade and many are envisaged to arrive ashore unless gaps in biosecurity systems such porosity of borders are addressed. Prevention is the most cost-effective option for managing IAS. This is achieved through constricting pathways by reducing and limiting the means of entry, intercepting movements at border points, and assessing risk of planned imports. However, this is only possible if there is adequate information on the highest risk species. This information also helps in developing early preparedness strategies so that likely invasions are detected early, contained and eventually eradicated if possible. Horizon scanning provides an opportunity to generate such information. It is the systematic search for potential biological invasions and an assessment of their potential socio-economic impacts and potential impacts on biodiversity, considering possible opportunities for mitigating the impacts. CABI has developed a horizon scanning tool that utilises information from the Crop Protection Compendium to select pests that have been reported in other countries but not the countries at risk. The tool has been used to generate pest lists for assessment in Burundi, Ghana, Kenya, and Zambia. Actions such as detection surveillances, regulation, deregulation, pest-initiated Pest Risk Analysis have been suggested for the prioritised lists.

The application of adaptive resource management to reptile eradications: A case study for achieving functional eradication of brown tree snakes

Melia Nafus[1], Amanda Reyes [2, 3], Thomas Fies [2], MJ Mazurek [4] and Scott M. Goetz [1]

[1] U.S. Geological Survey, Pacific Island Ecosystems Research Center, Hawaii National Park, HI 96718, USA
[2] Research Corporation of the University of Guam, UOG Dean Circle, House 24, Mangilao, GU, 96923, USA
[3] University of North Carolina – Greensboro, 1400 Spring Garden St, Greensboro, NC 27412, USA
[4] U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, HI 96850

mnafus@usgs.gov

Adaptive resource management is a specialized form of structured decision making that integrates a formal decision process in deciding and defining management actions, while identifying unknowns. The decision process iteratively evaluates previously identified metrics and executed actions against the selected goal allowing for the evolution of a management strategy, focused on achieving an originally identified goal. We applied this approach to first identify if a novel control tool could eradicate brown tree snakes in a barrier and then to determine which available tools would complement the original tool and whether eradication was necessary to achieve a conservation goal of avian recovery. Here, we will present our findings focusing on three elements including, 1) the three phases of the adaptive management program, 2) the response of the snake population to each and cumulatively, 3) the functional response of prey including lizards, rodents and birds, and 4) the tentative outcomes of a trial reintroduction.

Biological invasions in Australia's forests across space, time and the biosecurity continuum

Helen Nahrung [(1)] and Angus Carnegie [(2)]

[(1)] Forest Research Institute, University of the Sunshine Coast, Queensland 4568, Australia
[(2)] Forest Science, New South Wales Department of Primary Industries, Parramatta, NSW 2150, Australia

hnahrung@usc.edu.au

In a first for any Australian plant-based industry, we characterised the arrival, establishment, spread and impact of non-native insects and pathogens established in Australia's native, amenity and plantation forests. Our aim was to better-understand the ecological processes underpinning biological invasions and to link these historical arrivals with border interception frequencies, biological traits, commodities, and countries of origin, as well as to biosecurity mitigation measures. We also assessed recent forest-related insect and pathogen post-border detections and biosecurity responses, to identify factors that will lead to increased pest detection and to provide information for prioritising future eradication attempts. Finally, we compared exotic insect species that are considered threats to Australia's forests, with already-established non-native species in terms of their biological and phylogenetic traits, border interceptions, origins and geographic distributions, to identify similarities between groups and to assist with predicting future invasion events. In this way, we have (1) produced a comprehensive database of non-native pests in Australia's forests; (2) identified patterns that facilitated invasions; (3) provided data to support a national forest surveillance program; (4) created a workflow that can be applied to other plant-based industries to improve biosecurity outcomes.

What makes a good risk-based decision in biosecurity?

Melanie Newfield [1], Susanna Finlay-Smits [2], Christine Reed [3] and John M. Kean [4]

[1] Independent, Wellington, New Zealand
[2] Manaaki Whenua Landcare Research, Lincoln, Canterbury, New Zealand
[3] Pukaha National Wildlife Centre, Mt Bruce, Tararua, New Zealand
[4] AgResearch, Ruakura, Hamilton, New Zealand

melanienewfield@outlook.com

An important first step in improving decision-making is to understand what constitutes a good decision, from a range of different perspectives. We interviewed 33 participants in Aotearoa New Zealand's biosecurity system, including those in central government, local government, primary industry, infrastructure and non-governmental organisations, to understand how they judge decisions. In particular, the semi-structured interviews asked decision makers and stakeholders what characterises a "good" biosecurity decision from their perspectives. We then used thematic analysis to identify emergent themes across participant responses. Biosecurity decision makers emphasised the prevention of harm as the primary goal of biosecurity management, and recognised that harm could be both caused by a new organism and by biosecurity activities. Although interview questions asked separately about biosecurity decisions, decision-making processes and decision makers, responses frequently conflated these, suggesting they are closely entwined. Themes included a clear purpose, well-informed (including but not exclusively by science) involvement of stakeholders, transparency, timeliness and achievability. Participants indicated that decision makers should show "big picture", analytical and open-minded thinking. There was a strong feeling that the quality of biosecurity decisions can be determined by their outcomes. These themes are considered within the context of decisions about lepidopteran pests over the last 30 years, including painted apple moth (*Orgyia anartoides*), Hokkaido gypsy moth (*Lymantria umbrosa*) and great white butterfly (*Pieris brassicae*). The results of this research will help us to develop a new framework for biosecurity risk analysis in Aotearoa New Zealand that is inclusive of a wide suite of values (environmental, economic, socio-cultural and te ao Māori) and that facilitates "good" biosecurity decisions from the perspectives of both decision makers and affected stakeholders.

Valuing the biosecurity system – measuring the costs of invasives

Michael Ormsby

Biosecurity New Zealand, New Zealand Ministry for Primary Industries, New Zealand

michael.ormsby@mpi.govt.nz

Biosecurity New Zealand has appointed a Chief Biosecurity Officer to oversee the whole of the biosecurity system with a focus on providing assurance that the system functions well, both now and into the future. A range of initiatives have been identified to document strengths and gaps in the biosecurity system. One of these initiatives is to deliver a value model to determine the value of New Zealand's biosecurity system components and interventions over time and under variable conditions. In this regard, Biosecurity New Zealand seeks reliable, robust, and repeatable methods to value both individual components and the biosecurity system. Recognising these in terms of the impact they make in safeguarding New Zealand's natural, cultural, and economic assets. Communicating tangible value to Ministers, the indigenous people and the public will help secure appropriate investment for the maintenance and improvement of the biosecurity system. New Zealand critically relies on this system for the protection of our primary industry, social/cultural values, native biodiversity, and economic growth. This presentation will describe the many challenges faced by the model developers in accurately parametrising and analysing the pathways for pest and disease invasion, and the economic, social/cultural and environment impacts any successful invasion would incur on New Zealand.

Inside the BMSB gut – biosecurity measures and pest management potential

Chandan Pal [1], Jieyun Wu [2], Juncong Yan [3], Dongmei Li [3] and Sherly George [3]

[1] Zespri International Limited, 400 Maunganui Road, Mount Maunganui, New Zealand
[2] School of Biological Sciences, University of Auckland, New Zealand
[3] Plant Health and Environment Laboratory, Biosecurity New Zealand, Ministry for Primary Industries, PO Box 2095, Auckland 1140, New Zealand

chandan.pal@zespri.com

The brown marmorated stink bug (BMSB, *Halyomorpha halys*, Hemiptera: Pentatomidae) is one of the most unwanted agricultural insect pests worldwide. They are native to East Asia but have invaded countries in North and South America, Europe and Central Asia. They have a broad host range of over 300 plant species, including important agricultural commodities, and are considered a nuisance pest for households. Here, we characterised the gut reservoir of 10 BMSB adult samples shipped to New Zealand from five countries (Georgia, Italy, Hungary, Japan, Turkey) in a 'dead state', and one live BMSB adult from an incursion event in New Zealand with an unknown origin, to reveal the taxonomic blueprint of the gut including the gut microbiome, potential pathogens, plant contents, and carbohydrate digesting enzymes (CAZymes) using a shotgun metagenomics approach. We detected a high microbial diversity, including bacterial symbionts. The geographical origin of the BMSB had no major effect on their gut microbial diversity. Well-characterized plant pathogens, such as *Erwinia amylovora*, were also detected, indicating the possibility of the pathogens being transmitted from one plant host to another via BMSB as a vector. Deep sequencing also uncovered spore-forming microsporidian parasites, including *Nosema maddoxi* and other Nosema species in most adults, therefore this could be explored further as a potential biological control agent of BMSB. Furthermore, we identified regional plant species that BMSB might have fed on using the traces of plant DNA in the gut, indicating that besides inferring their diet preference and host range, BMSB gut flora can be used for tracing their potential geographical origin by recovering regional plant DNA materials from their guts. Taken together, this study reveals the hidden potential of the BMSB gut microbiota and gut contents as emerging indicators for biosecurity measures and pest management.

The complexity of biosecurity in aquaculture in New Zealand

Anjali Pande [1], Edric Pascual [1], Daniel Kluza [1] and Eugene Georgiades [1, 2]

[1] Ministry for Primary Industries, PO Box 2526, Wellington 6140, New Zealand
[2] Environmental Protection Authority, Private Bag 63002, Wellington 6140, New Zealand

anjali.pande@mpi.govt.nz

Aquaculture is a growing industry in New Zealand, with a government strategy to increase the sector's annual revenue to $3 Billion NZD by 2035. With such rapid expansion, the industry needs good biosecurity to protect and enable this amount of growth. Aquaculture in New Zealand consists of many different sectors, land based, marine and freshwater as well as research facilities and grow out facilities for release for sport fishing. In each sector the risk profile is different depending on how the facility is linked to the environment and to other facilities. Therefore, different management practices are required to achieve best practice biosecurity for each sector and in fact each facility. Government is working closely with industry partners, as well as representatives of other sectors and iwi to understand operational practices currently in play, how well and how widely biosecurity is understood and where the gaps are. Starting with the basic building block of farm-level practices and working towards more cohesive, collaborative area-based management, the aim is to work together to build and develop a pathway forward to be able to achieve industry-wide practical, consistent and effective biosecurity.

Asserting status to marine species in oceanic islands: native vs non-native

Manuela I. Parente [(1)], Andrea Z. Botelho [(1)], Behr Andre [(2)], Micael Joana [(3)] and Ana C. Costa [(1)]

[(1)] CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Pólo dos Açores, Faculdade de Ciências e Tecnologia da Universidade dos Açores, 9501-801 Ponta Delgada, Portugal
[(2)] NIDS, Faculdade de Ciências e Tecnologia da Universidade dos Açores, 9501-801 Ponta Delgada, Portugal
[(3)] Southwest Iceland Nature Research Centre, Garðvegur 1, 245, Suðurnesjabær, Iceland

manuela.ip.cardoso@uac.pt

Ambiguity in using species' ecological status as alien, cryptogenic, and native species can muddle communication and lead to endless debates, undermining management efforts. This problem is particularly significant in studies of non-indigenous species, often ambiguously called exotic, introduced, invasive and naturalised. It is frequently difficult to establish a species as native. The challenge arises for marine species as the study and knowledge of marine biodiversity are some centuries younger. Nevertheless, unequivocally asserting marine species status is not less important. Still, it can be challenging in geographic settings such as oceanic islands, where biodiversity studies can be even more scarce and inconsistent across taxa. Physical connectivity and distance between marine regions are determinants of marine species distribution. To assert species status requires knowledge of oceanographic processes and the species' biological, ecological, and evolutionary aspects. These features have been included in a reasoning framework flow to enable unequivocal access to the biographical status and overcome fuzzy discussions regarding the native, non-indigenous, cryptogenic or invasive species. An algorithm was developed to construct a digital interactive decision tree. This methodological approach was tested for macroalgal species in islands. Still, we consider it applicable to other organisms and adjusted to non-insular territories, especially those where marine biodiversity gap knowledge poses extra difficulties in deciding whether a species is native.

Bovine tuberculosis, an old problem that has relevance to emerging animal disease

Natalie Parlane

The Hopkirk Research Institute, AgResearch, Palmerston North, New Zealand

Natalie.Parlane@agresearch.co.nz

Bovine tuberculosis (bTB) might be viewed as one of the first biosecurity incursions when it was introduced to New Zealand with early cattle shipments. Subsequently, it has infected a range of animals including farmed deer, wild pigs, ferrets and possums. Now, the possum serves as a common reservoir for cattle and deer infections. In New Zealand, OSPRI manage the national TBfree programme to control and eradicate bTB because its presence affects overseas markets for NZ-grown meat and results in some production losses. There is no single test to diagnose bTB infection, so a combination of tests is used for diagnosis; regular skin test of cattle, blood test to measure the specific immune responses to the bacterium responsible for bTB, *Mycobacterium bovis* (not to be confused with the similar sounding *Mycoplasma bovis*) followed by culture of suspect lesions detected at post-mortem. Molecular methods such as PCR are now used for some initial diagnoses along with whole genome sequencing (WGS) to investigate bTB outbreaks in herds, utilising a database from over 25 years of research. We continue to research and trial new methodologies for WGS. Diagnosis can be confounded by environmental mycobacteria and by animals infected with Johne's disease. Interestingly, seals can also be infected with tuberculosis caused by a similar bacterium, *Mycobacterium pinnipedii*. BTB caused by *M. bovis* is a zoonotic disease, so we are able to work safely with grossly infected tissue and provide both diagnostic and research in the Hopkirk Research Institute PC3 facility at AgResearch in Palmerston North.

Genomic signals of local adaptation across the invasive ranges of the Queensland fruit fly, *Bactrocera tryoni*

Eli Parvizi [1], Amy Vaughan [2], Manpreet Dhami [2] and Ang McGaughran [1]

[1] Te Aka Mātuatua/School of Science, University of Waikato, Hamilton, New Zealand
[2] Biocontrol & Molecular Ecology, Manaaki Whenua Landcare Research, 54 Gerald Street, Lincoln, 7608, New Zealand

ellie.parvizi@waikato.ac.nz

The success of biological invasions can be influenced by two key evolutionary processes: local adaptation and gene flow. Here, we investigate how gene flow with native range can impact local adaptation responses in the invasive ranges of the Queensland fruit fly, *Bactrocera tryoni*. Native to the wet sub-tropical coasts of eastern Queensland and north-eastern New South Wales, *B. tryoni* has recently expanded its range towards temperate (south-eastern New South Wales) and arid (central Northern Territory) regions of Australia, as well as several tropical/subtropical Pacific Islands following the expansion of horticulture. This wide climatic and geographic range suggests high levels of climatic adaptability in this species. Using high-throughput sequencing of 28 populations from native and invasive ranges, we found changes in the allele frequency of single nucleotide polymorphisms that are associated with genes important to the fly's ability to survive in new environments (e.g., heat and desiccation tolerance). These allele frequency changes were observed in geographically disjunct and genetically isolated invasive populations in central Northern Territory and the Pacific Islands. However, the invasive populations in southeast Australian temperate zones had substantial gene flow with the native populations and did not exhibit a remarkable genomic signal of local adaptation. These results suggest that the level of connectivity between invasive populations and their native counterparts has played a variable role in shaping the local adaptation patterns of different invasive populations. Our findings provide valuable insights into how this important horticultural pest has successfully invaded different environments with varying climate conditions.

Ultra violet lights and molecular diagnostics for wide area surveillance of recent invasive species establishments

Stephen Pawson [1], Simon Bulman [2], Andrew Cridge [3], Manpreet Dhami [4], Andrew Dophiede [4], Preeti Panda [2], Carl Wardhaugh [3], Shaun Wilkinson [5] and Graeme Woodward [6]

[1] School of Forestry, University of Canterbury, New Zealand
[2] The New Zealand Institute for Plant & Food Research Limited, Lincoln, Canterbury, New Zealand
[3] Scion, Rotorua, New Zealand
[4] Manaaki Whenua Research, Lincoln, New Zealand
[5] WIlderlab NZ Ltd, Miramar, Wellington, New Zealand
[6] Wireless Research Centre, University of Canterbury, New Zealand

steve.pawson@canterbury.ac.nz

Most biosecurity surveillance programmes use traps baited with lures to attract a single species, e.g., pheromones, or group of related species, e.g., protein baits for ants. Such programmes have been instigated in response to risk assessments that identify these groups/species as high priority threats to our primary sectors or natural environment. However, we know it is not possible to establish specific surveillance programmes to detect potential establishments from the huge diversity of species that are detected by border inspections. Attraction to ultra violet (UV) light is a highly conserved feature amongst insects, thus it makes a suitable species agnostic lure for the detection of a wide range of species. UV lights attract large numbers of individuals, which presents diagnostic challenges to sort new incursions from species already present in New Zealand. Metabarcoding is one approach for overcoming this diagnostic impediment. We present an operational workflow for using UV light traps to detect new incursions at points of first arrival and transitional facilities. The trap is a UV-LED baited flight intercept trap designed to attract flying insects. It is solar powered and internet connected via Lorawan to allow remote monitoring (battery voltage, light status) and the scheduling of periods when the light is on or off. We describe our approach to create a bespoke barcode reference library that combines species known to be present in New Zealand, with sequences of unwanted pests, and native species commonly associated with the environments surveyed. We discuss the benefits of our particular approach to extractions and the use of multiple primers to provide greater confidence in the identification of species incursions. Finally, we discuss the limitations of currently available DNA reference libraries and potential pathways for addressing this.

Early detection and eradication of invasive ants via New Zealand's national invasive ant surveillance programme (NIAS)

Lora Peacock [1], Disna Gunawardana [2], Paul Craddock [3], Quentin Higgan [4], Asha Thomas [2] and Bede McCarthy [5]

[1] Biosecurity Surveillance and Incursion Investigation Group, Ministry for primary industries, 14 Sir William Pickering Drive, Christchurch, New Zealand
[2] Plant Health Environment Laboratory, Ministry for primary industries, 231 Morrin Rd, St Johns, Auckland, New Zealand
[3] AsureQuality Ltd, 131 Boundary Rd, Blockhouse bay, Auckland, New Zealand
[4] AsureQuality Ltd, 507 Eastbourne Street West, Hastings, New Zealand
[5] Plant Health Environment Laboratory, Ministry for primary industries, 14 Sir William Pickering Drive, Christchurch, New Zealand

lora.peacock@mpi.govt.nz

Invasive ants are multi sectoral pests causing impacts globally. Invasive ants lead to substantial economic costs for their management in mitigating the harmful impacts caused. New Zealand's National Invasive Ant Surveillance (NIAS) programme began in 2003 with the detection of *Solenopsis invicta* (red imported fire ant) at Auckland International airport in 2001. This was subsequently eradicated in 2003. NIAS targets exotic ants arriving at the border by surveying all international sea and airports and high risk transitional facilities that devan cargo. The programme uses a combination of bar-coding technology and GIS dashboards for surveillance and incursion management. On average 16 traps detect exotic ants per annum, which illustrates the high propagule pressure of ants arriving at the border. Exotic ant incursions and nests are treated immediately on detection under the 'urgent measures' function in an investigation within the biosecurity system. The successful eradication of the incursions is due to early detection of established populations that are small and eradicable. This highlights the effectiveness of preparedness and targeted surveillance programmes for early detection of invasive species for management purposes.

Real-time invasive marine species detection using computer vision deployed on remotely operated vehicles

Jeremy Bulleid, Rose Pearson, Gareth Preston and Leigh Tait

National Institute of Water and Atmospheric Research (NIWA), 10 Kyle St, Riccarton, 8011, Christchurch, New Zealand

rose.pearson@niwa.co.nz

Early detection of invasive species is critical in the eradication and ongoing management of impacts to primary industries and the environment. In marine environments detection and delimitation is traditionally achieved by human divers performing marine biosecurity surveys. This is expensive and can be dangerous. Remote Operated Vehicles (ROVs) offer another tool that can be used to supplement the work performed by human divers. Camera equipped ROVs are increasingly accessible at reduced price-points and with improved usability. But ROV-based surveys typically remain more expensive than those performed by human divers. This is in part due to the time and expertise required to review the captured video imagery. Deep learning is a machine learning (ML) technique that is well suited to image-based object detection. We present an ROV-integrated system for automated marine species detection with location tracking. The system is designed to be as generic as possible, such that it can be deployed on different ROVs. It is composed of a Jetson Xavier NX board, which is widely used in industry, connected to a GPS unit and an ROV camera. A Python application on the Jetson manages streaming the camera-feed into a ML model for real-time species detection. The NVIDIA DeepStream libraries are leveraged to facilitate integration with a wide range of cameras. The system interfaces with a laptop-based client application, which supports remote system control. The client application also allows configuration to different ROV cameras and supports model updates. We use transfer learning applied to pretrained convolution neural networks as the basis of our model development process. We then share preliminary results exploring the efficacy of the system when used for Mediterranean fanworm (*Sabella spallanzanii*) detection. Efficacy is considered by comparing the system detections against those made by experts reviewing the captured ROV video feed.

Hawaiian forest mortality trajectories associated with Ceratocystis wilt of ʻōhiʻa

Ryan Perroy [1], ʻNaiʻa Odachi [1], Timo Sullivan [2], Berea Etherton [3], Marc A. Hughes [4], Karen Garrett [3] and Lisa Keith [5]

[1] Spatial Data Analysis & Visualization Research Laboratory, University of Hawaii at Hilo, Hilo, HI, USA
[2] Island Conservation, City of Industry, California, USA
[3] Department of Plant Pathology, University of Florida, Gainesville, FL, USA
[4] Institute for Pacific Islands Forestry, Pacific Southwest Research Station, USDA Forest Service, Hilo, HI, USA
[5] Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center, USDA Agricultural Research Service, Hilo, HI, USA

rperroy@hawaii.edu

Hawaiian native forests, primarily on the islands of Kaua'i and Hawai'i, are experiencing widespread mortality to the keystone ʻōhiʻa tree (*Metrosideros polymorpha* Gaud.). This recent mortality is largely due to the fungal pathogen *Ceratocystis lukuohia*, which infects trees through open wounds and causes the systemic vascular disease Ceratocystis wilt of ʻōhiʻa. The crowns of infected trees follow a predictable progression of visible symptoms, eventually defoliating over a period of months. Beginning in 2016, we collected repeat cm-scale resolution visible wavelength imagery via small unoccupied aerial systems (sUAS) and manned helicopters over selected sites on the islands of Kaua'i and Hawai'i, to gain insights into forest mortality trajectories and severity in different settings. Older aerial and satellite lower-resolution images were included to extend the time series back to pre-outbreak conditions. Within each study site we identified all ʻōhiʻa trees (living and dead) and developed a classification system for detecting the symptomatic leaf stages of infected trees to measure spatial and temporal patterns of mortality over time. Molecular analysis via real-time PCR was used to confirm the presence of *Ceratocystis* spp. in wood samples from selected symptomatic trees. Cumulative ʻōhiʻa mortality curves at the site level generally show a rapid initial increase in new mortality over low background (pre-outbreak) levels, reaching ~20% mortality within a few years. This sharp increase is then followed by lower but persistent rates of new infections that continue to the present, with maximum cumulative mortality levels now reaching 35% with pockets of 100% mortality. Spatial patterns of disease spread at the site level are best fit by an inverse-power law model. These trends may suggest a primary initial site-level infection event, potentially related to intense storm activity, followed by secondary spread of the disease via other mechanisms. The duration of symptomatic stages following infection is inversely related to relative humidity, which is relevant for detection and monitoring efforts. Ungulate presence plays an important role in disease incidence, with significant reductions in ʻōhiʻa. mortality evident within fenced (ungulate-free) areas.

Where in New Zealand can fall armyworm survive winter?

Craig B. Phillips [1], Yujie Han [2], Nicholas Davies [1] and John Kean [3]

[1] AgResearch, 1365 Springs Road, Lincoln 7674, Private Bag 4749, Christchurch 8140, New Zealand.
[2] Massey University, Private Bag 11 222, Palmerston North 4442, New Zealand.
[3] AgResearch, 10 Bisley Road, Enderley Hamilton 3214, Private Bag 3123, Waikato Mail Centre, Hamilton 3240, New Zealand

craig.phillips@agresearch.co.nz

Fall armyworm (FAW), *Spodoptera frugiperda* (Lepidoptera: Noctuidae), is a pest of corn/maize and other crops that is native to the Americas and has recently reached Africa, India, China, Japan, SE Asia, Indonesia and Australia. It was first discovered in New Zealand (NZ) in Tauranga in March 2022 and has since been recorded at many additional NZ locations. The inability of FAW to diapause renders it vulnerable to cold winters, which is why it only persists year-round in regions with tropical/subtropical climates such as central America and southern USA. In spring, it migrates northwards from its winter range to infest crops as far north as Ontario and Québec in Canada. In contrast to continental regions, however, NZ has a temperate oceanic climate with generally much higher minimum temperatures. Thus, key questions for NZ include:(i) Are NZ winters sufficiently cold for long enough to kill FAW? (ii) If not, where in NZ is it likely to persist? (iii) How much will FAW's winter range in NZ vary with annual climatic fluctuations and longer term climate change? We generated predictions of FAW's winter range in China and USA from five published Climex models, an isotherm model and an ensemble of eight correlational models using a range of climate datasets. We also created additional ensembles from subsets of the models and climate datasets. To evaluate the models' predictions, records were compiled of locations in China and USA where FAW has been observed to either survive or perish during winter, and predictions were compared with observations. Predictions from the isotherm model and one of the Climex model's corresponded particularly well with the observations and were used to predict locations where FAW can survive winter in NZ. Both models gave similar predictions for NZ: Under current climatic conditions FAW should be capable of surviving winter during most years in most locations north of about Auckland (latitude -37°) and also around coastal parts of the North Island's East Cape. During some warmer winters it could also survive in many coastal regions of the lower North Island, and more occasionally in coastal parts of the South Island in Westland, Tasman, Marlborough and Canterbury.

Culturally directed engagement with Māori on fall armyworm in Te Tai Tokerau/Northland

Jordan Pickering [1], David AJ Teulon [2, 5], Teresa Waiariki [3], Alby Marsh [4,5], Hone Ropata [1], Frances MacDonald [1], Kelly McKenzie [6], Waata Papali'i-Smith [6].

[1] The New Zealand Institute for Plant & Food Research Limited, Private Bag 92169, Auckland 1142, New Zealand
[2] The New Zealand Institute for Plant & Food Research Ltd, Private Bag 4704, Christchurch 8140, New Zealand
[3] The New Zealand Institute for Plant & Food Research Ltd, 121 Keri Downs Road, Kerikeri 0294, New Zealand
[4] The New Zealand Institute for Plant & Food Research Ltd, Private Bag 11600, Palmerston North 4474, New Zealand
[5] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)
[6] The Ministry for Primary Industries, Biosecurity New Zealand, 34-38 Bowen St, Wellington 6011, New Zealand

jtpickering2000@icloud.com

Fall armyworm (FAW) (*Spodoptera frugiperda*) is a recent invader of Aotearoa New Zealand and was detected in field crops, particularly corn/maize, from many locations in the North Island in the summer of 2022/23. FAW is a sub-tropical/tropical noctuid insect, and the extent to which it will overwinter and develop damaging populations in New Zealand is still being determined. Preliminary climate modelling and current field observations indicate that FAW is likely to be most problematic in Te Tai Tokerau (TTT)/Northland, a region of New Zealand with a significant Māori population and economic and non-economic plants of value to Māori (taonga) (rongoā/medicinal, raranga/weaving, māra kai/gardens), which are potentially at risk to FAW. This study details outreach with local iwi/Māori (Mana Whenua) in TTT, providing resources with information on the biosecurity system in general and on FAW and explores concerns about the FAW incursion. In the summer of 2021, prior to the current incursion, outreach was initiated with the Māori growing community in TTT. A poster was developed on FAW and its potential risks, including to indigenous plants, should it arrive and establish in New Zealand. In the summer of 2022, after FAW was first found in New Zealand, we continued further discussion with key iwi/Māori in TTT. Two FAW fact sheets were developed specifically for Māori/iwi in TTT in Te Reo and English. From these, videos on FAW in Te Reo and English were produced by the senior author as a summer student hosted by B3/PFR and the Ministry for Primary Industries (MPI). These videos aim to aid Mana Whenua in TTT to mobilise their surveillance for FAW, how to find it, how to identify it and how to distinguish it from other insect pests that may also be in the crop. These videos also aspire to continue fostering partnerships with Mana Whenua in TTT. Iwi/Māori-relevant and focused materials are required to appropriately engage with these communities on current and potential biosecurity incursions.

Advancing quantitative pre-border risk assessment frameworks for forecasting invaders and invasions

Arman Pili and David G. Chapple

School of Biological Sciences, Faculty of Science, Monash University, Clayton 3800, Australia

armannorciopili@gmail.com

Despite centuries of invasion, the rate of emergence of new alien species is ceaselessly escalating, owing to the ever-increasing and expanding globalisation. This emphasises the dire need for pre-border biosecurity tools (e.g., blacklist systems) that can effectively screen alien species with the potential to become invasive if introduced and, thus, should be prevented from entry. However, most pre-border biosecurity tools rely on information on invasion history in assessing alien species' invasion risk, markedly reducing their accuracy and precision in assessing alien species with no prior history of invasion elsewhere. We showcase a state-of-the-art quantitative risk assessment framework for forecasting would-be alien species invaders. Our tool first models invasion syndromes (i.e., traits that make a species a successful invader) by fitting regression and machine learning algorithms with phylogenetically-imputed life-history traits, along with indices describing species' ecology (e.g., commonness, habitat generalism, tolerance to disturbance). We then use this model to predict global species with invasion syndromes (i.e., candidate species pools). We demonstrated our tool's usefulness for pre-border biosecurity decision support by its high accuracy in retrospectively predicting accidentally transported alien amphibians and reptiles in New Zealand. Our framework addresses the longstanding need for robust quantitative pre-border biosecurity risk assessment tools for forecasting high-invasion risk alien species, especially those with no prior history of invasion elsewhere.

The value of New Zealand's biosecurity system

Julia Polak, Christine Li, John Baumgartner, Andrew Robinson and Tom Kompas

Centre of Excellence for Biosecurity Risk Analysis (CEBRA), School of BioSciences, University of Melbourne, VIC 3010 Australia

julia.polak@unimelb.edu.au

New Zealand operates a comprehensive biosecurity system to protect its extensive natural and agricultural resources, along with cultural assets. Substantial research efforts have been made to evaluate specific biosecurity measures and the damages incurred from particular biosecurity threats. However, no comprehensive attempt has yet been made to evaluate the entire system. The value of the entire biosecurity system and its components is of a great interest to government, Treaty partners and the public, and is crucial for ensuring appropriate resource allocation for the maintenance and optimization of the biosecurity system. Evaluating the whole biosecurity system requires a novel methodology. Such a methodology was recently developed and applied to Australia's biosecurity system. It is now being adjusted for New Zealand's biosecurity system. We are developing a comprehensive, dynamic and large dimensional simulation model to estimate the value of New Zealand's biosecurity system. Starting with detailed asset layers and potential damage functions from invasive pests, the model will simulate the arrival, spread, and impact of biosecurity hazards (in terms of asset yield or value reduction) under different biosecurity operational scenarios. It will also estimate the economic value of biosecurity interventions. This talk will present the framework for accurate estimation of the tangible value of New Zealand's biosecurity system, as a whole, in terms of the impact it makes in safeguarding New Zealand's natural, cultural and economic assets. This is a large and ambitious project, in which we estimate the value of seventeen NZ assets (e.g. agriculture, fishery, flood control, gene-pool, tourism and Māori customary values) and how they may be damaged by exotic invaders (pests and pathogens) over time. We are considering about 60 biosecurity hazards that may affect New Zealand's vegetation, agriculture, animals, aquaculture and marine ecosystems, and cultural assets. As it is still a work in progress, the final total value is not available yet. However, the methodology is well established, and this is the focus of this talk.

Use of Whole Genome Sequencing (WGS) for improving understanding of linkages between livestock and wildlife *Mycobacterium bovis* infection in New Zealand

Marian Price-Carter [1], Rudiger Brauning [2], Geoff de Lisle [1], Gillian Atkinson [3], Barb Frey [3], Holly Williams [3], Kevin Crews [4] and Des Collins [1]

[1] AgResearch, Hopkirk Research Institute, Palmerston North, New Zealand
[2] AgResearch, Invermay Agricultural Centre, Mosgiel, New Zealand
[3] TBfree NZ, Palmerston North, New Zealand
[4] TBfree NZ, Christchurch, New Zealand

Marian.Price-Carter@agresearch.co.nz

Present-day transmission cycles of Bovine Tuberculosis (bTB) in New Zealand (NZ) have resulted from introductions by European settlers of both the causative agent, *Mycobacterium bovis (M. bovis)*, and the wildlife maintenance host, the brushtail possum. Simple test and cull strategies that have led to eradication of bTB from livestock in other parts of the world are hampered here by wildlife reinfection. A farmer driven organization, now called OSPRI TBfree, has greatly reduced bTB herd prevalence by taking an active all-inclusive approach where they monitor and control infection in livestock herds, prior to livestock movements and in wildlife populations. New Zealand's latest bTB National Pest Management Plan includes the objectives of TB freedom in livestock by 2026, and in possum vectors by 2040. At this stage in the maturing program, knowing the source of every newly identified infected herd is vital to ensure that objectives can be achieved and sustained. For over two decades molecular strain typing carried out at AgResearch has assisted disease managers in determining the most likely source of new infections and has helped inform the wildlife (possum) control program. Recent advances in technology have decreased the cost and turnaround time making it feasible to use the greater resolution of whole genome sequencing (WGS) analyses for routine surveillance typing. WGS provides a significant increase in the level of discrimination between individual *M. bovis* isolates, which has helped link livestock isolates to wildlife isolates and also helps to corroborate case investigation findings of livestock movement related spread of the infection. Genomes of new isolates are currently compared to 1200+ genomes from livestock and wildlife isolates of representative types, spanning over 30 years in our WGS database. The single nucleotide polymorphism (SNP) lineages that result from our WGS analyses provide greater granularity than the "types" characterised by previously employed typing assays. As there are so many more similarities and differences to consider in WGS lineages, there is less chance for misinterpretation of the relationship between isolates. Through comparison of shared and differing SNP content of *M. bovis* isolates from livestock and wildlife origins, WGS can suggest probable transmission linkages of new isolates to others within the same herd, between livestock herds and within local and distant wildlife populations. Improved understanding of *M. bovis* transmission in different livestock and wildlife populations enhances efficient control program design and minimizes errors in source attribution.

Enhancing Animal Health and Biosecurity through partnership in the Pacific region

Andrew McFadden, Thomas Rawdon and Oliver Quinn

Ministry for Primary Industries 66 Ward Street, Upper Hutt 5019

oliver.quinn@mpi.govt.nz

Capacity in animal health is critical to livelihoods, regional stability, and food security. This is particularly important in the Pacific region where there is a need to improve sustainable food production. In parallel, preparedness activities for emerging transboundary animal diseases (TAD), in the region such as African Swine Fever, Foot and Mouth Disease and Lumpy Skin Disease, are vital. However, there is a lack of information on key priorities for animal health capacity building at the regional, but also at the national level where it is important to understand local concerns and constraints. A common regional constraint is the shortage of veterinarians alongside limited resources assigned to animal health and biosecurity initiatives. Here we outline the Pacific Partnership animal health teams' approach, while giving an overview of our current work program and associated training in the region focusing on six program countries: Fiji, Tonga, Vanuatu, Samoa, Niue, and the Cook Islands. The Pacific Partnership team is part of MPI's Surveillance and Diagnostic Services Directorate and contributions by the Plant Health and Environment Laboratory (PHEL) and the Animal Health Laboratory (AHL) will be highlighted. Our aim is to mitigate risk of entry and spread of TADs through biosecurity initiatives that build foundational para-veterinary, biosecurity and diagnostic skills. In addition, we aim is to support ongoing efforts to assess the burden of key disease of animal and human health concern in relevant host species. Using a facilitated self-assessment approach each Pacific Island Country (PIC) animal health and biosecurity system is reviewed. The review develops several recommendations, which are agreed and prioritised by country participants, and out of this a program of work is developed. These country-tailored programs aim to develop strong Ministry-to-Ministry partnerships between New Zealand and each PIC. Biosecurity and animal health capability and capacity is enhanced through training focused on improved animal disease surveillance, incursion investigation, response, sampling, and diagnostics. Through collaborative engagement with other donors and agencies working in the region we aim to reduce duplication, while complementing and strengthening each country's biosecurity system.

Characterisation of the epiphytic microbiome of myrtaceous species and implications for infection by *Austropuccinia psidii*

Hayley Ridgway, Fernanda Nieto-Jacobo, Kirsty Boyd-Wilson, Soonie Chng, Loreto Hernandez, Monika Joshi, Farhat Shah and Preeti Panda.

The New Zealand Institute for Plant & Food Research Ltd, Lincoln 7608, Canterbury, New Zealand

Hayley.Ridgway@plantandfood.co.nz

A large and complex community of microbial epiphytes, including bacteria, fungi, archaea and yeasts, colonise the phylloplane or leaf surface. This microbial community is known to have a role in plant growth and development, including protection from disease. In 2017 the invasive rust *Austropuccinia psidii* was first reported in New Zealand. *Austropuccinia psidii* has a broad host range, infecting the new foliage of myrtaceous species causing death of tissues and, in severe, repeated infection causes plant death. To investigate the role of the epiphytes on infection success the phylloplane community of new (young) and previous (old) season's growth of three myrtaceous species, pōhutakawa, ramarama and mānuka, sampled from seven sites in New Zealand, was characterised by metabarcoding using Illumina sequencing. The results showed that the microbial community on the leaf surface was distinctive between hosts, site and tissue age. Ramarama, the most susceptible host, supported the richest microbial community (P=0.00011), whereas pōhutakawa and mānuka were less rich but not different from each other (P=0.15). The phylloplane communities of young and old tissues differed. In mānuka and ramarama, young tissues had a greater relative abundance of species within the genus *Sporobolomyces*, whereas the older tissues of pōhutakawa had a greater relative abundance of species within the genus *Capnobotryella*. Further work, in which young tissues were inoculated with the phylloplane microbiome sourced from older tissues, and the impact on infection by *A. psidii* will be discussed.

Biosecurity and pathways into Aotearoa New Zealand: relating biosecurity detections to tourism

Andrew P. Robinson [1] and Mark R. McNeill [2, 3]

[1] CEBRA, The University of Melbourne, Melbourne, Australia
[2] AgResearch Ltd, Lincoln Research Centre, Christchurch, New Zealand
[3] Better Border Biosecurity (B3) (www.b3nz.org), New Zealand

apro@unimelb.edu.au

International trade and tourism, while essential to the world's economy, has also been implicated as facilitating the dispersal of exotic species. Tourism, in its broadest sense, can provide significant economic gain to a country's GDP, but if not managed carefully then economic, social, cultural and environmental costs may arise. From a biosecurity perspective, the sometimes massive and rapid movement of people associated with international tourism has been implicated in the dispersal of exotic organisms both across and within countries, some of which become invasive. Although between-country tourism is established as a facilitator of the spread of invasive alien species, little attention has been paid to the question of whether tourism contributes to the arrival and subsequent dispersal of exotic organisms within national borders. To assess the strength of evidence that tourism is a driver for the accidental introducing and dispersal of exotic organisms, we sourced three national databases covering the years 2011 to 2017, namely (i) international and domestic hotel guest nights, (ii) national population counts, and (iii) records of exotic organism detections collected by the Ministry for Primary Industries, which is the New Zealand government agency that oversees biosecurity. The exotic organisms database comprised records of insects, Arachnid spp. (spiders and mites), snails, plants (terrestrial and aquatic), nematodes and microbes (bacteria, fungi and viruses) that were detected post border. We fitted statistical models to assess the strength of relationship between monthly exotic organism interception rate, guest nights and population, the latter as a baseline. The analysis showed that levels of incursion detection were significantly positively related to tourism records ($P = 0.00078$), reflecting the travel of both international and domestic tourists, even when base population was taken into account. There was also a significant positive statistical correlation between the levels of detection of exotic organisms and human population ($P = 0.0046$). The number of nights duration spent in specific accommodation, which is a key indicator of within-country human population movement, is statistically significantly correlated to the contemporaneous detection of exotic pests. In each case the amount of variation explained was small. We conclude that this study provides evidence of impact of within-country movement upon the internal spread of invasive species, although important caveats need to be considered. The results also reinforce the need for biosecurity authorities to continue to allocate resources to managing the tourism pathway.

Biosecurity alerts – early detection via Australia's largest biodiversity data infrastructure

Erin Roger, Andrew Turley, Martin Westgate and Cam Slatyer

Atlas of Living Australia – CSIRO, GPO Box 1700, Canberra ACT 2601 Australia

erin.roger@csiro.au

An effective biosecurity system is critical for the protection of Australia's agricultural, forestry and fisheries exports, as well as our environmental assets – which are under increasing pressure from a changing climate and expanding international trade. Early surveillance and detection for new incursions of species of biosecurity concern is a crucial component of an effective biosecurity system. The Atlas of Living Australia (ALA) is Australia's largest open-source biodiversity data infrastructure with more than 850 data providers and 112 million occurrence records. As such, the ALA is often the first platform where new species incursions are recorded; including through the fastest growing source of data for the ALA – citizen science. For over a decade the ALA has been receiving reports of species of biosecurity concern, but until recently there has been no systematic mechanism for notifying relevant biosecurity authorities. To address this, the ALA partnered with the Commonwealth Department of Agriculture, Fisheries and Forestry to develop a biosecurity alerts system. Here, we detail how the alert email system was set up, initially using the default ALA notification system, and more recently using a bespoke solution implemented in the R programming language. Both systems work by querying the ALA database for species that match lists provided by government departments. Two years on, the project has demonstrated the benefits of alert emails; in some cases, the notification system has provided over 9 months' earlier warning of an incursion than would otherwise have been undetected. We conclude by detailing our plans to expand the alert system to other jurisdictions and for system-wide improvements to further enhance our national response to alien pest and disease species.

Potential impacts on rata vines (*Metrosideros* spp.) of myrtle rust caused by *Austropuccinia psidii*

Hone Ropata, Rob Beresford and Nick Waipara

The New Zealand Institute for Plant & Food Research Limited, 120 Mount Albert Road, Mount Albert, Auckland, New Zealand

Hone.Ropata@plantandfood.co.nz

Myrtle rust (causal agent: *Austropuccinia psidii*) is a fungal disease that arrived in New Zealand in 2017. Myrtle rust only attacks plants in the Myrtacae and among the potential host species are the New Zealand native rātā vines (*Metrosideros* spp.), which are closely related to the iconic native pōhutukawa (*Metrosideros robusta*). The Māori name for these vines is *aka* and they are a *taonga*, or treasured entity to the indigenous people of New Zealand. They have a traditional role as food, fibre, and medicine, which assured continued wellbeing of pre-contact Māori peoples. Only newly emerged shoot tissues are susceptible to *A. psidii* infection because leaves develop ontogenic resistance by the time they are fully expanded. Annual shoot flush patterns therefore determine seasonal development of myrtle rust epidemics. An experiment was run to assess seasonal growth rates for three of the six vine species, which were planted in Auckland and monitored for 1 year. Growth was measured both as shoot length and number of emerged leaf pairs. The data are being analysed and the seasonal growth characteristics will be used to help interpret the relative vulnerability to myrtle rust of these native treasures.

Rapid fingerprinting metabolomics: a new complementary tool for biosecurity and quarantine diagnostics

Alastair Ross [1, 2], Hadley Muller [1, 2], Scott Hardwick [1, 2], Arvind Subbaraj [1, 2], Shery Hanna [1, 2], Ines Homewood [1, 2], Gabby Drayton [2, 3], Adriana Najar-Rodriguez [2, 3], Lloyd Stringer [2, 3], Flore Mas [2, 3], Sandra Visnovsky [2, 3], Jessica Vereijessen [2, 3] and Karen Armstrong [2, 4]

[1] AgResearch, Lincoln, New Zealand
[2] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)
[3] The New Zealand Institute for Plant & Food Research, Lincoln, New Zealand
[4] Lincoln University, Lincoln, New Zealand

alastair.ross@agresearch.co.nz

Diagnosis of potential biosecurity threats is a key part of any biosecurity response process but is complicated by the similarity of threat organisms to endemic species or by other considerations such as whether a detected specimen was alive when arriving in a country. An array of taxonomic and molecular genetic tools are used for identification at various species levels to provide the most fundamental information on biological risk. But non-taxonomic information such as distinguishing infection from environmental stress or how reproductively mature was the insect in the trap are gaps that could supply a more holistic view of the actual risk. As a subset of metabolomics, rapid fingerprinting metabolomics could supply such information, with benefits for biosecurity application of using instruments that typically do not require sample preparation before analysis, and analysis times can be as short as 5-10 seconds per sample. As a proof of concept, we have used rapid evaporative ionisation mass spectrometry (REIMS) and direct analysis in real time mass spectrometry (DART-MS) to determine whether (a) psyllid-mediated *Candidatus* Liberibacter solanacearum (CLso) infection could be detected in tomato plants, and (b) species and time of death could be detected in clover root weevil (*Sitona lepidus*) and Argentine Stem Weevil (*Listronotus bonariensis*). Using REIMS and DART-MS, CLso infection could be detected in roots and leaves at 5 weeks post inoculation, mirroring PCR detection. REIMS was able to detect sufficient metabolite information from a single weevil leg to differentiate between CRW and ASW. The metabolite fingerprint of weevil legs changed after death, suggesting that it will be possible to predict time since death based on REIMS data. Mating status of females was also reflected in the weevil leg metabolic fingerprint for both species. These results suggest that rapid fingerprinting metabolomics could be a useful adjunct to the biosecurity diagnostics toolbox. Future work will focus on testing the ability of this methodology to work in real-world situations and further expand on what additional information can be obtained from the mass spectral fingerprints.

Local and landscape-scale drivers of non-native plant richness and cover in New Zealand native shrublands

Laureline Rossignaud [1, 2] and Philip E. Hulme [1, 2]

[1] Department of Pest Management and Conservation, Lincoln University, PO Box 85084, Lincoln, Canterbury 7647, New Zealand
[2] Bioprotection Aotearoa, PO BOX 85084, Lincoln University, Lincoln, Canterbury 7647, New Zealand

laureline.rossignaud@lincoln.ac.nz

Multiple factors influence the resilience of a native habitats against non-native plant invasions. However, few studies have disentangled the relative roles of biotic and abiotic factors on plant invasions at national scales. Here we investigated the role of biotic and landscape factors of non-native plant invasions in mānuka and kānuka shrublands which are widespread but threatened native habitats in New Zealand. We based our analysis on 247 permanent plots from the National Vegetation Survey databank with associated landscape and climate data. We calculated native species richness and cumulative cover at ground, understory, and canopy tiers. We examined plant invasions in the ground tier as described by non-native species richness and mean species cover in relation to biotic resistance (native richness and cumulative cover), landscape (proportion of adjacent anthropogenic land cover, distance to nearest road or river) and climate variables. Similar models were run to assess whether the same factors also predicted native richness and mean species cover in the ground tier. A positive correlation between native and non-native plant species richness was not explained by their similar responses to the factors examined in this study. Non-native richness increased in areas receiving lower levels of precipitation, while native richness was more influenced by temperature. Non-native richness and mean cover increased with the proportion of adjacent anthropogenic land cover, whereas for native richness and mean cover this relationship was negative. Higher native canopy richness resulted in lower non-native richness and mean cover whereas higher native ground richness was associated with higher native canopy richness. Adjacent anthropogenic land cover not only facilitates non-native species arrival by being a source of propagules but also their spread as a result of fragmentation. Our results highlight the importance of examining different vegetation tiers to better understand resistance to non-native plant invasions.

From red-listed to rogue: current research on the biology and management of the native planthopper Pentastiridius leporinus that became an invasive vector of the new sugar beet disease syndrome "basses richesses"

Michael Rostas [1], Pamela Bruno [1], René Pfitzer [2], Justus Detring [1, 2] and Mark Varrelmann [2]

[1] Division of Agricultural Entomology, Department of Crop Sciences, University of Goettingen, Germany
[2] Institute for Sugar Beet Research, Goettingen, Germany

michael.rostas@uni-goettingen.de

The planthopper *Pentastiridius leporinus* (L.) (Hemiptera: Cixiidae) is the main vector of *Candidatus* Arsenophonus phytopathogenicus, a phloem-restricted γ-proteobacterium causing the low-sugar content syndrome of sugar beet (*Beta vulgaris* L.) known as "basses richesses" (SBR). This disease was first identified after tremendous yield losses in eastern France in the 1990s. Since 2009, SBR has been rapidly expanding east and northward, thus becoming a major problem for sugar beet cultivation in Germany and Switzerland. The planthoppers spend most of their life as root-feeding nymphs, where they are protected from insecticide treatments. After sugar beet harvest, the nymphs are able to complete their life cycle in the subsequent winter wheat crops from where they re-infest sugar beet. Potential sustainable management strategies against SBR and its vector include crop rotation, breeding for tolerant or resistant sugar beet varieties, and biological control of the insect vectors. To develop these, there is urgent need for a deeper understanding of the biology and chemical ecology of *P. leporinus*. Here we present an overview of our current research on the above-mentioned topics and first results addressing the question why this, until recently, widespread but endangered species could have become invasive.

Tooling up for Predator Eradication

Olivia Rothwell and Dan Tompkins

Predator Free 2050 Limited, PO Box 106040, Auckland City 1143, New Zealand

oliviar@pf2050.co.nz

Predator Free 2050 Limited launched its 'Products to Projects' (P2P) initiative in 2019 to accelerate development and commercialisation of new tools that will help achieve mainland elimination of possums, rats and mustelids at landscape scale without the use of fences. In its second tranche in 2021, we have also started to support 'best practice' development for tool use in eradication projects. As it is crucial to be continually innovating to get New Zealand to the 2050 national eradication goals at pace, the focus of P2P is to provide options for more efficient and cost-effective ways of achieving and maintaining predator eradication at increasing scale. These new investments span innovative traps, long-life luring, detection devices, remote communications, more selective toxin approaches, and guidance on the use of mātauranga (traditional knowledge) for predator eradication. In this talk I will outline all of the P2P investments made to date. With a focus on availability to end-users in the short-term, seven new tools are already in use, with a further 23 products expected to all be completed and available by December 2024. I will also present some of the early feedback received from end-users, and how this is influencing our plans for ongoing tool development and support.

Documenting and predicting future risk of biological invasions

Helen Roy

UK Centre for Ecology & Hydrology, Maclean Building Benson Lane, Crowmarsh Gifford, Wallingford, Oxfordshire, United Kingdom, OX10 8BB

hele@ceh.ac.uk

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment's message is stark: biodiversity – the diversity within species, between species, and of ecosystems – is declining faster than at any time in human history. Invasive alien species, introduced by humans into regions beyond their natural distribution, were identified as one of the five top direct causes of biodiversity loss. Biological invasions can threaten biodiversity and ecosystems, particularly through their interactions with other drivers such as climate change and land- and sea-use change, potentially with multiple impacts spanning plant, animal, wildlife and human health. Cross-sectoral sharing of information is critical to inform action. It is widely recognised that the most effective action against biological invasions is preventing the arrival of invasive alien species. Therefore, there has been increasing focus on horizon scanning to predict which invasive alien species pose an imminent emerging threat. Prioritising invasive alien species in the context of the pathways by which they might arrive can be informative for decision-making. Horizon scanning for invasive alien species that could arrive and pose a threat to biodiversity and ecosystems around the world has underpinned species prioritisation to enhance biosecurity and inform action including risk assessments to inform lists of invasive alien species of concern.

A century of weed change in New Zealand's forage seed multiplication industry

Jesse M. Rubenstein [1], Philip E. Hulme [2], M. Philip Rolston [3], Alan V. Stewart [4] and John G. Hampton [1]

[1] Department of Agricultural Sciences, Lincoln University, Lincoln, New Zealand
[2] Department of Pest Management and Conservation, Lincoln University, Lincoln, New Zealand
[3] Foundation for Arable Research, Christchurch, New Zealand
[4] PGG Wrightson Seeds Ltd, Kimihia Research Centre, Lincoln, New Zealand

jesse.rubenstein@lincolnuni.ac.nz

International seed trading is a pathway through which weed seeds can be introduced, and many globally established weeds originally came from imported agricultural seed lots. Forage crop seed lots could be considered higher risk than arable and vegetable seed lots, as they often have a significantly higher percentage of contaminated seed lots. Using historical and current seed lot purity test results from 1912 to 2019, we examined the frequency, identity and temporal changes of weed seeds found within New Zealand grown seed lots of perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*), two of the most commonly used temperate forage crops worldwide. Overall, the percentage of contaminated seed lots decreased over the study period, indicating management practices were increasingly effective for weed control. However, our findings also highlight certain species that pose a potential future risk, either because they were common, or they showed a significant increasing presence trend in seed lots. These included *Chenopodium album*, *Poa annua*, *Sherardia arvensis* and *Vulpia bromoides*. Additionally, we found a significant difference in the percentage of contaminant species that were grasses between seed lots of perennial ryegrass and white clover. As New Zealand contributes significantly to the global supply of forage seed and trades with approximately half of the world's countries, our study provides crop managers, policymakers, and seed suppliers with a unique insight into changes of the weed spectrum throughout the seed for sowing system over the last century.

The global contribution of invasive vertebrate eradication as a key island restoration tool

Dena R. Spatz [1], Nick D. Holmes [2], David Will [3], Stella Hein [3, 8], Zachary T. Carter [4], Rachel M. Fewster [4], Bradford Keitt [5], Piero Genovesi [6], Araceli Samaniego [7], Donald A. Croll [8], Bernie Tershy [8] and James C. Russell [4]

[1] Pacific Rim Conservation, Honolulu, Hawaii, USA
[2] The Nature Conservancy, Santa Cruz, California, USA
[3] Island Conservation, Santa Cruz, California, USA
[4] University of Auckland, Auckland, NZ
[5] American Bird Conservancy, Santa Cruz, California, USA
[6] Institute for Environmental Protection and Research, Rome, IT
[7] Manaaki Whenua—Landcare Research, Auckland, NZ
[8] UC Santa Cruz, Santa Cruz, California, USA

j.russell@auckland.ac.nz

Islands are global hotspots for biodiversity and extinction, representing ~ 5% of Earth's land area alongside 40% of globally threatened vertebrates and 61% of global extinctions since the 1500s. Invasive species are the primary driver of native biodiversity loss on islands, though eradication of invasive species from islands has been effective at halting or reversing these trends. A global compendium of this conservation tool is essential for scaling best-practices and enabling innovations to maximize biodiversity outcomes. Here, we synthesize over 100 years of invasive vertebrate eradications from islands, comprising 1550 eradication attempts on 998 islands, with an 88% success rate. We show a significant growth in eradication activity since the 1980s, primarily driven by rodent eradications. The annual number of eradications on islands peaked in the mid-2000s, but the annual area treated continues to rise dramatically. This trend reflects increases in removal efficacy and project complexity, generating increased conservation gains. Our synthesis demonstrates the collective contribution of national interventions towards global biodiversity outcomes. Further investment in invasive vertebrate eradications from islands will expand biodiversity conservation while strengthening biodiversity resilience to climate change and creating co-benefits for human societies.

Growing rust fungi on artificial substrates – A step closer to studying infection in the laboratory without the use of plants

Sarah Sale [1, 2, 3, 4], Yiling Sun [2, 3, 4], Grant Smith [5], Volker Nock [2, 3, 4] and Ashley Garrill [1, 3, 4]

[1] School of Biological Sciences, University of Canterbury, Christchurch 8041, New Zealand
[2] Department of Electrical and Computer Engineering, University of Canterbury, Christchurch 8041, New Zealand
[3] The MacDiarmid Institute for Advanced Materials and Nanotechnology, Wellington 6140, New Zealand
[4] Biomolecular Interaction Centre, University of Canterbury, Christchurch 8041, New Zealand
[5] The New Zealand Institute for Plant & Food Research Limited, Lincoln 7608, New Zealand

sarah.sale@pg.canterbury.ac.nz

New Zealand faces increasing risks from the impacts of plant diseases, such as those caused by the largest group of plant pathogens, rust fungi. Rust fungi are plant pathogens that infect, weaken and/or kill a large number of plant species and the disease that they cause can have major environmental, economic and cultural impacts. Currently there are no rust specific fungicides on the market, there is limited research on the use of exogenous dsRNA strategies to curb infections and traditional approaches of breeding for resistance in the plants has been regularly overcome by the fungi. Therefore, novel tools/approaches are required to help tackle these pathogens. In particular, there is an urgent need to screen biological control agents (BCA) for their ability to reduce rust fungi virulence. Lab-on-a-chip (LOC) devices can accelerate such screening enabling pathogen-BCA interactions to be observed at a single-cell level with high-throughput. One potential problem with these devices is that they require the pathogen to be grown separately from its natural host(s) in an artificial environment. Since rust fungi require a living host to complete their asexual reproductive life cycle, growth on artificial substrates is currently not possible. Using three rust fungi, *Puccinia triticina* (wheat leaf rust), *Melampsora larici-populina* (poplar rust) and *Austropuccinia psidii* (myrtle rust), we report the growth of rust fungi on artificial substrates. These substrates include flat and heterogeneous high-resolution leaf surface replicates made of either silicone polymers or of agar-based media. The fungi demonstrated surface growth, pre-penetration structure formation, surface penetration and internal growth within the artificial substrates. We also show comparable results from collaborative work using myrtle rust. These results get us a step closer to growth of the pathogen in a laboratory setting without the need for the host plant and the ability to use LOC devices for high throughput screening of BCAs.

Cage closed: the effects of introduced herbivores in forest regeneration in Isla de los Estados, Argentina

Amira Salom [1, 2], Klemens Putz [3], Andrea Raya Rey [1] and Fernando Biganzoli [4]

[1] Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Intendente Güiraldes 2160, C1428EGA Buenos Aires, Argentina
[2] Laboratorio de Ecología y Conservación de Vida Silvestre, Centro Austral de Investigaciones Científicas, Consejo Nacional de Investigaciones Científicas y Técnicas CADIC-CONICET, Bernardo Houssay 200, 9410 Ushuaia, Tierra del Fuego, Argentina
[3] Antarctic Research Trust, Am Oste-Hamme-Kanal 10, 27432 Bremervörde, Germany
[4] Facultad de Agronomía, Universidad de Buenos Aires, Av. San Martín 4453, C1417DSE Buenos Aires, Argentina

amirasalom@gmail.com

The presence of introduced herbivorous mammals on oceanic islands usually involves the exposure of native forest, evolved in isolation, to functional groups previously absent in these ecosystems. Such is the case of Isla de los Estados mixed-evergreen forest of *Drimys winteri* and *Nothofagus betuloides* in Tierra del Fuego, Argentina, where red deer (*Cervus elaphus*) and goats (*Capra hircus*) were introduced over 50 and 100 years ago, respectively. The early stages of tree life cycles are usually the most vulnerable to grazing and trampling, so the successful establishment and development of seedlings and saplings is a key indicator of the potential of forests to regenerate over time. We evaluated the effect of these introduced herbivores on the survival and establishment of the two dominant tree and two shrub species (*Berberis ilicifolia* and *Chiliotrichum diffusum*) which are widely distributed at the study site and are main components of the understory of the forest and in the diet of these species. We monitored the survival and growth of 577 seedlings over three years (2019-2021) within two treatments, exclosure and exposure to herbivores. Analysis were performed applying generalized linear mixed models (GLMMs). We found that seedlings of all four species showed a significant increase in survival and height inside the exclosure. Overall, 79% of seedlings survived inside the exclosure, while only 26% did so in the open plots. From the surviving seedlings, 40% passed to an advanced regeneration state, exceeding a height of 10 cm within the exclosure, while only a 4% of the seedlings exposed to herbivores did. In turn, the number of leaves of all species showed a general pattern of increase within the exclosure, but only *D. winteri* and *B. ilicifolia* exhibited significant changes. Our study suggest that the introduced herbivores could be affecting the establishment of seedlings and saplings of the species studied by increasing their mortality either by trampling or browsing and at the same time strongly diminishing growth of surviving seedlings. Red deer and goats clearly impact negatively on the development of seedlings into saplings and small trees, decreasing the recruitment of these species into larger size-classes. This results in forest degradation and possibly impeding its regeneration, which in turn could be affecting the structure and heterogeneity at landscape scale in the long-term.

Double-stranded RNA as a novel control for myrtle rust

Rebecca Degnan [1], Alistair McTaggart [2], Louise Shuey [3], Leny Jane Pame [1], Grant Smith [4], Donald Gardiner [2], Volker Nock [5], Rebecca Soffe [5], Sarah Sale [5, 6], Ashley Garrill [6], Bernard Carroll [1], Neena Mitter [2] and Anne Sawyer [1, 2]

[1] School of Chemistry and Molecular Biosciences, The University of Queensland, St Lucia, Queensland, Australia
[2] Queensland Alliance for Agriculture and Food Innovation, Centre for Horticultural Science, The University of Queensland, St Lucia, Queensland, Australia
[3] Queensland Department of Agriculture and Fisheries, Ecosciences Precinct, Dutton Park, Queensland, Australia
[4] The New Zealand Institute for Plant & Food Research Limited, Lincoln, New Zealand
[5] Department of Electrical and Computer Engineering, University of Canterbury, Christchurch, New Zealand
[6] School of Biological Sciences, University of Canterbury, Christchurch, New Zealand

a.sawyer@uq.edu.au

Myrtle rust is a plant disease caused by the highly invasive fungal pathogen *Austropuccinia psidii*, which infects more than 480 Myrtaceae species and is a major threat to natural ecosystems and native plant industries. Management of myrtle rust in nurseries and plantations relies on the use of clean planting material, treatment with chemical fungicides and the selection of resistant cultivars. However, these control strategies are not suitable for natural environments and growers are transitioning away from chemical pesticides. We have been exploring the use of double-stranded RNA (dsRNA) as a novel environmentally sustainable control for myrtle rust. This approach, also known as spray-induced gene silencing (SIGS), involves exogenously applying pathogen-specific dsRNA to host plants to trigger RNA interference (RNAi) and silence targeted pathogen genes. We used *in vitro* spore germination assays, detached leaf assays and whole plant infection assays to examine the impact of rust-specific dsRNA on *A. psidii* urediniospore germination and disease development. We found that dsRNA either associates externally or is internalised by urediniospores during the early stages of germination and that dsRNA targeting essential *A. psidii* genes significantly reduced urediniospore germination and the development of infection structures such as appressoria and infection pegs. dsRNA was similarly effective *in planta*, significantly reducing disease symptoms on detached leaves and in 1-year-old rose apple trees. Using comparative genomics, we identified RNAi genes across 15 species in eight families of Pucciniales, indicating that RNAi is conserved across rust fungi and that other species might also be amenable to dsRNA-based control. Our findings indicate that dsRNA targeting essential genes has the potential for broad-use management of *A. psidii* across natural and agricultural systems alike.

Elaborating on invasive species management: The influence of increasingly engaging communication on management acceptance

Ingrid E. Schneider [(1)], Brett Rannow [(1)], Marcella Windmuller-Campione [(1)], Matt Russell [(1)] and Angela Gupta [(2)]

[(1)] University of Minnesota – Twin Cities, Department of Forest Resources, 1530 Cleveland Ave North, 115 Green Hall, St Paul, Minnesota, 55108 USA
[(2)] University of Minnesota – Twin Cities, Extension, 863 30th Avenue SE, Rochester, Minnesota, 55904 USA

ingridss@umn.edu

The integration of stakeholder perceptions to invasive species management and policy is 'vital' as is stakeholder buy-in. Still, communicating about and garnering acceptance of invasive species management approaches remains a pervasive challenge. Advanced information communication technologies (ICT), including augmented and virtual reality (AR and VR, respectively), show promise to meaningfully engage the public, increase their understanding of change and accept management. The Elaboration Likelihood Model posits message elaboration and attitude change emanates from engaging, personally and issue-relevant information. A paucity of research in ICT and invasive species management exists, however. As communication technologies advance and calls for expanded invasive species management research grow, this research explored if and how increasingly engaging communication mediums impacted visitor acceptance of select management treatments in response to a terrestrial invasive species: the emerald ash borer (*Agrilus planipennis*; EAB). EAB is a costly and destructive insect capable of tree death, killing trees in four years and entire ash forests within a decade. Globally, EAB's southward migration from Russia threatens olive plantations in Southern Europe and the Middle East and, in the United States, has been identified as one of the most damaging and costly forest-borer insects since its 2002 introduction. An experiment tested four informational mediums focused on forest management in response to EAB. Informational mediums included photos with text, AR, VR, and a control. The message content was consistent across mediums but communicated through increasing levels of interactivity, engagement, and, subsequently, presumed greater elaboration. Forested park visitors were randomly assigned to one of four informational mediums and, following message exposure, assessed the acceptability of select forest management treatments to EAB. Without any information, all management approaches except "doing nothing" were acceptable. Comparative analysis revealed that more engaging mediums influenced acceptance for nearly half of the treatment scenarios. Findings partially support previous research that messages incorporating the ELM, when used in an outdoor context can promote issue-relevant thinking and influence preferences and behavior intentions. Future research can broaden and refine the utility of AR and VR and managers can consider how to optimize resources and communication effectiveness.

New marine biosecurity toolkit for Pacific Island countries and territories

Kimberley Seaward [1], Henry Lane [2], Graeme Inglis [1], Bradley Myer [3] and Isabell Rasch [3]

[1] National Institute of Water and Atmospheric Research Ltd (NIWA), PO Box 8602, Riccarton, Christchurch 8440, New Zealand
[2] National Institute of Water and Atmospheric Research Ltd (NIWA), Private Bag 14901, Kilbirnie, Wellington 6241, New Zealand
[3] Secretariat of the Pacific Regional Environment Programme (SPREP), 46JM+5MG, Avele Rd, Apia, Samoa

kimberley.seaward@niwa.co.nz

The introduction and spread of marine non-indigenous species to Pacific Island countries and territories is a threat to biodiversity, economy, socio-cultural values, and in some cases even human health. The Global Environment Facility 6 (GEF6) Regional Invasive Project aims to reduce the threats from non-indigenous species to biodiversity in the Pacific by developing and implementing comprehensive national management frameworks. In response, NIWA worked with the Secretariat of the Pacific Regional Environment Programme (SPREP) to develop a Pacific Marine Biosecurity Toolkit. The toolkit was launched in March 2022 and contains a series of guidance documents to help tackle marine biosecurity issues and support government departments and ministries responsible for biosecurity and the management of invasive species. There are six key elements to the toolkit; these include species identification guides on known global marine invaders, guidance on performing biofouling and ballast water assessments with an easily accessible ballast water risk assessment tool. General sampling guidance to aid identification and preservation of specimens, and potential management and mitigation strategies for those species identified in the ID guides if they do arrive and establish self-sustaining populations.

Indigenous-led approaches to design and deliver effective biosecurity and invasive species management systems in Northern Australia

Andy Sheppard [1], Cathy Robinson [2], Andrew Hoskins [3], Justin Perry [4] and Ben Hoffmann [5]

[1] CSIRO, GPO Box 1700 Canberra ACT 2602, Australia
[2] CSIRO, GPO BOX 2583, Brisbane QLD 4001, Australia
[3] CSIRO, Private Mail Bag, Aitkenvale, QLD 4814, Australia
[4] NAILSMA, ATSIP Building 145, James Cook Drive, James Cook University, Townsville, QLD 4810, Australia
[5] CSIRO PRIVATE BAG NO 44, Winnellie, NT 0821, Australia

andy.sheppard@csiro.au

CSIRO has been supporting Indigenous-led biosecurity and invasive species management activities for a number of years in far north Queensland, the Northern Territory and Western Australia. These activities are focussed on vertebrate pest, invasive ant and weed management. The aim of these projects is to develop and provide Indigenous rangers and Indigenous businesses with technological and digital solutions tailored to their needs to assist them with collection of species distribution and abundance data, management planning, management decision making and near real time monitoring and evaluation capability to really support the development of cost-effective management approaches that support ecosystem restoration. All these projects take a multiple benefits approach, which includes not only conservation and biodiversity benefits for cultural assets On Country, but also supporting other benefits. For feral animal management these includes sustainable food harvesting, tropical animal disease management, effective herd control planning for culling programs and measuring and benefiting from carbon benefits from feral herd management. For invasive ant management these projects support Indigenous communities in localised effective eradication of invasive ants that are affecting both biodiversity and social wellbeing. For weed management the multiple benefits include the application of biological control for the effective widespread management of key invasive alien plants affecting environmental and cultural assets, and the restoration of critical wetlands as “bush supermarkets” that support indigenous livelihoods and protect iconic Indigenous cultural assets. In this talk we will cover a number of these projects in more detail highlighting how technology is leading to step changes in the planning and delivery of Indigenous-led invasive alien species management. Ultimately this goal is to support sustainable Indigenous livelihoods On Country in Australia.

Exploring the two-way relationships between fire and two Australian fire-adapted plant invaders to support ecosystem management

Joaquim S. Silva [1, 2], Ernesto Deus [1, 2], Mauro Nereu [1, 2], Luís Queirós [1, 2], Sheila F. Riveiro [3], Dionathan Gerber [2, 4] and Paulo Fernandes [5]

[1] Polytechnic Institute of Coimbra, Agriculture School, Bencanta, 3045-601, Coimbra, Portugal
[2] University of Coimbra, Centre for Functional Ecology, Department of Life Sciences, Coimbra, Portugal
[3] University of Santiago de Compostela, Department of Functional Biology, BIOAPLIC Group, 15782 Santiago de Compostela, Spain
[4] Polytechnic Institute of Bragança, Mountain Research Centre (CIMO), Campus Santa Apolónia, 5300-253 Bragança, Portugal
[5] University of Trás-os-Montes and Alto Douro, Centre for the Research and Technology of Agro-Environmental and Biological Sciences, Portugal

jss@esac.pt

The invasion by fire-adapted plants may create a feedback loop in which fire facilitates invasion, which in turn facilitates fire, due to fuel accumulation and increased fire hazard. This two-way relationship may have challenging implications for ecosystem management, namely by increasing the needs for fuel reduction and invasion control, while limiting the use of prescribed fire and other disturbance-based control approaches. This is the case of *Hakea sericea* and *Acacia dealbata* , two woody species of Australian origin that constitute a serious threat to native ecosystems in Central and Northern Portugal. *Hakea sericea* is a seeder featuring a canopy seed bank, while *A. dealbata* is a facultative resprouter that develops a soil seed bank. Both species form thick monospecific stands where native vegetation is in many cases totally suppressed. We studied the two-way relationships between fire and these two species, aiming at: a) assessing the changes in fire hazard in invaded areas and b) testing the use of disturbance-based treatments, including fire, for their control. *Hakea sericea* strongly increases fire hazard when compared with the most hazardous native fuel models of Central Portugal, as shown by fire behaviour simulations. In *A. dealbata* there is a considerable difference between young and adult stands, with the latter showing lower fire hazard compared to several native fuel models, due to the compacted litter and the suppression of understorey vegetation. The use of control techniques was tested through eight experimental blocks of treatments for each of the two species. Each block featured four treatments: slash, burn, slash-and-burn, and an undisturbed plot. Plots were monitored over 3 years to record stem density and stem height. Disturbance treatments applied to *A. dealbata* revealed to be ineffective showing an increase in stem density compared with the undisturbed plots. However, *H. sericea* stands were successfully eradicated by applying slash-and-burn treatments. A high residence time of the fire front seems to produce the best results. Therefore, the two fire-adapted invasive species revealed very distinct fire-related characteristics, and a very different response to the same treatments. Our results show that a one-size-fits-all approach is far from being appropriate in the management of fire-adapted invasive woody plants, calling for deep knowledge of the ecology and fuel characteristics of each particular species.

The ongoing challenge of managing fall armyworm: a west Australian perspective

Helen Spafford

Plant Biosecurity, Department of Primary Industries and Regional Development, Western Australia

helen.spafford@dpird.wa.gov.au

Fall armyworm, *Spodoptera frugiperda*, has proven to be a challenging pest to manage wherever it is found. After its incursion into Western Australia in early 2020, larvae were found infesting grass crops especially maize and sweetcorn throughout the northwest. We sought to rapidly answer four critical questions: (1) Where will fall armyworm be a problem? (2) What will it feed on? (3) How do we monitor for it? and (4) How can we manage it?

In Western Australia, maize and sweet corn have been substantially affected. Some growers are no longer planting sweet corn due to fall armyworm. Maize crops have decreased yields and now require substantial inputs to minimize damage. Other grass crops that have been fed upon by larvae include millet, sorghum, and Rhodes grass, but few horticultural crops have been affected. Our research found that fall armyworm could successfully complete development on weedy barnyard grass and pasture grasses, such as blue grass and sabi grass, though no field evidence has been found to date. It is clear from host use patterns overseas that there is potential for host expansion in Western Australia.

One of the initial challenges after incursion was identifying fall armyworm, especially young larvae, which look very similar to other noctuids that inhabit the same crops. We developed a LAMP assay that can be reliably used to identify eggs and young larvae. An additional challenge was obtaining an estimate of levels of infestation. Fall armyworm infestations begin in hotspots or patches that are often difficult to detect through traditional scouting. Although drone surveillance and satellite imagery has shown promise to detect fall armyworm in large acreages, we found the technology not fit for purpose at this time.

Existing and evolving pesticide resistance is an ongoing threat to successful management of fall armyworm. The pesticides that are available have variable levels of effectiveness and are not necessarily cost effective. Alternatives and integration of tactics needs to be developed especially as transgenic crops are not available in Australia. Natural enemies need to be included as part of the management strategy and while there are existing natural enemies already present and utilising fall armyworm, the augmentation and conservation of these needs to be researched further. As we reflect on the management of fall armyworm 3 years after invasion, the impacts and adaptiveness of this pest mean that developing a management strategy will require significant ongoing research.

Biological control programmes for the global invader *Drosophila suzukii*, Spotted-wing Drosophila

Judith Stahl [1, 2], Xingeng Wang [3], Paul Abram [4], Antonio Biondi [5], Matthew Buffington [6], Brian Hogg [7], Jane Lee [8], Fabrizio Lisi [2, 5], Lukas Seehausen [9] and Kent Daane [2]

[1] CSIRO Black Mountain, GPO Box 1700, 2601 Acton ACT, AUS
[2] Department of Environmental Science, Policy, and Management, University of California Berkeley, 130 Mulford Hall #3114, Berkeley, CA 94720-3114, USA
[3] Beneficial Insects Introduction Research Unit, Agricultural Research Service, United States Department of Agriculture, 501 South Chapel Street, Newark DE 19713-3814, USA
[4] Agriculture and Agri-Food Canada, Agassiz Research & Development Centre, 6947 Highway 7, PO Box 1000, Agassiz, British Columbia V0M 1A2, CA
[5] Department of Agriculture, Food and Environment, University of Catania, Via Santa Sofia 100, 95123 Catania, Sicily, IT
[6] Systematic Entomology Laboratory, Agricultural Research Service, United States Department of Agriculture, Smithsonian National Museum of Natural History, 1000 Madison Drive, Washington DC 20560, USA
[7] Invasive Species and Pollinator Health, Agricultural Research Service, United States Department of Agriculture, 800 Buchanan Street, Albany CA 94710, USA
[8] Horticultural Crops, Disease, and Pest Management Research Unit, Agricultural Research Service, United States Department of Agriculture, 3420 NW Orchard Avenue, Corvallis OR 97330-5098, USA
[9] Section Invasion Ecology, CABI Europe – Switzerland, Rue des Grillons 1, 2800 Delémont, Jura, CH

judith.stahl@csiro.au

Drosophila suzukii, also known as the spotted-wing drosophila, is an invasive agricultural insect pest that feeds on berries and cherries. Originally from Asia, it was first recorded in North America and Europe in 2008 and has since become the primary pest of soft-skinned fruit in these invaded areas. The insect has now also been reported in Africa, and climatic models suggest that it could thrive in New Zealand and parts of Australia, posing a significant threat to the horticultural industries in these regions. Current management relies predominantly on insecticide applications, which have had negative environmental effects and led to resistance development. Here I will give an overview of a more environmentally friendly management alternative that focusses on the use of parasitoids as biological control agents for *D. suzukii*. This will include our work on mass rearing and experimental releases for augmentative biological control using pupal parasitoids. Furthermore, I will specifically report on our national collaborative biological control programme that commenced in 2013 with foreign explorations in the native East Asia range of *D. suzukii* for candidate parasitoids that eventually culminated in the first releases of a classical biological control agent, a larval-pupal parasitoid against *D. suzukii* in the United States in 2022. Results from this work will inform proactive and future efforts of *D. suzukii* biological control in New Zealand and Australia.

New Zealand's contribution to a global solution: collaborative research approaches to developing new tools for managing the Brown Marmorated Stink Bug

Lloyd Stringer [1, 2], Gianfranco Anfora [3], Gonzalo Avila [4, 2], Eckehard Brockerhoff [2, 5, 6], Kevin Chase [7], Catherine Duthie [8], Matt Dyck [9], Kim Hoelmer [10], Kiran Horrocks [2, 11], Joseph Kaser [10], Andrew Liebhold [12], Rory MacLellan [13], Valerio Mazzoni [14], Daniel Miller [15], Nam Hải Nguyễn [16], Laura Nixon [17], Anna Rathé [18], Gerardo Roselli [3], Taylor Welsh [19], Jin-Ping Zhang [20] and Max Suckling [1, 2]

[1] The New Zealand Institute for Plant & Food Research Limited, Lincoln, New Zealand
[2] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)
[3] Centre Agriculture Food Environment, University of Trento, San Michele all'Adige, Italy
[4] The New Zealand Institute for Plant & Food Research Limited, Auckland, New Zealand
[5] Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf, Switzerland
[6] School of Biological Sciences, University of Canterbury, Christchurch, New Zealand
[7] Bartlett Tree Research Laboratory, Charlotte, North Carolina, United States of America
[8] Ministry for Primary Industries, Wellington, New Zealand
[9] Kiwifruit Vine Health, Mount Maunganui, New Zealand
[10] Beneficial Insects Introduction Research Unit, USDA-ARS, Newark DE, United States of America
[11] Agroscope, Reckenholzstrasse 191, 8046 Zürich, Switzerland
[12] US Forest Service Northern Research Station, Morgantown, WV, United States of America
[13] Biosecurity New Zealand, Wellington, New Zealand
[14] Research and Innovation Centre, Fondazione Edmund Mach, San Michele all'Adige (TN), Italy
[15] USDA Forest Service, Southern Research Station, Athens, GA, United States of America
[16] Department of Agricultural Life Science, Sunchon National University, South Korea
[17] USDA-ARS Appalachian Fruit Research Station Kearneysville, WV, United States of America
[18] Horticulture New Zealand, Wellington, New Zealand
[19] Scion, Christchurch, New Zealand
[20] CABI East Asia and South East Asia, Beijing, P. R. China

lloyd.stringer@plantandfood.co.nz

Halyomorpha halys, the Brown Marmorated Stink Bug (BMSB), is a highly-damaging invasive non-native species in parts of North America and Europe. It is present in South America and likely to invade more areas globally. When it was discovered outside of its natural range, there was little knowledge about this insect and even fewer tools to manage it. Today, a number of tools have been developed for BMSB pest management and eradication that are ready for field validation prior to deployment in an incursion response. This has been achieved through a multi-partner, cooperative science collaboration in New Zealand as well as valuable international collaborations. A pre-emptive cost-sharing approach for readiness and response research between the New Zealand government and a number of industry bodies facilitated by the Government Industry Agreement is also in place. This paper discusses the development of some response tools like the pre-emptive biological control studies on *Trissolcus japonicus*, surveillance and management with semiochemicals, and the sterile insect technique. This has only been successful due to the collaborative nature of all those involved.

Educative biosecurity trails in New Zealand botanic gardens

Nicola Sullivan [1], Manoharie Sandanayaka [2, 3], Natalie Page-Weir [2, 3], Vicky A. Davis [2, 3], Hone T. Ropata [2, 3] and David Teulon [1, 3]

[1] The New Zealand Institute for Plant & Food Research Ltd, Private Bag 4704, Christchurch 8140, New Zealand
[2] The New Zealand Institute for Plant & Food Research Ltd, Private Bag 92169, Auckland 1142, New Zealand
[3] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

nicola.sullivan@plantandfood.co.nz

New Zealand has recognised the importance of recruiting a 'Team of 5 Million' to address its current and future biosecurity challenges. To do this, the general population must be engaged in appropriate ways and in locations familiar to them. With our botanic garden colleagues, we have established educative Biosecurity Trails in the Auckland Botanic Gardens (April 2019), the Christchurch Botanic Gardens/Te Māra Huaota o Waipapa (May 2021) and the Wellington Botanic Garden ki Paekākā (July 2021). Each Trail consists of between 7 and 12 'stations', each located beside a selected plant species, with information on important invasive pest or pathogen species that threaten these plants. Images of the invasive pests or pathogens are displayed at each station along with information about their host plant ranges. Visitors can scan a QR code at each station to access either a video or a website for additional information. Biosecurity threats to taonga, plants of particular importance to Māori, are also outlined. A pamphlet provides an illustrative map and summary of the complete Trail, general advice on how to prevent/minimise the entry of invasive pests and diseases into New Zealand, and how to minimise/control their spread if they arrive here. The Trails have become a useful teaching resource for local school students, and we are looking to make them more interactive, for example, by adding life-sized model organisms attached to the plant.

An abstract for a presentation at the pre-Congress workshop on the Value of Botanic Gardens to Biosecurity

Survey and monitor techniques of ʻŌhiʻa impacted by Ceratocystis wilt

Dustin Swan [1], Kepano Carvalho [2], Riley De Mattos [3], Naia Odachi [4] and Brian Tucker [5]

[1] Big Island Invasive Species Committee, Research Corporation of the University of Hawaii, Hilo, HI, USA
[2] Oahu Invasive Species Committee, Research Corporation of the University of Hawaii, Kailua, HI, USA
[3] Department of Land and Natural Resources, Division of Forestry and Wildlife, Hilo, HI, USA
[4] Spatial Data Analysis & Visualization Research Laboratory, University of Hawaii at Hilo, Hilo, HI, USA
[5] Research Corporation of the University of Hawaii, Hilo, HI, USA

dswan@hawaii.edu

Rapid ʻŌhiʻa Death (ROD) is a fungal disease causing mass mortality to the keystone forest tree species (*Metrosideros polymorpha*) in Hawaiʻi. The potentially devastating impacts to native ecosystems and watersheds are a top concern throughout the state, and have prompted a multifaceted interagency response. Land managers and research partners in Hawaiʻi continue working to identify best practices for locating new outbreaks and tracking the spread of the pathogen throughout the islands. Integrating new technologies into these efforts has been essential for a rapid response to the disease, and efficient collaboration between the various organizations involved. A few of the tools that will be discussed include: aerial mapping and tracking using a platform designed by the US Forest Service to monitor forest health from a helicopter with a consumer-grade tablet, using drones (sUAS) and high-resolution satellite imagery for detecting and directing sampling efforts, and field data collection on phones/tablets for sharing data in real-time with partners across the state.

Leveraging technological advances in robotics and computer vision for management of marine pests

Leigh Tait [1], Jeremy Bulleid [1], Daniel Clements [2], Rose Pearson [1], Lily Pryor Rodgers [1] and Graeme Inglis [1]

[1] National Institute of Water and Atmospheric Research (NIWA), 10 Kyle St, Riccarton 8011, Christchurch, New Zealand
[2] National Institute of Water and Atmospheric Research (NIWA), Hillcrest, Hamilton 3251, Christchurch, New Zealand

leigh.tait@niwa.co.nz

Detection, management, and control of biological invasions in marine systems is inherently restricted by the aquatic medium. To enhance our underwater capabilities, we must increasingly leverage emerging tools which can complement, replace, or optimise traditional techniques. Here we summarise the latest advancements in remote operated vehicles (ROV), active acoustics, and computer vision techniques for the detection and geolocation of submersed marine pests. We show that ROVs provide comparable detection sensitivities as specialist divers. However, current ROV methods are unable to approach the same efficiencies as dive teams as expressed in costs per unit time (ROVs detected 0.2 NIS min^{-1} compared to divers 0.5 NIS min^{-1}). Here we present progress in improving the efficacy and efficiency of remote vehicles including the application of computer vision algorithms for improving the efficiency of imagery processing. We identify advances and prospects of autonomous vehicles for collecting data on scales orders-of-magnitude greater than current methods and present research using active acoustics (i.e., sonar) to overcome severe limitations in water clarity which are problematic for divers and camera-based systems. While the marine environment presents significant challenges to detecting, delimiting, and managing pests, we present technological solutions that can improve outcomes for marine biosecurity.

Working towards strengthening the biosecurity capability in the Cook Islands

Piriariki Maao [(1)], Pavai Taramai [(1)], Ngatoko Ngatoko [(1)], Cecilia Samuela Touariki [(1)] and James Haw [(2)]

[(1)] Biosecurity Division, Ministry of Agriculture, Arorangi, Rarotonga, Cook Islands
[(2)] Plant Health and Environment Laboratory, Ministry for Primary Industries, Christchurch, New Zealand

pavai.taramai@cookislands.gov.ck

Since year 2018, the Ministry of Agriculture (MOA) Cook Islands and the New Zealand's Ministry for Primary Industries (MPI) have been working together to strengthen the biosecurity capability of the Cook Islands through a New Zealand Ministry of Foreign Affairs and Trade funded Aid project. Since the commencement of the programme, several training sessions have been conducted in the Cook Islands as well as in New Zealand, mostly focusing on insect pest diagnostics and surveillance. Since 2022, the programme has further expanded to also include plant disease diagnostics, strengthening border clearance services, establishing new pest surveillance programmes, and providing animal health support. In the 2022/2023 financial year, five improvements were made. 1) Two biosecurity officers from Rarotonga joined a 9-week border clearance services training in New Zealand, which provided them with an opportunity to observe the processes at MPI and analyse our own systems to suggest enhancements. 2) MOA staff attended a 2-week disease diagnostic training in New Zealand, learning how to isolate and identify plant pathogens. 3) A surveillance system was set up in Rarotonga for a quarantine pest fall armyworm (*Spodoptera frugiperda*) and laboratory staff were trained on how to identify suspect fall armyworm finds. 4) A Remote Microscopy Diagnostic (RMD) system was established between MOA and MPI laboratories to enable real time microscopic examination sessions to support pest diagnostics in the Cook Islands. 5) MOA staff participated in a variety of training sessions to enhance our disease investigation and baseline surveillance capability in animal health area. These activities have greatly improved the biosecurity capabilities in the Cook Islands and the benefits and implementation challenges will be further discussed.

CRB invasion genomics for biosecurity and management strategies

Wee Tek Tay [1], A Popa-Baez [1], A Gofton [1], A Bachler [1], T Hogarty [1], R Rane [2], MJ Melzer [3], D Cho [1], AL Blas [4], GFJ Dulla [5], J Sundalangi [6], M Hosang [7], T Jackson [8], S Marshall [8], JC Alouw [9], M Faheem [10], L Perera [11], K Gordon [1], BD Hoffmann [12]

[1] CSIRO Black Mountain Science & Innovation Park, Clunies Ross Street, ACT 2601, Australia
[2] CSIRO, 323 Royal Parade, Parkville, VIC 3052, Australia
[3] Plant and Environmental Protection Sciences, University of Hawaii, 3190 Maile Way St. John 315, Honolulu, HI 96822, USA
[4] CRB Management Prrogram, Guam Department of Agriculture, Biosecurity Division Guam
[5] College of Natural and Applies Sciences, Western Pacific Tropical Research Center, University of Guam, Guam
[6] Indonesian Palm Crops Research Institute, Indonesia
[7] Indonesia Palm Research Institute, Indonesia
[8] AgResearch New Zealand, 1365 Springs Road, Lincoln 7674, Christchurch 8140, New Zealand
[11] Ministry of Primary Industries, New Zealand
[12] CSIRO Health & Biosecurity, PMB 44, Winnelllie, NT 0822, Australia

weetek.tay@csiro.au

The economically and ecologically important coconut rhinoceros beetle (CRB) *Oryctes rhinoceros* is a highly damaging pest within Pacific Island countries and territories (PICTs). Management of CRB in PICTs has traditionally relied on the Oryctes rhinoceros Nudivirus (OrNV). Recently, a CRB population that is seemingly resistant to OrNV (CRB-G), has been identified based on partial molecular characterisation of the mitochondrial DNA cytochrome oxidase subunit I (mtCOI) gene. CRB-G populations have increasingly been detected in different PICTs and may explain the increased severity of damage symptoms observed in coconut palms within these countries. We conducted whole genome sequencing to characterise populations of CRB from PICTs, and used our findings to evaluate OrNV biocontrol management efforts for CRB. We present our results on genetic distinctiveness and spread of CRB-G populations, and highlight future research needs for the management and biosecurity preparedness of this priority pest species across the Pacific.

Coconut Rhinoceros Beetle in Papua New Guinea: An ongoing threat

David Tenakanai

National Agriculture and Quarantine Inspection Authority , G55V+XF8, Port Moresby, Papua New Guinea

dtenakanai@naqia.gov.pg

The Coconut Rhinoceros Beetle (CRB), first reported during the 1950s, is a major agricultural pest in Papua New Guinea, causing significant damage to coconut and other palm trees. This has caused significant losses for local farmers, as the destruction of their crops leads to a decrease in their income and an increase in their vulnerability. In addition, the destruction of valuable timber trees has led to a decrease in the availability of wood for construction and fuel. A new CRB haplotype (CRB-G) was discovered in National Capital District (NCD) in 2012/13 and has since been spreading rapidly. This haplotype has been found to be more aggressive than the original CRB, leading to increased damage in coconut and other palm trees. As this new haplotype is more resistant to traditional control methods, it is likely that its spread in the country will continue unless new methods of control are developed. Here, we examine the ongoing challenges posed by the CRB in Papua New Guinea and describe some of the current work for controlling and mitigating its effects.

The mechanism of polyploidy-enhanced photosynthetic capacity endowing *Solidago canadensis* L. with heat tolerance

Zhongsai Tian [1], Jiliang Cheng [1, 2], Dongyan Feng [1], Shiguo Chen [1], Xianghong Yang [1], Timothy Grey [3], Sheng Qiang [1]

[1] Weed Research Laboratory, Nanjing Agricultural University, Nanjing 210095, China
[2] Guangdong Provincial Research Center for Environment Pollution Control and Remediation Materials, College of Life Science and Technology, Jinan University, Guangzhou 510632, China(
[3] Crop and Soil Science Department, University of Georgia, Tifton, GA 31794, USA

2018216004@njau.edu.cn

Polyploidization-enhanced heat tolerance drives the global geographical differentiation of *Solidago canadensis* through maintaining photosynthetic capacity under heat stress; however, the physiological and molecular mechanisms involved in the photosynthetic process remain unclear. Here, the variability of photosynthetic capacity and heat tolerance of native and introduced diploid, tetraploid, and hexaploid *S. canadensis* was investigated using fast chlorophyll a fluorescence rise O-J-I-P and ChlF parameters. Furthermore, the transcriptome of the native and introduced diploid and hexaploid at ambient and high temperatures was performed to compare the differentially expressed photosynthesis-related genes. The results showed that significant differentiation of photosynthetic capacity existed between diploidy and polyploidy populations, in particular, in the introduced ranges. The heat stress caused less inhibition of the oxygen evolution complexes (OEC) and inactivation of PSII reaction centers (RCs) in polyploids than in diploids. Ploidy, latitude, and ambient temperature significantly influenced the differentiation of photosynthetic capacity and heat tolerance of *S. canadensis*, and there was a significant correlation between ambient temperature, latitude and heat tolerance of *S. canadensis*. Photosynthesis-related genes, especially light reaction-related genes, were significantly enriched under high temperature, and expression of these genes was higher in hexaploids than in diploids. Therefore, polyploidization-driven rapid adaptive evolution in photosynthetic ability conferred *S. canadensis* with heat tolerance leading to its successful invasion. This study provides a systematic physiological and gene expression profile in the photosynthetic response of *S. candaensis* to heat stress, which may provide a new insight into the mechanism of plant invasion.

Using the PRONTI tool to select non-target scale species for prey-range testing with *Neoleucopis* n. sp. B (Diptera, Chamaemyiidae)

Jacqui Todd [1, 2], Umar Lubanga [3], Nick Collinson [3], Penny Mills [4] and Greg Lefoe [3]

[1] The New Zealand Institute for Plant & Food Research Limited, Private Bag 92169, Auckland 1142, New Zealand
[2] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)
[3] Department of Energy, Environment and Climate Action, Agriculture Victoria, AgriBio Centre, Bundoora, VIC 3083, Australia
[4] School of Biological Sciences, The University of Queensland, St Lucia [Brisbane] Qld 4072

jacqui.todd@plantandfood.co.nz

The giant pine scale (GPS), *Marchalina hellenica* (Hemiptera, Margarodidae), was detected in Australia in 2014. The species has become a pest, causing damage to *Pinus radiata* trees in Melbourne's urban and peri-urban settings where the scale is currently contained. The species is a threat to the Australian pine forest industry and would likely also be a threat to the New Zealand pine industry if it arrives here. A predatory biological control agent (BCA), the chamaemyiid fly *Neoleucopis* n. sp. B, has been collected from Greece, the native range of GPS. Australia has a significant and unique scale fauna. Release of this predatory fly could pose a risk to non-target scale species; however, it is impossible to conduct prey-range tests to assess this risk with every non-target scale species within Australia. To aid the selection of non-target species for testing, we used the PRONTI (priority ranking of non-target invertebrates) decision-support tool. Data on 127 non-target scale species were entered into the Eco Invertebase, a database that forms the basis of the PRONTI tool. This data was used to inform five selection criteria: (1) the potential hazard posed by the BCA to each non-target species; (2) the potential degree of exposure of each non-target to the BCA; (3) the hypothetical ecological impact that may result from the exposure of the non-target to the hazard; (4) the estimated economic, social and cultural value of each non-target; and (5) the assessed ability to source each non-target and to conduct tests. These criteria were used to rank the non-target species for testing using the PRONTI model. The resulting prioritised list will be presented, along with an assessment of the uncertainty in the rankings, and a discussion of how the list could be used to select species for quarantine-based prey-range tests.

Engaging with and learning from how Indigenous Rangers contribute to biosecurity in Northern Australian

David Cann and Renae Todd

Indigenous Ranger Biosecurity Program (IRBP)
Department of Agriculture, Fisheries and Forestry, Australia.

david.cann@aff.gov.au

Northern Australia is a unique biosecurity operating environment, with a vast coastline, sparse population, and the risk of biosecurity incursion through unregulated pathways. In recognition of these considerations, the Indigenous Ranger Biosecurity Program (IRBP) engages Traditional Owners across northern Australia to conduct surveillance for invasive plant, animal, and aquatic pests and diseases. Sixty-five Indigenous ranger group organisations from Western Australia, Northern Territory and Queensland have fee-for-service contracts with the Department of Agriculture, Fisheries and Forestry (DAFF) to complete biosecurity activities as part of the IRBP.

The IRBP consists of three key tenets – scientific rationale, a focus on enhancing rangers and ranger group capability, and community engagement. Scientific support and training are provided by the Northern Australia Quarantine Strategy, a DAFF program that has conducted surveillance in the region for over 30 years. Capability is built through a series of grants, training workshops and procurement of equipment. Engagement with Indigenous rangers acknowledges their deep connection to Country, traditional methods of protecting Country, and the threats that biosecurity incursions hold for Aboriginal and Torres Strait Islander lore, culture, and way of life. The IRBP employs Community Liaison Officers (CLO) to engage rangers through on-Country visits, and successive evaluations of the program have highlighted the importance of the CLO network to the ranger groups they work alongside.

As both the biosecurity and cultural value of the IRBP, and the awareness and capability of Indigenous rangers to conduct biosecurity surveillance alongside it, continues to grow, opportunities exist to learn from past experiences, to amplify the role of First Nations people in designing and building similar programs, and to strengthen biosecurity networks into the future.

The breakthrough science needed for Predator Free 2050 success

Dan Tompkins

Predator Free 2050 Limited, PO Box 106040, Auckland 1143, New Zealand

dant@pf2050.co.nz

A key purpose of Predator Free 2050 Limited is to drive the breakthrough science needed for mission success – the elimination of possums, rats, and mustelids from the country. This is a critical role as there is little or no other strategic investment for this purpose, yet the need for science breakthroughs for the mission to be achievable was fully acknowledged at mission launch in 2016. Here I outline the priority outcomes of the mission that are most in need of breakthrough science advances to achieve, and a transparent assessment of the likelihood of different research activities in meeting those needs. This assessment forms the basis of a 'minimum viable proposition' (MVP) research pathway for best achievement of the mission interim target to "develop a breakthrough science solution to eradicate at least one small mammal predator from the New Zealand mainland". I conclude by presenting the steps taken by Predator Free 2050 Limited to build this research pathway, and the gaps still to be filled for this MVP to have at least some chance of successfully achieving the mission's breakthrough science interim goal.

Aotearoa New Zealand's Biosecurity System for the future

Stu Hutchings, Aliki Weststrate, Ursula Torres and Eden Skipper

Ministry for Primary Industries, Charles Ferguson Building, Ballantrae Place, Pipitea, Wellington 6011

ursula.torres@mpi.govt.nz

New Zealand places significant importance on biosecurity because it helps us to protect our valued productive species, biodiversity, our culture, our livelihoods, and our health. While our biosecurity system has served us well, the threats we face are growing in scale and complexity, with changing risk pathways, climate change, and pressure from established pests. Moreover, our biosecurity system is a multi-layered, interconnected network of people, infrastructure and technology, processes, and regulatory activities. A strengthened, more strategic, and strongly led biosecurity system should be better at coping with emerging threats. A new national strategy is being developed with the intent to inform the overall strategic direction for biosecurity in Aotearoa New Zealand, beyond 2025 and over the long term. This strategy is being developed through engagement with stakeholders and review of key strategic documents. This talk will present progress so far on the development of the strategy. Six key strategic priority areas have been identified for the system to operate more effectively and collaboratively along with objective and activities to support these areas. A thriving, well-functioning biosecurity system will provide direct outcomes such as improved protection of our indigenous and valued introduced species, biodiversity, ecosystems and landscapes. It will enable safe travel, trade and food supplies, and protect our cultural, social, and economic wellbeing.

3D-printing of the brown marmorated stink bug for community engagement

Joel Tregurtha [1], Te Matau O. Te Rangi Allen [2, 3], Euan R. Coutts [1], Ali Reza Nazmi [1], Paul Tolson [1], Brenda Greene [4], David A.J. Teulon [2, 3]

[1] School of Product Design, Te Kura Hanga Otinga, University of Canterbury, Private Bag 4800, Christchurch 8041
[2] New Zealand Institute for Plant & Food Research Ltd, Private Bag 4704, Christchurch 8140
[3] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)
[4] UC Biosecurity Innovations, Te Rōpū Rangahau, University of Canterbury, Private Bag 4800, Christchurch 8041

jtr61@uclive.ac.nz

Effective biosecurity relies on an informed and engaged public, yet many are unaware of invasive species' threat to Aotearoa New Zealand's valued plant systems. One such biosecurity threat is the brown marmorated stink bug (BMSB) (*Halyomorpha halys*). This work aimed to build an accurate 3D-printed model using a suitable material, assess options for producing 3D-printed BMSB models for educational use, and raise awareness about BMSB and other similar invasive species. A digital model of an adult BMSB was sculpted in Blender software with combined and independently designed features. Reference images of adult BMSBs were used to make the model as scientifically accurate as possible. Characteristics of an adult BMSB were applied to the bug's body (head, thorax and abdomen), legs, and antennae, in the digital model from high-resolution images to inform the visual finishing of 3D-printed models. Additional design steps improved the 3D-printed model's resolution and structural integrity. Digital models were then printed using different printing technologies and materials. 3D printing was performed using fused deposition modelling (FDM) and stereolithography (SLA) printers with various materials and printer settings to achieve the best results. The digital and 3D-printed models were optimised iteratively based on repeated trials, each informing potential for specific usage. To improve the handling properties and robustness of the 3D prints, the legs and antennae were thickened to three times their proportions relative to the body. For some larger models, stickers with characteristics of the BMSB's dorsal and ventral body were carefully designed using Blender, Photoshop, DALL-E 2, and Illustrator, printed, cut using a vinyl printer, and pasted onto 3D-printed models. Our results displayed the advantages and disadvantages of each printing technology and material. A range of prototypes, digital and 3D-printed models, have been developed for application in various educational and communication settings. Models can be used to raise awareness of biosecurity and the danger of invasive species in Aotearoa New Zealand.

How can we get people to care about invasive species management? Insights from recent social research in Australia

James Trezise [(1)], Amber Sprunt [(1)], Tania Sincock [(1)], Gabriel George [(1)], Peter Lewis [(2)], Hannah Barnett [(2)], Jane Garcia [(2)] and Mayank Gurani [(2)]

[(1)] Invasives Species Council PO Box 818, Katoomba NSW 2780
[(2)] Essential Media Company, Level 1, 341 George St, Sydney, NSW 200

jamest@invasives.org.au

Invasive species have been a major driver of biodiversity decline and extinction in Australia. Research has shown that invasive animals, plants and pathogens have been the primary driver of more than 40% of Australia's known or recorded extinction events. Feral cats alone have been implicated in the extinction of at least 27 mammal species. Despite the impacts of invasive species being well documented, their management and control can be some of the most controversial and contested conservation policy areas. The Invasive Species Council has worked with national polling and social research company Essential Media to better understand the Australian public's attitudes towards native biodiversity conservation and invasive species management. The project spanned 6 months and utilised both quantitative polling analysis and in-depth focus groups across a range of communities to explore perceptions of invasive species management. This included understanding different communities' engagement with invasive species issues in the context of Australia's biodiversity crisis, community attitudes towards different control methods and new technologies (such as bio-controls) along with people's willingness to engage in general biosecurity surveillance. The project also explored community perceptions of some of Australia's most controversial invasive species management issues, including the control of feral horses in the Australian Alps, managing domestic and feral cats as well as attitudes toward the growing risk of feral deer across the country. The results of the project presented a series of recommendations and a framework for how to effectively communicate with different audiences on controversial and challenging invasive species management issues that will have broad applications for researchers, campaigners, practitioners and policymakers alike.

Leveraging biodiversity infrastructure for biosecurity surveillance and analysis

Andrew Turley, Cameron Slatyer, Donald Hobern, Martin Westgate and Erin Roger

Atlas of Living Australia (CSIRO) GPO Box 1700, Canberra ACT 2601

andrew.turley@csiro.au

Introduced and invasive species now make up a significant proportion of all species recorded in Australia, but until recently the data to show this has been elusive. The Atlas of Living Australia (ALA) is an open access biodiversity data infrastructure, which has been aggregating occurrences of all species within Australia since 2009. The ALA holds records of at least 2,383 exotic species and over 1.9 million occurrences of pests, weeds, and diseases; many of which are reported though citizen science. Through the aggregation of data from over 850 data partners and leveraging existing biodiversity infrastructure, the ALA is now able to provide an integrated view of invasive species across Australia. ALA's data was critical to Australia's most recent State of the Environment report, where it was used to show changes in the prevalence of exotic species in Australia and helped identify invasive species as the most common pressure on Australian native fauna. Despite this success, significant challenges remain. Here, we discuss how we are approaching user concerns around taxonomy, data standards, and sensitivities in aggregating biosecurity data. We conclude by detailing our work to expand the aggregation of invasive species data into the ALA and how it will help protect Australia's agricultural, forestry and fisheries exports, as well as our environmental assets.

Refined forecasting capabilities to diagnose Trans-Tasman Dispersal within Aotearoa/New Zealand dispersal of Fall Army Worm

Richard Turner [1], Stuart Moore [1] and Scott Sinclair [2]

[1] NIWA, 301 Evans Bay Parade, Hataitai, Wellington 6021
[2] Ministry for Primary Industries, Charles Fergusson Building, 34-38 Bowen Street, Pipitea, Wellington 6011

richard.turner@niwa.co.nz

NIWA (National Institute for Water and Atmospheric Research, New Zealand) operates the NAME-III (Numerical Atmospheric-dispersion Modelling Environment) dispersion for use in modelling long-range aerial dispersal of pathogens such as Trans-Tasman movement of Myrtle Rust down to the potential farm-to-farm movement of Foot-and-mouth virus. With respect to the current Fall Army Worm (*Spodoptera frugiperda*) incursion, NIWA has deployed "Trans-Tasman" and "within-country" configurations of NAME-III to evaluate when Fall Army Worm could have dispersed to different regions of New Zealand from various source regions in Australia and to also evaluate where moths may have dispersed from known (trap) locations within New Zealand. The 4 km grid-spaced Trans-Tasman weather model (NZLAM4) and the 1.5 km New Zealand regional model were both used to provide detailed wind and weather analyses to NAME-III. With the investment in the weather model and NAME development and automation over the past few years, these detailed analyses and "forecasts" can be done very efficiently and are much less labour-intensive than in the past. Details and results of the NAME modelling will be presented in the talk. Fall Army Worm was first trapped in the Waikato in mid-April 2022 and in other parts of the North Island such as Gisborne, Auckland and Northland in the weeks and months following. Thus far simulations have been done for the period February and March of 2022 prior to the first trap capture to identify likely dates of arrival and to try and assess whether other trap captures were due to long-range or domestic dispersal. The initial indications are that there were few opportunities for Trans-Tasman dispersal to occur in this 2-month period and further runs for Jan 2022 and for the April to October 2022 are now underway. Forecast dispersal simulations have also been conducted in real-time as of November 2022 to February 2023 to assess the likelihood of further dispersal to New Zealand as well as to indicate likely areas where new trap captures could occur.

How many ways are there to manage the biosecurity risks from global trade?: A Menu of Measures for effective risk reduction.

Rieks D. van Klinken and Jane Muller

CSIRO Health and Biosecurity, Brisbane, Australia

rieks.vanklinken@csiro.au

Global trade brings significant biosecurity risks that regulators must manage whilst minimising restrictions to trade. At the same time, production and supply chains are becoming increasingly sophisticated through the use of technology. Technological advancements provide considerable opportunity for innovative approaches to managing biosecurity risks. To support this transition, we have developed a clear conceptual risk framework, or "*Menu of Measures*", that organises the diversity of phytosanitary measures currently in use to manage plant biosecurity risks across all managed pathways. From a comprehensive global literature review of more than 1800 measures, we identified 39 unique types of measures that each reduce risk in different ways. These were classified according to how they reduce risk under four risk reduction objectives (minimise exposure to pests, reduce host vulnerability, reduce infestation rates and reduce establishment risk), and where they can be applied in the production system or supply chain. The conceptual framework developed is relevant to the diversity of possible trade pathways, such as fruit, grain, shipping containers and vehicles, and the plant pests, such as insects, pathogens and weeds, that they can host or carry. Importantly, we considered both phytosanitary measures that are mandated by regulators and "commercial measures" that reduce risk but are not necessarily officially mandated or monitored. The resulting Menu of Measures provides regulators and industry with a comprehensive range of options to select from, and is intended to facilitate harmonisation of approaches to phytosanitary risk management. The review highlighted a lack of agreement regarding how efficacy and compliance for many of the measures should be demonstrated, potentially contributing to their underutilization. For example, advanced optical grading technologies are widely used to quality-grade fruit, but agreed methods for quantifying the contribution of such technologies to biosecurity risk reduction through the removal of infested fruit is lacking. This is now a focus of ongoing research and consultation. The Menu of Measures offers a foundation for industry and regulators to develop innovative approaches to effectively manage biosecurity risks. The use of technology in the production and supply chain should contribute to this and will be a key focus for future implementation.

Preparing for a *Xylella* incursion: Presence and movement of spittlebugs in New Zealand landscapes

Jessica Vereijssen [1, 7], Simon Bulman [1, 7], Rebecca Campbell [2, 7], Kate Colhoun [3, 7], Gabby Drayton [1, 7], Ronny Groenteman [4, 7], Aliesha Kean [1, 7], Mette Nielsen [1, 7], Joanne Poulton [5, 7], Joanna Sharp [1, 7], Tara Taylor [6, 7] and Lisa Watkins [1, 7]

[1] The New Zealand Institute for Plant & Food Research Limited, Private Bag 4704, Christchurch Mail Centre, Christchurch 8140, New Zealand
[2] The New Zealand Institute for Plant & Food Research Limited, 55 Old Mill Road, RD 3, Motueka 7198, New Zealand
[3] The New Zealand Institute for Plant & Food Research Limited, 990 Earnscleugh Road, RD 1, Alexandra 9391, New Zealand
[4] Manaaki Whenua Landcare Research, PO Box 69040, Lincoln, New Zealand
[5] The New Zealand Institute for Plant & Food Research Limited, Private Bag 92169 Auckland 1142, New Zealand
[6] The New Zealand Institute for Plant & Food Research Limited, Private Bag 1401, Havelock North 4157, New Zealand
[7] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

jessica.vereijssen@plantandfood.co.nz

True spittlebugs (Aphrophoridae) are known vectors of *Xylella fastidiosa* (Xf) overseas, but information on endemic and exotic spittlebugs in New Zealand is rare and outdated. To prepare for an incursion of Xf in New Zealand, we investigated which spittlebug species are present in New Zealand's productive areas and the adjacent natural vegetation, and if they move between these areas. Structured sampling was conducted in citrus in Kerikeri, apricot orchards in Clyde, and vineyards in Hawke's Bay and Waipara. There were three to four survey sites in each region. We sampled in the productive area and adjacent natural vegetation, as well as on the border between the two from 2020 to 2022 in the spring-summer period using multiple established techniques. The number of spittlebugs caught differed between the four regions, with none caught in Kerikeri and most caught in Waipara. Ninety-nine percent of the specimens caught were the exotic meadow spittlebug (*Philaenus spumarius*). At the sites where spittlebugs were confirmed, movement between the natural vegetation and crops was detected. We complemented our structured sampling with opportunistic sampling in other landscapes to obtain as many species as possible. This sampling showed that the endemic spittlebug species were primarily present in larger areas of native vegetation. All spittlebugs were morphologically identified to species where possible. Single legs were taken from selected individuals for future DNA barcode identification. We have started the next phase where we will use the presence and movement data in mechanistic simulation modelling to understand the level of risk associated with these vectors moving from the surrounding vegetation onto nearby crops in varying landscapes.

Phytophthora cinnamomi in a changing climate

Leann Vinson

School of Biological Sciences, Univeristy of Canterbury, Christchurch, New Zealand

leann.vinson@pg.canterbury.ac.nz

Phytophthora cinnamomi is an hemitrophic oomycete that exhibits a broad host range observed on a global scale. *P. cinnamomi* disperses via soil run off, streams, animals or antropogenetic activities during warm and wet weather. Given the increasing risks posed by climate change, the expected global climate patterns have begun to shift. This results in an increased temperature in colder regions and a decline in warmer regions. This gradual change impacts native flora and fauna, potentially driving adaptation, migration or, in extreme cases, extinction of plant species. Climate change causes irregular weather events, including changes in temperature and rainfall patterns, leading to drought, flooding and increased soil salinity. Pathogens exposed to climate change may experience both positive and negative effects on pathogenicity, host range and global spread. This raises important questions regarding the future development of biosecurity, forestry and agricultural sectors in response to potential increased pathogen threats. Our research focuses on how climate change induced by drought and salinity stress affect *P. cinnamomi* performance and respectively, its interaction with host plants. To investigate the potential impacts of climate change on *P. cinnamomi*, we conducted a study utilizing 25 *P. cinnamomi* samples subjected to osmotic and salinity stress conditions through the exposure of varying concentrations of polyethylene glycol (PEG) and sodium chloride (NaCl), respectively. A range of *P. cinnamomi* factors, including mycelial growth, zoospore production, reactive oxygen species (ROS) levels, physiological characteristics, as well as proteomic were analysed under these stress conditions. Our results demonstrate that exposure to various concentrations of PEG and NaCl did not significantly affect the growth of *P. cinnamomi*. Interestingly, *P. cinnamomi* displayed an enhanced capability to thrive under the applied stress conditions, growing at a significantly accelerated rate compared to the non-stressed control group. Moreover, preliminary observations suggest that *P. cinnamomi* zoospores exhibit high abundance under abiotic stress conditions. Notably, we anticipate that ROS levels will increase in response to the rising stress treatment concentrations during ROS detection. In addition, we predict that stress-related proteins and genes will be upregulated. These findings may suggest that *P. cinnamomi* has undergone adaptations to stress conditions, or possess mechanisms that trigger accelerated growth, thereby facilitating its transmission and promoting survival in an unfavourable environment, i.e., drought and salinity stress. Furthermore, this research aims to provide insight into the interplay between heightened pathogen performance and host plant immunity, as well as the potential implications of prolonged exposure to climate change on native ecosystems and its implications for the future of biosecurity in Aotearoa New Zealand.

Bringing tikanga Māori (Māori values) into biosecurity research: Te Haere huihui tahi (A journey gathering together)

Teresa Waiariki [1, 3], Waipaina Awarau-Morris [2, 3], Alby Marsh [1, 3], Mark McNeill [2, 3] and Virginia Marroni [1, 3]

[1] The New Zealand Institute for Plant & Food Research Limited
[2] AgResearch Limited, New Zealand
[3] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

Teresa.Waiariki@plantandfood.co.nz

A project started in 2021 to assess the risk of rapid ōhi'a death (ROD) to Aotearoa. One of the project objectives required *Metrosideros* seed (pōhutukawa and rātā) from Aotearoa to be sent to Hawai'i to be assessed for susceptibility to the ROD pathogens. This also required developing links between researchers and the indigenous peoples of Aotearoa and Hawai'i. Respect and integration of tikanga Māori values are critical pertaining to research on taonga Aotearoa species and within the Pacific peoples. Tikanga — Māori beliefs that are inherited values and concepts practised from generation to generation. Values include the importance of te reo, whenua, and whānau–hapū–iwi and stories/ legends. Any intention to work with taonga requires the development of genuine and respectful relationships with the kaitiaki of those taonga, be they whānau, hapū or iwi groups or trusts. Permission to work in their space is everything. It also means developing opportunities and lasting connections with hapū/kanaka Maoli, building research capability, upskilling and ongoing learning, and putting these lessons learnt into action. During the process we must be respectful as the visitor in honouring the whanau or hapū customs, which can vary across the different rohe. Each hapū has their own way; completely acceptable for what suits their life and customs. Respectful communications and practices also include greetings and hui, karakia rongoā Māori, and mele oli and malama 'aina (caring for giving and taking back to the land) in Hawai'i. Here the steps we took to integrate tikanga Māori into our research are outlined. These included seeking approval from the indigenous people, respecting data sovereignty, sharing of information, and acknowledgment of Māori contributions.

Development projects in SE Asia support biosecurity incursion responses and management of potential invasive insect pests in New Zealand and PICTs

Graham Walker

The New Zealand Institute for Plant & Food Research Limited, Private Bag 92169, Auckland Mail Centre, Auckland 1142, New Zealand

graham.walker@plantandfood.co.nz

Natural and modified habitats in New Zealand and Pacific Island Countries and Territories (PICT) are at risk from pest incursions from overseas. With climate warming there is increasing risk from unwanted exotics from tropical regions that may find increasingly more suitable climatic conditions in New Zealand and/or PICTs. An example is the recent incursion of Fall Armyworm (FAW), *Spodoptera frugiperda*, first detected in New Zealand in February 2022, and now recorded in many parts of New Zealand, mostly in the northern (warmer) provinces. Scientists from Plant & Food Research have been undertaking MFAT (New Zealand Ministry of Foreign Affairs and Trade)-funded development projects focused on 'safe vegetables' in Cambodia and central Viet Nam for 10 years. The project work involves training local farmers and agronomists to identify what are infesting their crops, whether pests or natural enemies, and the risks from the different pest species. This practical one-on-one training in various crop types grown in different provinces and seasons in SE Asian countries has provided a unique opportunity to study the predicted impacts of unwanted pests in New Zealand and PICTs, to better understand their behaviour, damage, interactions with local natural enemies, and impacts of various pest management practices. This knowledge will enable countries to be proactive in biosecurity initiatives and have rapid responses to new pest incursions. For example, experience in identifying fresh damage in corn crops in Cambodia led directly to the early identification of caterpillars of FAW infesting corn in New Zealand. This overall practical knowledge has been useful in informing farmers, stakeholders and affected sectors on how to scout crops and identify FAW infestations, both for biosecurity surveillance, and for pest management after a new incursion. There is a range of unwanted pest species and pest types that are being studied in SE Asia. These include tephritid fruit flies, leaf and flea beetles, caterpillar pests, sucking bug pests, thrips, and leaf-miner species that are not currently present in New Zealand or PICTs. Examples of unwanted insect pests from SE Asia will be discussed, their risks and likely impacts, and integrated pest management (IPM) tools that will be useful if and when these new pests arrive.

Policy co-design: opportunities, challenges and risks for community, government and industry

Ruth Wallace

Faculty of Arts and Society, Charles Darwin University, Australia

Ruth.Wallace@cdu.edu.au

A growing policy direction in biosecurity is to create "shared responsibility" across different sectoral stakeholders, and this presents both significant challenges and opportunities. Some research has investigated community and industry understandings of responsibility. (e.g., Maller et al. 2007). Codesign has been adopted in New Zealand and Australia to quote and reference Indigenous policy improvement. The implementation of the codesign principles across a range of policy areas has shown the approach has strengths and challenges. This presentation explores different models of codesign and the key issues that need to be considered in the development, implementation, and evaluation of codesign approaches. The extension of codesign principles from policy and community to engage industry will also be considered with reference to biosecurity management.

Egg morphology of key insect pests as related to fumigation efficacy

Jonathan Powell and Spencer Walse

USDA-Agricultural Research Service, San Joaquin Valley Agricultural Sciences Center, 9611 South Riverbend Avenue, Parlier, CA 93648, USA

spencer.walse@usda.gov

Knowledge regarding egg morphology can aid the selection of postharvest fumigants for insect control, as fumigants must be able to permeate through the chorion to react with biomolecules and/or disrupt cellular processes. Accordingly, scanning electron microscopy (SEM) was used to examine eggs of key invasive insect pests. The influence of abiotic factors such as temperature, exposure time, pressure, and concentration on ovicidal efficacy of fumigants has been well documented across many insect species and in general, the functional and operational parameters have been identified for each fumigant, including: phosphine, hydrogen cyanide, propylene oxide, methyl bromide, sulfuryl fluoride, and ethyl formate. The differential response of species to the same fumigant is critically linked to a variety of biotic factors, however, including the structure and composition of the egg chorion as related to fumigant permeability, and developmental rate, a proxy for cellular/metabolic activity required for fumigant activity (e.g., glycolysis inhibition, electron transport inhibition). Here we report findings linking these biotic factors toward the efficacy of a given fumigant across pest species.

International Congress on Biological Invasions, from 2009 to 2023

Fanghao Wan [1], Nianwan Yang [2, 3] and Cong Huang [2]

[1] Chinese Academy of Agricultural Science, P.R.China
[2] State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Science, Beijing 100193, P.R.China
[3] Western Agricultural Research Center, Chinese Academy of Agricultural Sciences, Changji 831100, P.R.China

wanfanghao@caas.cn

Invasive alien species (IAS) are considered to be one of the most serious challenges to humankind, biodiversity and the environment in the 21st century. International cooperation is the key to prevent and manage IAS globally. In response to the IAS challenge, the International Expert Committee was established in 2009 to launch the "International Congress on Biological Invasions (ICBI)" in Fuzhou, China, which was a stimulating forum for information exchange and innovation ideas for basic research on the management of IAS. The "Fuzhou Declaration" was announced at the end of the congress, and it was recommended by scientists that the ICBI should be conducted as a regular international event on biological invasions every 4 years. Since then, the 2nd and 3rd ICBI were successfully held in 2013 and 2017, at Qingdao and Hangzhou, China, respectively and achieved "overwhelming success" with over 1500 participants from more than 50 countries in attendance. On the closing ceremony of ICBI2017, New Zealand was announced to hold the 4th ICBI. When summarizing the themes and presentations of four congress, it was noticed that attention moved from influence of biological invasions to innovation, collaboration and partnership, and that big data, omics and novel technologies will play a more important role in elucidating invasion mechanism and in IAS management. In China, Fang-hao Wan and his research team launched 4E Actions for IAS management, which includes Early warning (E1), Early monitoring & rapid detection (E2), Early Eradication & Blocking (E3) and Entire mitigation (E4). In the era of omics, it was expanded to 4E+ Actions by the initiation of the genome project of 1000 invasive alien species (IAS1000 Project) in 2018. The E4+ omics aimed to providing a collaboration platform for IAS genomics, while using whole-genomes to elucidate invasion process and mechanism, as well as innovating new technology and method for IAS management.

The inducement and cytological mechanism of thelytoky and the comparative biological control potential of two strains of *Diglyphus wani* (Hymenoptera: Eulophidae)

Weijie Wan, Sujie Du, Fuyu Ye, Shiyun Xu, Fanghao Wan, Jianyang Guo and Wanxue Liu

State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing, 100193, China

wan_wei_jie@126.com

In Hymenoptera species with a haplo-diploid sex determination system, the reproductive mode is usually arrhenotoky, where haploid males arise from unfertilized eggs and diploid females from fertilized eggs. However, a few species reproduce by thelytoky, where unfertilized eggs develop into diploid females. *Diglyphus wani* (Hymenoptera: Eulophidae), a recently reported thelytokous species, is a dominant parasitoid that attacks agromyzid leafminers in China. Thelytoky in Hymenopteran species has several causes and is generally induced by bacteria. To assess whether endosymbionts induce thelytoky in *D. wani*, we carried out multiple methods to explore the inducement. Our findings revealed that the thelytoky of *D. wani* was not associated with the actual presence of the endosymbionts. Then, we further studied the cytological mechanism by which thelytokous *D. wani* produce diploid females in the absence of mating. Our finding revealed that *D. wani* is the first eulophid parasitoid wasp in Hymenoptera whose thelytoky was not induced by bacteria to form an apomictic thelytoky based on direct cytological observation in the early embryonic stage and microsatellite markers results. Subsequently, the arrhenotokous *D. wani* were discovered in Yunnan and Guizhou of China. We compared the morphological characteristics of thelytokous and arrhenotokous strains. However, the females of two strains had a strongly similar morphology, and showed subtle differences in forewing, resulting it is difficult for the untrained researchers to accurately distinguish them. Thus, a rapid molecular identification method was developed to rapidly distinguish two strains based on a one-step multiplex PCR method. As a potential agent, exploring the differences in biological control parameters of both strains is necessary. We also performed a comparison between the two strains of *D. wani* to evaluate the life table and host-killing rate. The results demonstrated that thelytokous strain of *D. wani* performed better than the arrhenotokous strain in terms of population growth, net parasitism, host-feeding, host-stinging, and total host-killing rates. Therefore, the thelytokous strain of *D. wani* should be given priority in future biocontrol applications owing to the cost savings of breeding only females to our knowledge. Above findings will provide a baseline for the real causes, future inner molecular genetic studies, origin of ameiotic thelytoky, and give implications for the subsequent application of *D. wani*.

Construction sand trade network topology shapes the patchy distribution pattern of an invasive plant, *Flaveria bidentis* (L.) Kuntze

Rui Wang, Qianmei Wu, Jingjing Cao, Zhipeng Li, Fanghao Wan and Jianying Guo

State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing, 100193, China

wangrcaas@163.com

Patchy distribution has become the prevalent spatial expansion pattern of non-native species at the dispersal front zone, which requires careful resource allocation to controlling non-native plant populations. Identifying the underlying determinants for patchy expansion pattern is important to prevent a non-native species from further spreading after successful introduction/establishment. *Flaveria bidentis* (L.) Kuntze, a non-native plant that was introduced to China in the 1990s, has showed patchy distribution patterns at its expansion frontier zone. To identify the factors that shaped its patchy distribution patterns, we identified the dispersal pathway of F. *bidentis* by comparing the minimum arrival speed with the seed dispersal rate estimated from classic long-distance dispersal pathways such as anemochory. We further combined experimental simulation and network analysis to investigate the relationships between the topology of construction sand distribution centers and the patchy distribution pattern of F. *bidentis*. Our results showed that minimal arrival speed was 2.42 km per year, which were at least one order of magnitude higher than the simulated seed dispersal rates on the extreme winds (0.06 km per year). The maximum distance of seed dispersal as hitchhiker adhered to the wheels of trucks distributing the sand was less than the minimum distance between the earliest occurrence points of clustered patches. Whereas there were significant spatial correlations between the centrality of nodes of the construction sand trade network and the frequency of occurrence points ($P \leq 0.01$). These findings suggest that F. *bidentis* spread as contaminant in sand for construction and the topology of the network determined the patchy distribution pattern of exotic species. This study can provide a reference for develop effective strategies to detect early populations of F. *bidentis* and prevent further invasions.

Suppression of vector immune response promotes the global invasion of tomato yellow leaf curl virus

Xiao-Wei Wang

866 Yuhangtang Road, Hangzhou, China

xwwang@zju.edu.cn

Tomato yellow leaf curl virus (TYLCV) causes one of the most devastating diseases of tomatoes worldwide and has quickly spread from the Mediterranean region to more than 50 countries. TYLCV is exclusively transmitted by the whitefly *Bemisia tabaci* in a circulative manner and is maintained through plant-insect-plant cycle. We found that the JAK/STAT pathway in *B. tabaci* functions as an antiviral mechanism against TYLCV infection in whiteflies. Two STAT-activated effector genes, BtCD109-2 and BtCD109-3, mediate this anti-TYLCV activity. To counteract this vector immunity, TYLCV has evolved strategies that impair the whitefly JAK/STAT pathway. Infection of TYLCV is associated with a reduction of JAK/STAT pathway activity in whiteflies. Moreover, TYLCV coat protein binds to STAT and blocks its nuclear translocation, thus abrogating the STAT-dependent transactivation of target genes. We further show that inhibition of the whitefly JAK/STAT pathway facilitates TYLCV transmission but reduces whitefly survival and fecundity, indicating that this JAK/STAT-dependent TYLCV–whitefly interaction plays an important role in keeping a balance between whitefly fitness and TYLCV transmission. These findings reveal the important roles of vector immune suppression in the global spread of TYLCV.

A potential parasitoid *Microplitis prodeniae* with effective control of *Spodoptera frugiperda* larvae

Yaru Wang [1, 2], Liuying Lin [1], Xiangyun Cai [1], Limin Chen [1], Zhongming Wang [1], Jinda Wang [2], Jianquan Yang [1], Sheng-Yen Wu [1] and Youming Hou [1]

[1] State Key Laboratory of Ecological Pest Control for Fujian and Taiwan Crops, Key Lab of Biopesticide and Chemical Biology, Ministerial and Provincial Joint Innovation Centre for Safety Production of Cross-Strait Crops, College of Plant Protection, Fujian Agricultural and Forestry University, Fuzhou 350002, P. R. China
[2] National Engineering Research Center of Sugarcane, Fujian Agricultural and Forestry University, Fuzhou 350002, P. R. China

wangyaru0617@163.com

Spodoptera frugiperda (J.E. Smith) is a major migratory agricultural pest threatening many commercial crops worldwide. In a field survey, the collected fall armyworm larvae were parasitized by the same parasitoid identified as *Microplitis prodeniae*. This parasitic relationship was not confirmed until the invasion of such pest into China, although *M. prodeniae* is great for the control of *Spodoptera litura* and *Spodoptera exigua*. Here, we systematically assessed the biological characteristics of the parasitoid growing and developing in the 1st to 4th instar stages of the fall armyworm larvae. The parasitoids displayed apparently higher parasitism efficiency in 2nd and 3rd instars of the host, but were low in 1st and 4th instars, likely due to increasing fitness costs for the reproductive effort. Likewise, lower cocooning and emerging rates and longer developmental period of *M. prodeniae*, accompanied by more killed *S. frugiperda* larvae caused by the non-reproductive effect of the parasitoid, occurred in the treated 1st and 4th instar hosts. Based on these findings, promising adaptions of *M. prodeniae* on *S. frugiperda* demonstrate not only its wider host range, but also potentials for an alternative to effectively control this threatening pest and the suitable host instars for mass propagation of the parasitoid as a biological control agent.

Components of *Sirex noctilio* and *Sirex nitobei* venoms and their parasitic nematodes

Zhengtong Wang [1], Chenglong Gao [2] and Juan Shi [1]

[1] Beijing Key Laboratory for Forest Pest Control, Beijing Forestry University, Beijing, 100083, China.
[2] Guangdong Academy of Forestry Sciences, Guangdong, 510630, China

m13121279533@163.com

Sirex noctilio Fabricius and *Sirex nitobei*, two wound boring pests which are members of Hymenoptera, Siricidae, *Sirex*. In the northeast of China, *S. noctilio* is a devastating international forestry quarantine pest. It jointly damages the same host- *Pinus sylvestris* var. *mongolica* as *S. niotbei, a* native species. They have caused the weakening and even death of large areas of *P. sylvestris* var. *mongolica* forests. We combined transcriptome and proteome techniques to explore the composition, synthesis and secretion genes, genetic evolutionary relationship of two wood-wasp venom proteins. In addition, we also explored the parasitic natural enemy nematodes of two wood-wasps in China. The purpose of this study was to provide theoretical and technical support for the control of wood-wasps. To screen and identify genes related to venom protein secretion and synthesis of two wood-wasps, a total of 17,488 and 15,036 unigenes were screened; 14 and 10 highly expressed (TPM>200) genes were screened and identified, including laccase-2, Uncharacterized protein LOC107267239 and LOC107267239, Elongation factor 1-alpha, laccase-3, dynein β chain and activating transcription factor of chaperone isoform X2. Through the comparative analysis of all unigenes of the two wood-wasps venom gland, 4,246 orthologous genes were identified, among which 574 genes (381 up-regulated, 194 down-regulated) were significantly differentially expressed, mainly involved in basic metabolism such as translation, carbohydrate metabolism and endocrine system. Using the combined analysis method of transcriptome and proteome, it was determined that the venom proteins of *S. noctilio* and *S. nitobei* were mainly concentrated in 10 kDa and 100-140 kDa. A total of 950 and 1,095 venom proteins were identified, respectively, and 113 and 93 key venom proteins were screened, including laccase-3-like protein, chitooligosaccharidolytic β-N-acetylglucosaminidase and β-galactosidase, etc. 8 and 7 protein encoding genes were determined to be specifically expressed in venom glands. Through morphological and molecular identification, it was confirmed that both the two wood-wasps in China carried two nematodes, *Deladenus siricidicola* and *Deladenus nitobei*. Among them, *D. nitobei* is a newly recorded species discovered for the first time in China. We found for the first time that *D. nitobei* has the ability to parasitize and sterilize *S. noctilio*. In this study, it was not found that these two nematodes had significant sterilization ability to *S. nitobei*.

Transdisciplinary and transbounday partnerships: New models of collaboration for management of invasive alien species

Alison Watson [1] and Wee Tek Tay [2]

[1] ASEAN FAW Action Plan Secretariat, Singapore, CSIRO Health & Biosecurity, Singapore
[2] CSIRO Health & Biosecurity, Black Mountain Laboratories, Clunies Ross Street, ACT 2601, Australia

alisonwatson@aseanfawaction.org

Building partnerships through transdisciplinary approaches to the monitoring and management of Invasive Alien Species (IAS) in Asia-Pacific is now becoming critical. Risk factors that drive the expansion of IAS including population movement, trade and transport, land-use change, and biodiversity loss remain serious challenges. Rapidly changing climatic conditions, however, due to climate change are also now likely assisting the spread, establishment, and expansion of IAS across countries at unprecedented speed. The recent introduction and expansion of the transboundary pest Fall Armyworm across the Asia-Pacific region highlights the urgency for new models of working together. Despite the significant resources directed at managing this serious pest, its expansion and establishment across the region continue. Serious knowledge gaps persist about this pest in its invasive range as well as other unrealised future risks it might pose to food systems, biodiversity and ecosystems. Additionally, the harmful and unnecessary overuse of conventional chemical pesticides remains unabated in many countries. The establishment of new networks and forms of collaboration to help build and shape strong biosecurity systems at various scales is essential. Such collaboration must combine the knowledge and actions of both experts and non-academic stakeholders, including farmers, to reveal pragmatic solutions that can drive innovation and behavioural change. Lessons learnt from the establishment of the regional ASEAN Fall Armyworm Action Plan and implementation of various programmes including gender studies in the management of fusarium wilt, fall armyworm and fruit fly across Southeast Asia, as well as the current design of an ASEAN Bioprotection Research Centre, will be presented to demonstrate the urgent need for, and benefits of, building transdisciplinary partnerships for achieving stronger management of IAS.

Retrospective and future directions for management of Coconut Rhinoceros Beetle in Hawai`i.

Keith Weiser [(1)], Michael Melzer [(2)] and Darcy Oishi [(1)]

[(1)] Hawaii Department of Agriculture, 1849 Auiki St. Honolulu, HI 96819
[(2)] University of Hawaii, CTAHR, 3190 Maile Way, St. John 205 Honolulu, HI 96822

CRBops01@hawaii.edu

The Coconut Rhinoceros Beetle (CRB, Oryctes rhinoceros) are primarily pests of several palm species but have several secondary hosts including sugarcane, pandanus, and cycads. This causes significant economic harm to agriculture and threatens native ecosystems. CRB were first detected in Hawai`i in December 2013 and an emergency response was mobilized in 2014. Initial trapping and palm damage surveys delimited the range to two locations on Oahu. The spread was initially slow but accelerated as the beetles reached more ideal habitat. The development and approval of tools to more efficiently detect and suppress populations has been ongoing throughout the emergency response. The protocols and strategy have changed significantly since 2014 with the adoption of systemic insecticide treatments for palms, heat treatment and fumigation of infested material, canine surveys for breeding sites, GIS based in-field digital data recording, laws to limit the accidental spread of CRB, and insights into CRB behavior. We hope to share some of the most impactful insights from battling CRB for the last 9 years and the strategy for Hawai`i moving forward.

Te Whakahononga an approach that elevates mana whenua into the biosecurity and research system

Waitangi Wood [1], Juliane Chetham [2], Dave Milner [3], Alby Marsh [4], Nick Waipara [4] and Mark Bullians [4]

[1] WaiCommunications, Kaeo, Te Tairawhiti
[2] Chetham Consulting Ltd, Whangarei New Zealand
[3] Kahu Environmental Ltd, Greytown, New Zealand
[4] The New Zealand Institute for Plant & Food Research Limited, Auckland, New Zealand

waicommsltd@gmail.com

Developed by Biological Heritage, National Science Challenge, Nga Rakau Taketake Theme Co-leads, Te Whakahononga, is an approach that considers the importance of mana whenua engagement with western scientists, who are seeking solutions to address *Phytopthera agathadicida* (PA) and *Austropuccinia psidii* (myrtle rust) plant pathogens that are a threat to native plant species. This innovative approach invests in high integrity trust relationships with mana whenua, enabling mātauranga Māori authorities to engage in western research and address issues of data, information and taonga sovereignty. (The) Te Whakahononga approach encourages mana whenua to apply their own traditional knowledge, practices and solutions, while building a comprehensive understanding of the pathogen at place, the biosecurity system while enabling surveillance and monitoring capability. Te Whakahonoga uses a suite of tools that have been developed and tested across 11 mana whenua engaged to Nga Rakau Taketake research. This presentation will discuss the approach, our learnings including both successes and challenges, and how researchers and mana whenua can adopt the approach to enable better engagement and research outcomes.

Reducing risks on root crops from Pacific Island nations

Allan Woolf [1, 7], Fa'alelei Tunupopo [2], Seeseei Molimau-Samasoni [3], Stephen Wallace [1], Simon Redpath [1], Samuel Brown [1], Jack Armstrong [4], Mark Seelye [1], Cristian Baldassarre [1], Asha Chhagan [1], Amanda Hawthorne [1], Robert Tautua [3], Veronica Vaaiva [3], Seira Tofete-Adam [3], Joy Tyson [1], Robert Fullerton [1], Lee Alders [5], Farhat Shah [1], Chelve Rohan [5], Richard Oliver [1], James Pinfold [1], Barry Stevenson [6], Angelika Tugaga [3], Tanu To'omata [2] and Lisa Jamieson [1, 7]

[1] The New Zealand Institute for Plant & Food Research Limited, PO Box 92169, Auckland 1142
[2] MAF Samoa, Crops Division, Nu'u Research Station, Apia, Samoa
[3] Samoa-Scientific Research Organisation of Samoa, PO Box 6597, Apia, Samoa
[4] Quarantine Scientific Limited, 63 Stanners Road, RD2, Kerikeri 0295
[5] AgResearch Limited, Ruakura Research Centre, Private Bag 3123, Hamilton, New Zealand
[6] MECBES Design, Hamilton, New Zealand
[7] Better Border Biosecurity (B3), New Zealand (www.b3nz.org.nz/)

allan.woolf@plantandfood.co.nz

Taro (*Colocasia esculenta*) is a culturally and economically significant crop in Samoa. Most taro shipments exported from Samoa to New Zealand are fumigated with methyl bromide (MB) to control mites, nematodes, snails and other pests of concern. There are growing recapture restrictions on MB and alternative control measures are required. In association with Better Border Biosecurity (B3), we have developed an offshore non-chemical combined high pressure washing (HPW) and hot water treatment (HWT) to reduce the risks associated with taro. The project began with identifying the pest risks associated with taro and assessing the mortality responses of different life stages of key pests after exposure to different HWT temperatures and times. The time for the surface of the taro corm, where pests tended to be located, to reach target temperature was defined and the quality of taro was assessed after exposure to HWT for the duration to heat up the surface and the required time to kill mites and nematodes. A high pressure washing (HPW) system was constructed at Plant & Food Research (PFR), and installed in the MAF packhouse in Atele, Samoa. HPW taro on rolling brushes was a highly effective cleaning system with minimal taro damage. A HWT system was also built at PFR and shipped to Atele. After a series of trials, a final combination of HPW at 50 psi for 12–15 s followed by HWT at 48°C for 25 mins, hydrocooling and air-drying was established as an optimum treatment. Trimming the taro base and grading was added as a further mitigation step. Further work at the Ah Liki packhouse in association with Pacific Horticultural & Agriculture Market Access Plus Program examined the combination treatment on commercial shipments. Ten commercial taro consignments were treated using the above system then bagged and shipped to New Zealand. Ministry for Primary Industries quarantine staff inspected shipments on arrival and no mites were found on the treated taro and nematodes were found on one treated taro, while all untreated taro had to be fumigated. The treatment regime was further tested as an intervention against *Phytophthora colocasiae* for fresh taro export from Samoa to Australia. Laboratory scale experiments showed a 100% efficacy against Pc mycelia and sporangia when corms were treated at 48.0°C for 25 mins. Thus, the HPW-HWT, trimming, grading treatment combination shows potential for scale-up and ongoing commercial application on root crops from Pacific Islands to both NZ and Australia.

Polyploidy in invasive *Solidago canadensis* increased plant nitrogen uptake, and abundance and activity of microbes and nematodes in soil

Shuqi Wu [1], Jiliang Cheng [1], Xinyu Xu [1], Yi Zhang [1], Yexin Zhao [1], Huixin Li [1, 2], Sheng Qiang [1]

[1] College of Life Science, Nanjing Agricultural University, Nanjing 210095, China
[2] Jiangsu Collaborative Innovation Center for Solid Organic Waste Utilization, Nanjing 210095, China

shuqiwu@njau.edu.cn

Polyploidization (i.e., multiplication of genome size) is a major driver of plant evolution and is believed to play a significant role in plant invasion. One hypothesis states that polyploids possess larger root systems with increased root exudation, and thus induce a greater effect on the rhizosphere than their diploids counterparts. Few experiments, however, have explicitly tested the impacts of the polyploidy of plants on soil organisms in the field. Using a common garden approach, we examined the impacts of native and introduced populations of *Solidago canadensis* with differing ploids (diploid, tetraploid and hexaploid) on soil microbes, nematodes, and carbon (C) – nitrogen (N) turnover. Polyploidy generally increased microbial biomass in the soil: while the biomass of all microbial groups was significantly higher under introduced than native tetra- and hexa-ploids, there was no significant difference in soil bacteria, fungi, and actinomycetes between diploids of the native and introduced populations. The effect of polyploids on soil microbial biomass was greater in November than July, suggesting that the effect becomes stronger later in the growing season. The impact of polyploidy on nematodes was largely dependent on trophic status; polyploids did not significantly affect bacterivores or omnivores+carnivores, but tended to increase the abundance of fungivores, and significantly increased the number of herbivores. Extraradical biomass of arbuscular mycorrhizal fungi was significantly higher, but NO3--N and the net nitrification rate were significantly lower under tetra- and hexa-ploids than diploids. Together, these results suggest that polyploidization induces rhizosphere processes that improve plant nutrition and contribute to plant invasiveness through stimulation of soil microbial biomass and increased biological activity.

The database of invasive alien species in China and its roles in their management

Xiaoqing Xian [(1)], Rui Wang [(1)], Jianying Guo [(1)], Guifen Zhang [(1)], Wanxue Liu [(1)] and Fanghao Wan [(1, 2)]

[(1)] Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China
[(2)] Agricultural Genomics Institute at Shenzhen, Chinese Academy of Agricultural Sciences, Shenzhen 518000, China

xianxiaoqing@caas.cn

The diversified databases of Invasive Alien Species (IAS) have played an important role in IAS management worldwide, providing not only general information of IAS for the public and experts, but also detailed data support for IAS early-warning, monitoring and detection, as well as control and management. Based on the literature collection and field investigation, we have set up the Database of Invasive Alien Species in China (DIASC), which consisted of the basic information system of IAS, geographic distribution system of IAS, field data acquisition system of IAS, semi-quantitative risk assessment system for IAS in agroforestry ecosystem, DNA barcoding system for known insects with small size or difficult to be identified, and remote monitoring system based on sex pheromone trapping of important insects. For potential and newly emerging IAS in particular, we developed a web-based visualization system to realize the dynamic display of spatiotemporal data on species distribution, risk assessment, and customs interception. Based on this database, we analyzed the current status of IAS in Chinese agroforestry and freshwater ecosystems and summarized the newly emerging IAS in China in recent (last 20) years. For high-risk IAS, some case studies of pest risk assessment have been carried out based on the geographical distribution database. The other subsystems have served IAS field investigation and monitoring in multiple projects. In addition, this database has supported some IAS administrative tasks, including pest risk assessment of imported agricultural products seeds and establishment of the species list for IAS management in China.

Including climate change impacts posed on ecological niche overlap of three *Spodoptera* species in China maize planting areas

Yanling Xu, Yuan Zhang, Zihua Zhao, Zhihong Li and Yujia Qin

Key Laboratory of Surveillance and Management for Plant Quarantine Pests, Ministry of Agriculture and Rural Affairs, College of Plant Protection, China Agricultural University, Beijing, PR China

xyl0402@163.com

Spodoptera Guenée (Lepidoptera: Noctuidae); more than half of the species from this genus are world-wide pests. Most species pose important threats to crop production and cause huge economic losses. Based on the global occurrence data, climatic and crop type variables, we applied MaxEnt to predict distribution pattern of *Spodoptera frugiperda*, *Spodoptera exigua* and *Spodoptera litura*. Furthermore, we assessed the potential response of *Spodoptera* pests' distribution to climate change and crop types and compared the ecological niche overlap degree in main maize planting areas of China. The most critical factors affecting the distribution of the three *Spodoptera* species encompassed temperature and precipitation. The suitable areas of the two invasive species (*S. frugiperda*, *S. exigua*) were larger than native species (*S. litura*) under the historical situation, but along with climate change, the diffusion range of the native *S. litura* is the largest. The potential geographical distribution of the *Spodoptera* species were predicted to be expanded and northward in the future. The ecological niche overlap degree of the three *Spodoptera* species in the Huang-Huai-Hai plain summer-maize region, Southern hilly maize region and Southwest mountain maize region were at high level with the Schoener' *D* values mostly around 0.8. As the climate changes, their ecological niche overlap level tended to increase in most areas. Our findings indicated the competition degree of the *Spodoptera* species and provided an important basis for formulating the control strategy of main *Spodoptera* pests in China under the context of different maize planting areas.

Gene editing takes on the Spotted Wing Drosophila invasion

Ying Yan and Marc F. Schetelig

Department of Insect Biotechnology in Plant Protection, Institute for Insect Biotechnology, Justus-Liebig-University Giessen, Winchesterstraße 2, 35394 Giessen, Germany

Ying.Yan@agrar.uni-giessen.de

The Spotted Wing Drosophila (*Drosophila suzukii* Matsumura; Diptera, Drosophilidae) is an invasive insect pest of soft-skinned fruit crops. Originating in Japan in the early 20th century, it was not considered a major agricultural threat until its invasions in North America and Europe in 2008. Since then, it has rapidly spread to all continents except Oceania and has caused significant economic losses. To manage this pest in an environmentally friendly and cost-effective manner, genetic control strategies based on desirable and heritable genetic modifications through intraspecific mating have been proposed. Towards this goal, we have successfully demonstrated various genetic engineering methods in this pest, including transposon-mediated germ-line transformation, recombinase-mediated cassette exchange, and CRISPR-mediated gene editing. Additionally, various molecular elements such as the nuclear localization signal (NLS), the poly-lysine/CAAX membrane anchor, 2A self-cleaving peptides, cellularization gene promoters, and pro-apoptotic genes have been evaluated for their functionality both in vitro and in vivo. Thanks to efficient genetic engineering methods and functional molecular elements, several genetic control strategies have been developed for the management of *D. suzukii*, including sperm-marking, sex-ratio distortion, and female-killing. Based on the current findings, further developments in the genetic control of this species are proposed, including conditional CRISPR sterile insect technique and gene drives. The outcomes of these studies will not only aid in the sustainable control of *D. suzukii* but also serve as important reference for similar research in other economically or medically significant insect pests.

Potential dissolved oxygen impacts from hessian benthic barriers smothering *Lagarosiphon major*

Iñigo Zabarte-Maeztu, Ben Woodward, Mary de Winton and Deborah Hofstra

National Institute for Water and Atmospheric Research, Gate 10 Silverdale Road, Hillcrest, 3216 Hamilton, New Zealand

Inigo.Zabarte-Maeztu@niwa.co.nz

Invasive freshwater plants such as *Lagarosiphon major* pose a significant threat to New Zealand's water bodies, their native biodiversity and the ecosystem values and services they provide. This is of concern to both the general public and lake managers, and effective control tools are sought to manage this invasive species. Following mesocosm scale testing against target weed species, the use of biodegradable hessian to smother *Lagarosiphon* weed beds was operationalised in New Zealand. Benthic barriers of hessian material are now used at scale in the freshwater 'landscape', with hessian deployed to >7 km of shoreline infested by *Lagarosiphon* in South Island waterbodies since 2016. One advantage of using hessian, over other benthic barrier materials, is that it is biodegradable and allows for fast native plant recovery following weed control. However, there are knowledge gaps regarding its use, such as 'Is there potential for dissolved oxygen (DO) declines and ecological impacts from *Lagarosiphon* death and/or decay following hessian deployment?'. We undertook a mesocosm experiment in which we compared DO concentrations immediately surrounding the *Lagarosiphon* smothered by hessian vs intact weed bed treatments. Changes in DO levels were followed over 4 months, in association with checks on *Lagarosiphon* health condition. This work considered the potential for DO declines from *Lagarosiphon* control, and the potential for negative impacts on aquatic fauna. Overall, the effect of the hessian deployment on DO and community metabolism was not significant; however, short term DO decline and environmental respiration increase was observed due to weed bed decomposition. This is a first step towards understanding the trade-off between ongoing weed impacts and the potential for short-term impacts from control using hessian benthic barriers.

Determination of hourly distribution of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) using sex pheromones and ultraviolet-light traps in protected tomato crops

Gui-Fen Zhang [1], Yi-Bo Zhang [1], Lin Zhao [1, 2], Yu-Sheng Wang [1], Cong Huang [1], Zhi-Chuang Lü [1], Ping Li [3], Wan-Cai Liu [3], Xiao-Qing Xian [1], Jing-Na Zhao [1, 4], Ya-Hong Li [5], Fu-Lian Wang [2], Fang-Hao Wan [1] and Wan-Xue Liu [1]

[1] State Key Laboratory for Biology of Plant Diseases and Insect Pests, Key Laboratory of Invasive Alien Species Control, Ministry of Agriculture and Rural Affairs, Key Laboratory of Integrated Pest Management of Crop, Ministry of Agriculture and Rural Affairs, Center for Management of Invasive Alien Species, Ministry of Agriculture and Rural Affairs, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China
[2] Yangtze University, Jingzhou 434100, China
[3] The National Agro-Tech Extension and Service Center, Beijing 100025, China
[4] College of Plant Protection, Yunnan Agricultural University, Kunming 650201, China
[5] Yunnan Plant Protection and Quarantine Station, Kunming 650034, China

guifenzhang3@163.com

Tuta absoluta (Meyrick), a leafminer of tomato leaves, terminal buds, flowers, and fruits, is a destructive tomato pest globally and has been responsible for up to 80-100% tomato yield losses. Different insect species have different courtship-response and phototropic flight rhythms. Improving the trapping effects of sex pheromones and light traps is important for constructing an IPM (integrated pest management) system for *T. absoluta*. *Tuta absoluta* adults displayed strong responses to the sex pheromone trap placed on the ground and UV-light in the 380 nm wavelength. The present study discusses the 24 h hourly distribution of *T. absoluta* adults caught by sex pheromones (on the ground) and UV-light (380 nm) traps in greenhouses. The response of males to sex pheromone lures (false female) was detected at dawn and early morning. The responses lasted for 3 h, from 05:30 (1 h before sunrise) to 08:30 (2 h after sunrise), and 95.8% of males were caught during this period. A peak of male response to the sex pheromone was detected at 07:30 (from 06:30 to 07:30, 1 h after sun-rise), and 80.8% of males were caught during this period. The flying behavior of male (pro-portion of 54.3%) and female (45.7%) adults toward the UV-light trap occurred from 19:30 (time of sunset) to 06:30 (time of sunrise), lasted for 11 h, exhibited a scotophase rhythm; 97.4% of adults were caught during this period. The peak of adults flying toward the UV-light trap occurred at 21:30 (from 20:30 to 21:30, 2 h after sunset). The rhythm of males responding to sex pheromones or adults flying toward UV-light could help reveal the mechanisms of chemotaxis and phototactic and play a significant role in constructing the IPM system for this pest.

Prediction of the current and future distributions of the Hessian Fly, *Mayetiola destructor* (Say), under climatic change in the world

Qi Ma [(1)], Jin-Long Guo [(1)], Yue Guo [(1)], Zhi Guo [(1)], Ping Lu [(2)], Xiang-Shun Hu [(1)], Hao Zhang [(1, 3)] and Tong-Xian Liu [(1, 3, 4)]

[(1)] State Key Laboratory of Crop Stress Biology for Arid Areas, Northwest A&F University, Yangling 712100, China
[(2)] Yining Customs Technical Center, Yining 835008, China
[(3)] Key Laboratory of Integrated Pest Management on Crops in Northwestern Loess Plateau, Ministry of Agriculture and Rural Affairs, P. R. China, College of Plant Protection, Northwest A&F University, Yangling 712100, China
[(4)] Institute of Entomology, Guizhou University, Guiyang 550025, China

zhh1972@nwsuaf.edu.cn

The Hessian fly, *Mayetiola destructor* (Say) (Diptera: Cecidomyiidae), is a destructive wheat pest worldwide and an important alien species in China. Based on 258 distribution records and nine environmental factors of the Hessian fly, we predicted the potential distribution area in the world under three current and future (2050s and 2070s) climate change scenarios (RCP2.6, RCP4.5, and RCP8.5) via the optimized MaxEnt model. Under the current climate conditions, the suitable distribution areas of the Hessian fly in the world is accounting for 33.61% of the total land area, and the high suitable area is accounting for 13.69% of the total suitable area. The highly suitable areas are mainly located in America, Europe, West Asia and North Africa. With the rising global temperatures, most potential geographic distribution areas would expand in the future. The minimum temperature in February (tmin−2), precipitation in March (prec−3), maximum temperature in November (tmax−11), and precipitation seasonality (bio−15) are important factors that affect the potential geographic distribution of the Hessian fly. This study provides an important reference and empirical basis for management of the Hessian fly in the future.

Biological control research of *Halyomorpha halys* in kiwifruit in China

Jin-Ping Zhang [1, 2], Gonzalo A. Avila [3,] [4] and Feng Zhang [1,] [2]

[1] MARA-CABI Joint Laboratory for Biosafety, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, 2 Yuanmingyuan West Road, Beijing 100193, China
[2] CABI East Asia and South East Asia, 12 Zhongguancun South Street, Beijing 100081, P. R. China
[3] The New Zealand Institute for Plant & Food Research Limited, Mt Albert Research Centre, Private Bag 92169, Mt Albert, Auckland 1142
[4] Better Border Biosecurity, New Zealand

j.zhang@cabi.org

The brown marmorated stink bug (BMSB), *Halyomorpha halys*(Stål) (Hemiptera: Pentatomidae), is an invasive and polyphagous pest. *Trissolcus japonicus*(Ashmead) (Hymenoptera: Scelionidae) has been regarded as the most promising natural enemy for classical biological control of BMSB. Adventive populations of *T. japonicus* occur in the United States, Italy, and Switzerland, where classical biocontrol releases are already underway, and release approval (with controls) for *T. japonicus* in the event of BMSB arrival was granted in New Zealand in 2018. However, information on the biology and release strategies of *T. japonicus* in order to maximise its effectiveness against BMSB is still lacking. Between 2018 and 2022, we conducted laboratory studies to assess the fecundity and oviposition rate of *T. japonicus.* We conducted field studies in experimental kiwifruit orchards to determine the parasitoid's optimal release ratio and frequency in field cages, and we used information from such studies to plan and conduct experimental releases to assess impact on BMSB populations and feeding damage in kiwifruit. Results showed that fecundity of *T. japonicus* was 110.2 offspring produced over its lifespan and 82.6% female, the mean oviposition rate per female was 27.4 ovipositions within 24 h. Results from release ratio trials showed that releasing one wasp against one BMSB egg mass was more effective (i.e., 92% parasitism observed) than one wasp against two (i.e., 63.3% parasitism) or three (i.e., 30.1%). Release frequency experimental results using mesh cages showed that three consecutive releases (one release per week) achieved the highest parasitism results (i.e, 89.5%). In case of two times release, the parasitism was 67.5% with an interval of 7 days, the parasitism was 60.7% with an interval of 14 days. One-time release parasitism was the lowest at 45.6%. Results from field experimental releases of *T. japonicus*, where parasitoids were released in May 2022 during three consecutive weeks (one release per week) showed that mean parasitism over 3 weeks was significantly higher (i.e., 38.9%) in release plots than non-release plots (i.e., 12.3%). The average incidence of damaged kiwifruit was 21.6% from June to September in release plots, which was significantly lower than that on non-releasing plots (40.4%). Results from experimental releases provide with evidence that biological control using *T. japonicus* can be effective in reducing BMSB impacts in kiwifruit. However, further assessment and experimentation (e.g., trial different release numbers, additional sequential releases, release methodologies) is needed to maximise biological control of BMSB in kiwifruit.

Climate change will increase the global risk of Tephritidae pests

Yuan Zhang, Yujia Qin and Zhihong Li

Key Laboratory of Surveillance and Management for Plant Quarantine Pests, Ministry of Agriculture and Rural Affairs; Department of Plant Biosecurity, College of Plant Protection, China Agricultural University, Beijing, PR China

ryannzhangu@163.com

Climate change and biological invasion are two interrelated global concerns that are driving shifts in the distribution of invasive insect pests. More than 70 species of fruit flies are considered important agricultural pests and are of great concern to inspection and quarantine authorities around the world because they can easily spread long distances with the host fruit trade. The use of species distribution models to predict the potential geographical distribution of pests can provide a basis for biological control and management. In this study, the ensemble models were conducted by Biomod2 platform to predict the potential geographical distribution of six invasive economic important fruit flies, *Bactrocera dorsalis*, *B. tsuneonis*, *B. tryoni*, *Anastrepha ludens*, *Ceretitis capitata*, and *Zeugodacus cucurbitae*. Here, we used 19 bioclimatic variables and the species occurrence data to accomplish this. Niche models were then projected for two shared socio-economic pathways: SSP1-2.6 and SSP5-8.5 in 2050. Niche dynamics during global invasion were also considered. Our results showed that the TSS and AUC values of the ensemble model were above 0.9, indicating the high accuracy of the models. The ecological niche of the invaded area has changed compared with the native area, increasing the global invasion risk of the six invasive fruit flies. The potential geographical distribution range of the six invasive Tephritidae species tends to shift towards bipolar regions under climate change. In the context of climate change, more attention should be paid to reducing the negative ecological and agricultural impacts of these harmful invasive species.

The invasive plant virus (Tomato spotted wilt orthotospovirus) benefits its vector, the invasive *Frankliniella occidentalis,* due to metabolite re-arrangement in the host plant

Zhijun Zhang, Qizhang Chen, Jianyun He, Xiaowei Li and Yaobin Lu*

State Key Laboratory for Managing Biotic and Chemical Threats to the Quality and Safety of Agro-products, Institute of Plant Protection and Microbiology, Zhejiang Academy of Agricultural Sciences, Hangzhou, China

zhijunzhanglw@hotmail.com

The western flower thrips, *F. occidentalis*, is an invasive pest with a global impact, causing direct damage to plants by feeding and indirectly by vectoring viral diseases, such as Tomato spotted wilt orthotospovirus (TSWV). The plant virus TSWV increases host-plant quality for its thrips vector, *Frankliniella occidentalis*, which allows thrips to benefit from persistent transmission of the virus. Although metabolites play an important role in the process, few studies have investigated the biochemistry mechanism of insect benefit from transmitting viruses. Here, we showed the level of secondary metabolites, tropane alkaloids atropine and scopolamine that are toxic to insects, were decreased in TSWV-infected, compared with TSWV-uninfected, host plants (*Datura stramonium*). Expression analysis of corresponding tropane alkaloids biosynthesis pathway genes by qPCR, corroborated the results of analysis for alkaloids disturbance. Conversely, the level of primary metabolites, carbohydrates and amino acids that are main nutritional components for insect's growth, were elevated in TSWV-infected host plant. The benefits to thrips by reduction of these toxic secondary metabolites was validated. These findings provide a physiological and metabolic mechanism for virus effects on plant-insect-vector interaction.

Integrating biogeographic approach into the early warning and classical biological control of ragweeds (*Ambrosia* L.) under climate change

Haoxiang Zhao [1, 2], Xiaoqing Xian [2], Juan Shi [1] and Wan-Xue Liu [2]

(1) College of Forestry, Beijing Fforestry University, Beijing, China
[2] Institute of Pplant Pprotection, Chinese Aacademy of Agriculture Science, Beijing, China

zhao834323482@163.com

Invasive alien plants (IAPs) substantially affect native biodiversity, agriculture, industry, and human health worldwide. *Ambrosia* (ragweed) species, which are major IAPs globally, have a significant impact on human health and the natural environment. In particular, invasion of *A. artemisiifolia, A. psilostachya*, and *A. trifida* in non-native continents is more extensive and severe than that of other species. Classical biological control (biocontrol) measures for managing *Ambrosia* species are the safest and most cost-effective. However, the global distribution pattern of *Ambrosia* species and climate matching for the control efficiency of biocontrol candidates against *Ambrosia* species are likely to be underestimated. Here, we used biomod2 ensemble model based on environmental and species occurrence data to predict the potential geographical distribution, overlapping geographical distribution areas, and the ecological niche dynamics of three ragweeds. We further estimated the overlapping areas of the two most effective natural enemies (*Ophraella communa* and *Epiblema strenuana)* against *A. artemisiifolia* under climate change in China. We found that climate change has facilitated the expansion of geographical distribution and overlapping geographical distribution areas of the three *Ambrosia* species. Ecomanagement and cross-country management strategies are warranted to mitigate the future effects of the expansion of these ragweed species worldwide on the natural environment and public health. Climate change will likely increase joint-control efficiency in northern and northeastern China. The ecological niches of the two natural enemies of *A. artemisiifolia* were similar, overlapping in central and southern China in the near-current climate. The two natural enemies would be significant regulators of *A. artemisiifolia* in China.

Chemical communications mediates symbiosis invasion among pinewood nematodes, its vector beetle, associated microbes and pine trees

Lilin Zhao

State Key Laboratory of Integrated Management of Pest Insects and Rodents, Institute of Zoology, Chinese Academy of Sciences (CAS)

zhaoll@ioz.ac.cn

The most serious threat to pine forests worldwide is pine wilt disease (PWD). The pinewood nematode (PWN), *Bursaphelenchus xylophilus*, is the causative agent of PWD while the nematode forms the symbiotic interaction with its insect vectors *Monochamus* spp., associated bacteria and ophiostomatoid fungi in order to successfully infect and kill its pine host tree. PWN is native to North America, and causes little damage to pine trees in North America. However, upon introduction to non-native habitats, first to Japan in 1905, then to China in 1982, South Korea in 1988, Portugal in 1999, and Spain in 2008, PWN has caused high mortality of the native pine trees. The ascarosides secreted by PWN significantly increase the growth of *L. pini-densiflorae* and *Sporothrix* sp. 1, which are native fungal species in China that form a symbiotic relationship with PWN. Moreover, diacetone alcohol (DAA) from xylem inoculated with *Sporothrix* sp. 1 induced *B. xylophilus* to produce greater numbers of offspring. Its presence also significantly increased the growth and survival rate of *M. alternatus*. Ascarosides secreted by the dispersal third-stage nematode (LIII) larvae promote beetle pupation by inducing ecdysone production in the beetle and upregulating ecdysone-dependent gene expression. Meanwhile, the dispersal fourth-stage nematode (LIV) formation in *B. xylophilus* is induced by C16 and C18 fatty acid ethyl esters (FAEEs), which are produced abundantly on the body surface of the vector beetle specifically during the late development pupal, emerging adult, and newly eclosed adult stages. Once the beetle develops into the adult stage, it secretes ascarosides that attract LIV larvae, potentially facilitating their movement into the beetle trachea for transport to the next pine tree. Interestingly, host defence chemicals led to gene family expansions of xenobiotic detoxification pathways in *B. xylophilus* facilitating its survival in pine resin ducts. Furthermore, asc-C5 stimulates higher fecundity in invasive isolates of *B. xylophilus*, illustrating that pheromone-regulative reproductive plasticity (PRRP) is a main factor in promoting its successful invasion. To conclude, the interspecific communication between the nematode and its symbiotic partners, and the potential role of this communication in promoting pathogenicity and invasiveness of the PWN. We describe the chemical and molecular signals positively influencing the survival, reproduction and spread of the PWN. Knowledge and understanding of these signals could potentially be used to interfere with the propagation and dispersal of PWN.

MicroRNA regulation of distinct gene expression responses to thermal acclimation in Oriental fruit fly, *Bactrocera dorsalis*

Yan Zhao [1], Juntao Hu [2] and Zhihong Li [1]

[1] Key Laboratory of Surveillance and Management for Plant Quarantine Pests, Ministry of Agriculture and Rural Affairs, College of Plant Protection, China Agricultural University, Beijing, 100193, PR China
[2] Ministry of Education Key Laboratory for Biodiversity Science and Ecological Engineering, Institute of Biodiversity Science, Center of Evolutionary Biology, School of Life Sciences, Fudan University, Shanghai, 200438, PR China

zhaoyan1996@126.com

Phenotypic plasticity is thought to facilitate the colonization in novel thermal conditions and shape the direction of evolution of colonizing populations, while their gene regulatory mechanisms are not well understood. Here, we examine the regulatory role of miRNAs in transcriptional response to thermal acclimation of Oriental fruit fly, *Bactrocera dorsalis*, a notorious invasive species that has gradually spread northward in China in recent years. The fruit flies from northern-edge and southern-edge China populations were reared in a laboratory common garden for two generations and then exposed to warm (32°C), cold (17°C) and control temperature (25°C) for one generation. We found significant effects of thermal acclimation and population effects on variation in cold tolerance (CTmin), while only acclimation has significant effect on heat tolerance (CTmax). We then characterized gene expression profiles in head and thorax muscle tissues that are important for thermal adaptation. Gene expression differences primarily occurred in muscle, where thermal acclimation response genes are involved in chitin-based cuticle development, ion and carbohydrate transmembrane transport and energy metabolic process. Few differences occurred in the head, suggesting the head is less responsive to extreme temperatures. In the head, most differentially expressed genes showed fixed differences across temperatures between populations, while in the muscle, most differentially expressed genes showed conserved plasticity. We also observed the evolution of expression plasticity, with southern-edge populations mainly showing more plastic responses in gene expression compared to northern-edge populations, and to a large extent a pattern of assimilation. In addition, we identified a large population of mature miRNAs, especially miR-276b, that were differentially expressed between the two populations after thermal acclimation, and were involved in temperature adaptation by regulating mRNAs involved in energy metabolic processes, chitin-based cuticle development, carbohydrate and ion transmembrane transport. Overall, our results suggest that the evolution of miRNA expression ultimately underlies the evolution of gene expression evident across the populations, which could play an important role in the capacity of thermal acclimation in range expansion in this invasive insect.

The immune homeostasis between pinewood nematodes and its vector beetle

Jiao Zhou, Jing Ning and Chi Zhang

State Key Laboratory of Integrated Management of Pest Insects and Rodents, Institute of Zoology, Chinese Academy of Sciences

zhoujiao@ioz.ac.cn

Bursaphelenchus xylophilus (Bx; Nematoda: Aphelenchoididae), commonly known as the pinewood nematode, is the causal agent of pine wilt disease, which causes significant pine mortality in forests worldwide. In China and Japan, the infectious cycle of this plant-parasitic nematode is synchronizedwith the life cycle of the pine sawyer beetle *Monochamus alternatus* (Ma; Coleoptera: Cerambycidae), and Bx nematodes cannot be transmitted without Ma. Bx triggers epithelial reactive oxygen species (ROS) production in Ma. The entry of Bx induces increased expression of antioxidative genes, through which the ROS levels are balanced in the trachea of beetles. Furthermore, the up-regulation of antioxidative genes was induced by the interaction of Toll receptors. This results highlights the role of Toll receptors in mediating the activation of antioxidative genes in immune tolerance to plant parasitic nematodes. Furthermore, the dispersal fourth-stage nematode JIV of Bx carry negligible amounts of bacteria from the pupal chamber into the tracheal system and therefore prevent balance disruption of the immune system. MaGal2, a pattern-recognition receptor, was up-regulated following Bx loading. It is a negative regulator of melanization, and agglutinates the bacterias isolated from pupal chambers. This strategy for immune evasion of plant pathogen inside its vector, providing novel insights into the role of bacteria in parasite–host interactions. Moreover, the size of the C-type lectin (CTL) family genes of insect-vectored nematodes was found to be drastically reduced compared with those of self-dispersing nematodes, whereas the diversity of their functional domains was significantly higher. Phylogenetic analysis showed that some CTL genes of vector-borne plant-parasitic nematodes (PPNs) shared higher homology to the animal parasitic nematodes than other PPNs. Moreover, homology modeling predicted that the CTLs of insect-vectored nematodes bear remarkable structural similarity to the lectin genes of their vector's immune system. The loss of some CTL genes of vector-transmitted PPNs might be responsible for their parallel adaptations to a mutualistic relationship with their vector. These results expand our understanding of the evolutionary benefits of vector-mediated transmission for the nematode and vector-nematode co-evolution.

ICE1 -demethylation mitigated cold-tolerance drives range expansion of *Ageratum conyzoide* in China

Xin Zhou, and Sheng Qiang

Weed Research Laboratory, College of Life Science, Nanjing Agricultural University, Nanjing 210095, China

wrl@njau.edu.cn

Low temperature is one of the key factors limiting plant distribution range. Numerous studies have demonstrated strategies for plants to cope with low temperatures by increasing cold tolerance. *Ageratum conyzoides* L., which originates from tropical America, is quickly expanding northward from southern China. We assessed the cold tolerance of 139 geographical populations of *Ageratum conyzoides* L. by determining the cold injury symptoms, physiological and biochemical parameters and found a significant negative correlation between cold tolerance and latitude, that is, the southern populations which colonized first were more cold tolerant than the recently expanded northern populations which were cold sensitive. The expression of the CBF transcription pathway key genes among 6 geographically distinct *A. conyzoides* populations revealed that the CBF pathway played a key role in cold tolerance differentiation. Furthermore, the methylation level of *ICE1* depicted a positive correlation with cold tolerance. Hence, it was inferred that differentiation in cold tolerance of *A. conyzoides* is closely related to *ICE1* methylation variation. Based on the above results, it may be concluded that *A. conyzoides* expanded to temperate climate regions by reducing cold tolerance to avoid low temperature, which may be a unique strategy for an alien species native to the tropics to invade high latitudes.

Niche shifts and range expansions after the invasions of two major pests: Asian Longhorned Beetle and Citrus Longhorned Beetle

Yuting Zhou [1], Jing Tao [1], Jinglin Yang [2], Shixiang Zong [1] and Xuezhen Ge [3]

[1] Beijing Key Laboratory for Forest Pest Control, Beijing Forestry University, Beijing, China
[2] Mentougou Forestry Station, Beijing, China
[3] Department of Integrative Biology, University of Guelph, Ontario

zhouyuting725@163.com

In recent years, the quarantine forestry invasive pests Asian Longhorned Beetle (ALB) *Anoplophora glabripennis* and Citrus Longhorned Beetle (CLB) *Anoplophora chinensis* have spread across the Northern Hemisphere from eastern Asia, triggering concern about their potential distribution. Invasive species are commonly observed to shift their niches to adapt to novel environments. However, little is known about the niche dynamics of ALB and CLB after the invasion, making it difficult to accurately assess their potential ranges. We thus employed two distinct approaches (i.e., ordination-based and reciprocal model-based) to compare the native and invaded niches of ALB and CLB after their spread to new continents based on sufficient global occurrence collections. We further constructed models with pooled occurrences from both the native and invaded ranges to analyze the effects of occurrence partitioning on predicted ranges. We detected expansions in the invaded niches of both pests, indicating that the niches shifted to varying extents after the invasion. Comparisons along the single variables suggested that areas with more humid environments are preferred by invasive ALB, and CLB populations tended to be more intensive in conditions with lower temperatures and less precipitation. Also, large shares of the native niches of ALB and CLB remained unfilled by the invaded niches, revealing their tremendous potential for further invasion in new regions. The models calibrated with pooled occurrences obviously underestimated the potential ranges in invaded regions compared with the joint projections based on partitioned models considering native and invaded areas separately. These results emphasize the importance of grasping the niche dynamics of invasive species for obtaining accurately predicted ranges, which may help identify risk areas masked by the assumption of niche conservatism. Furthermore, prevention and quarantine measures for ALB and CLB are clearly needed in wider areas than currently affected areas of Europe and North America to avoid future serious damage to forest ecosystems.

Policy development for biofouling management in the Pacific region. The GloFouling Partnerships initiative

John Alonso [1] and Mohammed Zullah [2]

[1] International Maritime Organization (IMO), 4 Albert Embankment, London, United Kingdom
[2] Secretariat of the Pacific Regional Environment Programme (SPREP), Avele Rd, Apia, Samoa

mohammedz@sprep.org

The GEF-UNDP-IMO GloFouling Partnerships is a 6-year global initiative from the International Maritime Organization (IMO), in collaboration with the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), to protect marine ecosystems from the negative effects of invasive species transferred through biofouling on ships and other marine structures. The project drives actions in 12 developing countries and 6 regional seas through capacity building, awareness raising and a legal, policy and institutional review. The ultimate aim of GloFouling Partnerships is to help countries and regions in the development of a policy for the implementation of harmonised biofouling prevention and management measures that will reduce the risk of marine bioinvasions. SPREP acts as regional coordinating organization in the Pacific region and has led the implementation of activities sponsored under this initiative and other projects focused on invasive species. Under this proposal, an overview will be provided of the tools developed by GloFouling Partnerships and SPREP to date, including policy development guides, specialised reports and best practices in relation to all maritime industries affected by biofouling. In addition, an update will be provided on the results of efforts undertaken to date by countries in the Pacific and the challenges that have been identified in the development of national and regional policies.

Exhibitor profiles

CABI

CABI has worked on invasive species for over 100 years and our scientists are world leaders in biocontrol research. Through a range of projects and knowledge tools, we help protect livelihoods and biodiversity. We are currently working on over 80 invasive species around the world including insects, plants and vertebrates, quantifying their impact and using nature-based solutions such as biological and integrated control to manage them.

We produce a range of dedicated knowledge tools and resources to raise awareness about invasive species, prevent their spread, detect outbreaks and develop best practice solutions. For example, our open access Invasive Species Compendium is a comprehensive online reference work covering identification, biology, distribution, impact and management of the world's most invasive plants and animals. While our Horizon Scanning and Pest Risk Assessment tools can help to predict and prevent invasions. In addition, we help create policies, strategies and action plans at national and regional level.

www.cabi.org/invasives

CAAS

The Chinese Academy of Agricultural Sciences (CAAS) is a national, integrative agricultural scientific research organization with responsibility for carrying out both basic and applied research, as well as research into new technologies impacting agriculture. CAAS is dedicated to overcoming a broad range of challenges impacting agricultural development and support of the local rural economy. In 2009 CAAS initiated the "International Congress on Biological Invasions (ICBI)", and successively hosted the 2nd and 3rd ICBI in 2013 and 2017. The "Fuzhou Declaration" was announced as an outcome of the 1st ICBI that reach an agreement to establish International Expert Committee, and the congress would be an regular international event on biological invasions. CAAS promotes sustainable agriculture within and outside China, extending its reach through technology exchange and cooperative research agreements with agricultural research institutions/universities and global non-governmental organizations.

AgResearch

AgResearch is one of seven Crown Research Institutes established by the Government to provide impactful science and research for Aotearoa.

AgResearch's core focus is to deliver high quality science to enhance the value, productivity and sustainability of New Zealand's pastoral, agri-food and agri-technology sectors. Its team of more than 600 scientists and support staff includes world-leading experts in their scientific fields.

The institute is leading and collaborating on a broad range of research to make agriculture more productive, resilient, and sustainable in the face of challenges such as climate change. It is also committed to bringing Mātauranga Māori into equal footing with Western science, and embedding into its everyday work Te Ara Tika, which is a national plan to embrace Te Ao Māori values and tikanga based principles to better respond to Māori needs and better deliver to Māori aspirations.

agresearch
āta mātai, mātai whetū

Biosecurity New Zealand

Protecting Aotearoa-New Zealand from biosecurity threats

Biosecurity New Zealand is part of the Ministry for Primary Industries (MPI). It protects Aotearoa-New Zealand from damaging animal, plant and aquatic pests and diseases through strict border requirements and controls, and surveillance programmes. When biosecurity incursions occur, Biosecurity New Zealand works in partnership with Māori, industry, other government agencies, research providers and communities on control, eradication, and long-term management activities. We all play a part in protecting our country.

Biosecurity New Zealand's work is informed by the technical expertise and experience of many scientists across risk assessment, diagnostics, surveillance, investigation and response teams, to name a few. Science and technology are key to Biosecurity New Zealand's success and ensure New Zealand's biosecurity system stays agile and adapts to new challenges. Please visit Biosecurity New Zealand's stall (#2) at ICBI2023 to meet some of the people working in technical roles and hear their stories.

Biosecurity New Zealand
Ministry for Primary Industries
Manatū Ahu Matua

CSIRO

As Australia's national science agency, CSIRO is solving the greatest challenges through innovative science and technology.

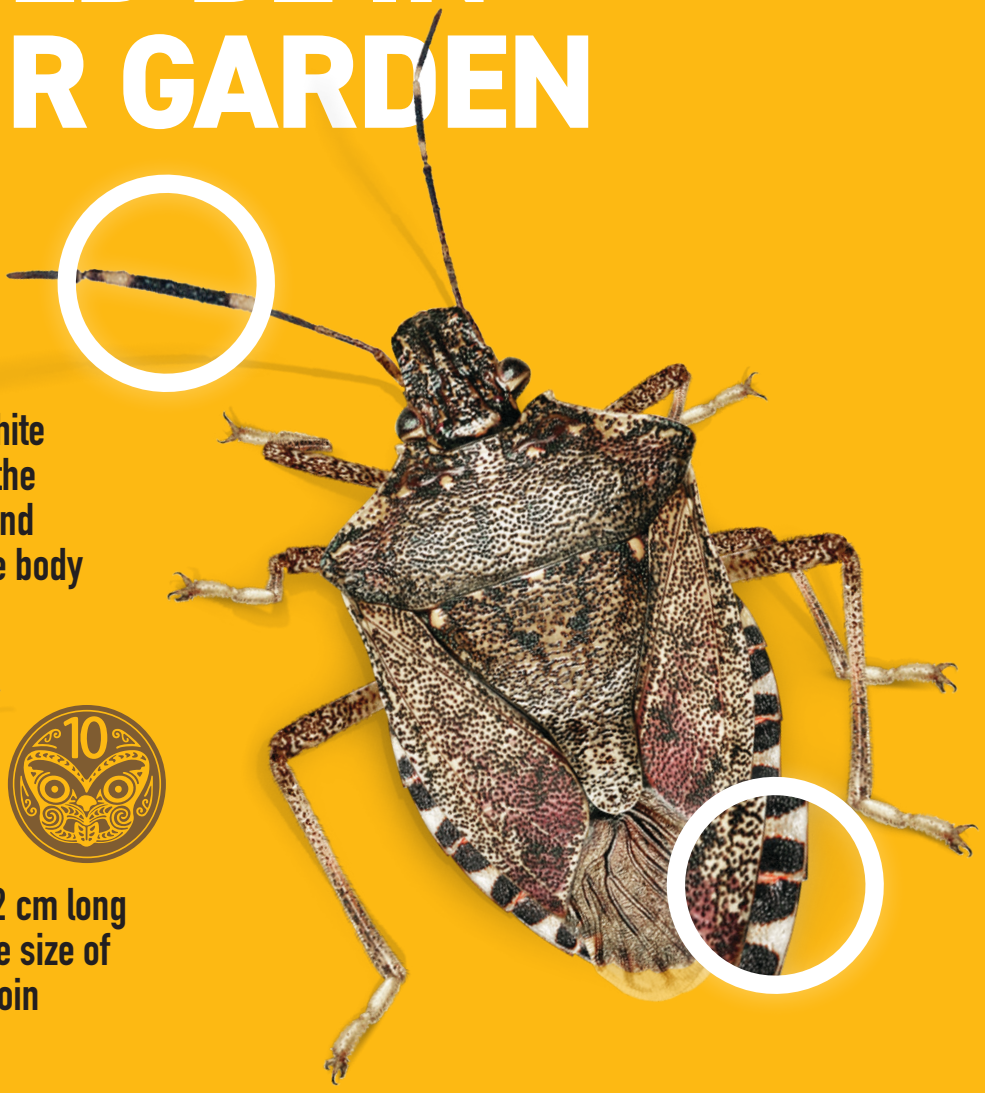
CSIRO has a strong record of delivering breakthrough innovations and technologies with real-world impact. We work with industry, government and the community to turn science into solutions. Our research is delivering a better future for everyone: people, our planet and our economy.

We are working to protect Australia from biosecurity threats arising from global travel and trade and exacerbated by urbanisation and climate change. Our goal is to deliver solutions to ensure Australia is prepared and ready to respond to existing and emerging risks to protect our environment, our agricultural industry, and our way of life.

To help meet this goal, we are developing the Catalysing Australia's Biosecurity initiative with the Australian Department of Agriculture, Fisheries and Forestry. Through this joint initiative we aim to work with wide ranging partners to drive technological innovation and transformation across Australia's biosecurity system.

Biosecurity New Zealand
Ministry for Primary Industries
Manatū Ahu Matua

THE BROWN MARMORATED STINK BUG COULD BE IN YOUR GARDEN



Look for white stripes on the antennae and sides of the body

It is about 2 cm long or about the size of a 10 cent coin

CATCH IT

SNAP IT

REPORT IT

0800 80 99 66