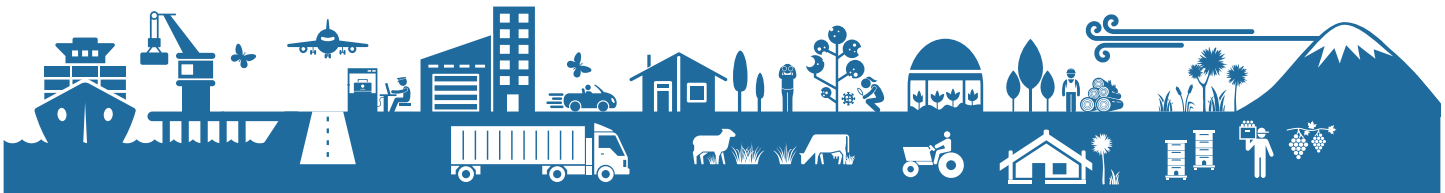
B3

Science Solutions for
Better Border Biosecurity
AOTEAROA NEW ZEALAND

B3 Annual Report 2022



System Innovation:

Major Initiatives to B3 Research Programme

Alignment to BHNSC 2014

1st B3 Conference 2014

Updated Strategy 2015

B3 Hui 2015

Operational Refresh 2016

Initiated Science Advisory Group 2016

Signed PBRI MOU 2019

Initiated Co-Invest Committee 2019

Updated Strategy 2020

Signed CEBRA MOU 2020

Māori CC Representatives 2021

Māori Research Lead 2021

Signed Uni Canterbury MOU 2022

Initiated Tech. Oversight Group 2022

Strategy

- Strategy renewed in 2015 and 2020 to respond to contemporary issues and future trends

Science rigour

- As part of the Operational Refresh, the Science Advisory Group was instigated to help maintain science excellence in the B3 programme

Responsiveness to Te Tiriti

- Partnership with Māori/iwi, and their vital role in biosecurity, has been recognised in many ways including appointments to the CC and TLG

Stakeholder engagement

- The B3 Conference is now a recognised feature of the Australasian biosecurity calendar

National & international collaboration

- B3 continues to extend its collaborations beyond its original partners with a range of MOU to co-ordinate research investment

Our purpose

To deliver research that adds value to Aotearoa New Zealand's biosecurity system.

Our vision

A world-leading plant border biosecurity system for Aotearoa New Zealand.

Our intended impacts

Our research results will minimise the entry and establishment of invasive pests (arthropods, pathogens and weeds) that threaten Aotearoa New Zealand's valued flora, including taonga. This will protect our biodiversity and the welfare of our environment, retain and build value in our important plant systems, underpin investor confidence for sector growth and innovation, and maintain market access for plant-based exports.

Contents

ABBREVIATIONS FOR ORGANISATIONS

AGR – AgResearch
BHNSC – Biological Heritage National Science Challenge
BNZ – Biosecurity New Zealand
BPRC – Bio-Protection Research Centre
CEBRA – Centre of Excellence for Biosecurity Risk Analysis
DOC – Department of Conservation
EPA – Environmental Protection Authority
FFNZ – Federated Farmers
FOA – Forest Owners Association
GIA – Government Industry Agreement for Biosecurity Readiness and Response
Hort NZ – Horticulture New Zealand
LU – Lincoln University
MPI – The Ministry for Primary Industries
MWLR – Manaaki Whenua Landcare Research
PBRI – Plant Biosecurity Research Initiative
PFR – Plant & Food Research
UC – University of Canterbury
UCBI – University of Canterbury Biosecurity Innovations
UOA – University of Auckland
UO – University of Otago
VUW – Victoria University of Wellington

NGĀ KUPU MĀORI

Hui – gathering/meeting
Kaiārahi – mentor
Tīna – lunch
Karakia – incantation/prayer
Kaupapa Māori – Māori theme/subject
Kōrero – discussion
Kotahitanga – collaboration/unity
Mahi – work/efforts
Mana whenua – people of the land
Mātauranga – knowledge
Mihimihi – introductions/welcome
Moana – ocean
Motu – islands
Ngāhere – forest
Powhiri – formal welcoming ceremony
Rangatahi - youth
Rangatiratanga – self-determination
Reo – language
Rohe – region/territory
Roopu – group
Taiao – environment
Tangata kokiri – Māori champions
Taonga – treasures/keepsakes
Te Ao Māori – The Māori world view
Tiakitanga - guardianship
Tikanga – customs
Tohu – environmental indicators
Waiata – song
Wānanga – discussion forum/workshop
Whakapapa – genealogy
Whakatau – welcome – less formal than Powhiri
Whenua – land

www.b3nz.org.nz

From the Director, Pourangahau and Chair

Kia ora koutou

Through minimising the entry and establishment of invasive pests, pathogens and weeds that threaten Aotearoa New Zealand's valued flora, the B3 science programme has a substantial role in mitigating the existential plant health, biodiversity and climate crises that this and other countries are currently facing. This annual report summarises the activities, achievements, impacts and outputs of B3 for these endeavours in 2021-22.

Eight major projects completed. A basic principle of B3 is that all parts of the biosecurity continuum are intricately related and cannot be considered in isolation. As such, B3 undertakes integrated research across risk assessment, pathway risk management, diagnostics, surveillance and eradication. In particular, this report highlights the large investment of eight five-year projects initiated in 2017 and completed in 2022, where examples of forward-thinking, novel, and world-leading plant border biosecurity research are illustrated. The outcomes of these include:

- new biosecurity concepts and applications, such as biosafety for pre-emptive biological control, and sentinel plants for pathogen risk assessment for native plants
- faster and more accurate identification of potential threats through enhanced genetic and molecular technologies
- optimised surveillance and response tools such as prototype insect smart traps, novel sensing technologies and application of the sterile insect technique
- supporting science for Port of Tauranga communities to improve awareness and action on biosecurity threats.

The report demonstrates the extensive uptake and application of B3 research by government, industry and community stakeholders and end-users.

Te Tiriti responsibilities to the fore. We have continued to place our Te Tiriti responsibilities to the fore with new kaupapa Māori projects, Māori specific outcomes targeted for all projects, kaiārahi for new projects, capability development opportunities for rangitahi, and the integration of tikanga into our day-to-day activities, building on actions in previous years to embed Māori into the governance and leadership of B3.

National and international collaboration key to success. B3 empowers an unrivalled national research collaboration between science, government, industry and community interests. Non-CRI stakeholders contribute significant in-kind contributions across B3 governance, leadership, and co-innovation, and directly fund operational and implementation activities utilising B3 capability. Current examples of aligned research funded from outside the B3 core funding include industry-specific risk assessment, surveillance for incursion response, pathogen diagnostics, and climate change research. For the fall armyworm, discovered in New Zealand in April 2022, B3 reflected its ability to respond to contemporary threats, focus its expertise, and intensify science activity to support an ongoing response, as it has done for the great white butterfly, kiwifruit vine canker (PSA) and myrtle rust outbreaks in the past. This short-term transitional position was expedient and necessary until other sources of funding became available through the GIA/MPI.

The reputation of B3 continues to attract and retain partners both nationally and internationally. The University of Canterbury and B3 signed an MOU to strengthen mutual interests in plant border biosecurity research and capability development, and Lincoln University renewed its strong support for B3 after the dissolution of the BioProtection Research Centre. Euphresco invited B3, and MOU partner PBRI, to co-host workshops and side sessions to explore the co-ordination of global plant health networks at an international conference. B3 continues to represent New Zealand at Euphresco and the International BioEconomy Forum Plant Health Working Group.

Fostering tomorrow's biosecurity experts. The B3 Collaboration Council reaffirmed the development of new biosecurity capability as a priority in 2021-22. B3's partners hosted six summer students, including rangitahi, several PhD students completed their studies, and new students were planned for new projects. B3 is optimising biosecurity capability development and co-ordination within New Zealand by working more closely with the Joint Graduate School in Plant and Food Science (University of Auckland), and the Joint Graduate School Food Transition 2050 (University of Canterbury, Lincoln University), both involving B3 partners.

Surveying our stakeholders. As noted, several large projects were concluded in June 2022, resulting in the largest B3 reinvestment for many years. Given the importance of this round, a stakeholder survey review on B3's Scope and Strategy and investment process was undertaken. Overall, feedback was positive with a range of useful comments, which were incorporated into the thinking for the new reinvestment round. Significantly, Plant & Food Research has shown its confidence in B3 by increasing its annual investment in response to the annual increase in the CPI.

COVID-19 impact. COVID-19 has continued to challenge our programme and, while successfully managed for the most part, it has had major impacts in a few areas. A significantly reduced publication rate, compared to recent years, may have reflected a productivity drop associated with extended lock-downs.

Good-byes and gratitude. During the year we said goodbye to Suzanne Keeling, Michael Bunce and Katrin Webb (all Collaboration Council), and Aurélie Castinel and Rod Hitchmough (both end-user co-ordinators), and thank them for their substantial contributions to B3 over several years. We welcome Chris Hill and Gavin Forrest (both Collaboration Council), and Sathish Puthigae and Murray Fea (both end-user co-ordinators) and Waata Papali'i-Smith (new MPI Māori rep) and look forward to working with them in the coming years. Those contributing to the B3 programme in 2021-22 can be found on page 27.

Ngā mihi

David Teulon
(B3 Director)

Alby Marsh
(B3 Pourangahau)

James Buwalda
(B3 Collaboration Council Chair)

Photo credit: Plant & Food Research

A Māori Strategy for B3

Māori have strong connections to the biological heritage of Aotearoa New Zealand, as intergenerational guardians of significant natural resources and indigenous knowledge, and owners and managers of commercial assets with views and belief systems that can underpin biosecurity decision-making, governance and stewardship.

B3 is enhancing partnership with Māori in all its activities. It will achieve this by taking a Treaty of Waitangi-based approach for all research investments. B3 will champion the importance and inclusion of mātauranga Māori in its research programme in a manner that gives effect to Māori conservation and bio-economic aspirations.

B3 will be guided by these principles and integrate these characteristics:

KOTAHITANGA

- A network of Māori champions (Tangata Kokiri) from across the country
- Strong, trusted relationships based on honesty, integrity and reliability
- Continuity of research partnerships
- Integrated research programmes

RANGATIRATANGA

- Joint summer studentships in partnership with end-user organisations
- Co-innovation, co-development, co-led programmes of research
- Development of a Pasifika Biosecurity Network

TIAKITANGA

- Kaupapa Māori-driven research projects
- Training programmes for mana whenua in pest and pathogen identification
- Tiriti-based wānanga
- Vision Mātauranga training

B3 will undertake these activities:

MAINTAINING

- Development opportunities for young Māori researchers within the B3 programme
- Identification of current B3 projects of relevance to Māori, in particular the protection of taonga

IMPROVING/INCREASING

- Reflection of Tiriti obligations throughout B3 structure: governance, investment, operations, engagement, research, and implementation
- Meaningful consultation and early engagement across the B3 research portfolio
- Participation in relevant wānanga, hui, conferences, forums and workshops
- Research in each of its five themes to mitigate risks to taonga from invasive species that are likely to invade Aotearoa
- A proportion of B3 investment targeting biosecurity issues for Māori

INITIATING

- The development of a Māori strategy reflecting representation across B3 (e.g. TLG, CC, SAG)

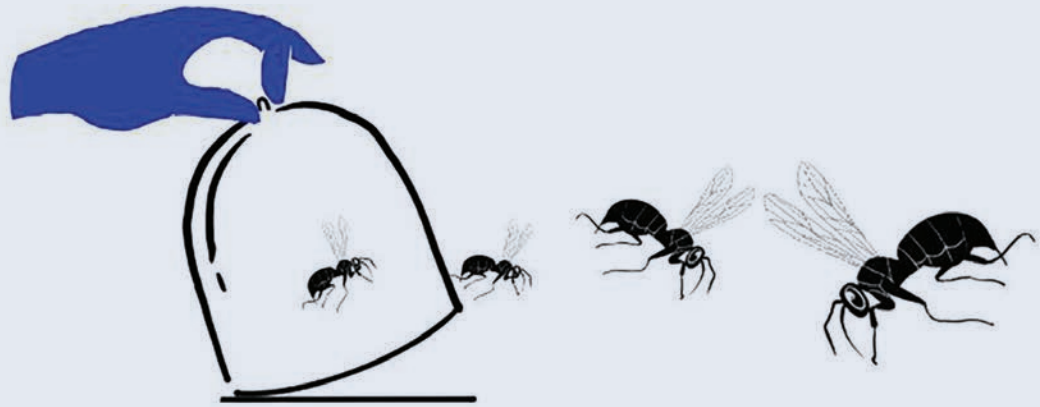
Biosecurity Based on Science

Recent examples of B3 science and its uptake and application by stakeholders

Knowledge / Innovation	Uptake / Outcome	Science substantiated*
Theme A - Risk: Intentional Introductions		
Principles of biosafety for importation of BCAs established	Publications referred to in applications to NZ EPA for release of BCAs	Andow et al. 2021, Gerard & Barratt 2021, Meurisse et al. 2021, Paula et al. 2021, Todd et al. 2021, Withers et al. 2021
Initiation of pre-emptive biological safety concept	First ever pre-emptive BCA approval by NZ EPA for BMSB parasitoid	Charles et al. 2019, Saunders et al. 2021
Theme B - Risk: Unintentional Introductions		
Chinese language databases and publications interrogated for information on biosecurity risks	Approach now used by MPI & several industry sectors	Teulon & Xu 2018, Xu & Teulon 2022
Sentinel plants (NZ plants grown in foreign locations) used for risk assessment	NZ indigenous plant / *Xylella* associations found in California, used to inform risk analysis	Mansfield et al. 2019, Boyd-Wilson et al. 2021
NZ-centric climate modelling tools developed	A co-funded app developed with Epi-interactive for use by MPI	Roigé & Phillips 2021
Integrated Biosecurity Risk Assessment Model (IBRAM)	A tool used by MPI for risk assessment	Jamieson et al. 2021
Theme C - Pathway Risk Management		
Catalysed early research on treatments for hitchhiker pests	Ethyl formate approved for border treatments of BMSB in NZ	Abrams et al. 2020
Heat for disinfection/disinfestation of horticultural produce	Hot water treatment for taro being advanced in Samoa	Fallik et al. 2020
Phytosanitary risks in seed for sowing pathway	Model for spread of hypothetical contaminants across the ryegrass and clover seeds trade networks	Buddenhagen et al. 2021, Rubenstein et al. 2021
Theme D – Diagnostics		
Stable isotopes signatures to determine origins	Tool used in BMSB and FF responses	Holder et al. 2019, Murphy et al. 2019
Pathogenic vs taxonomic diagnostic markers	New diagnostic protocol used regularly by MPI	Visnovsky et al. 2019, 2020
Theme E -Surveillance & Eradication		
Global Eradication and Response Data Base (GERDA)	Underpinned pathway interventions policy for MPI	Kean et al. 2022
Aerial release of sterile insects using drones	Operational requirements defined for use of drones for sterilised codling moths in Hawkes Bay orchards	Esch et al. 2021
Multiple-species trapping with combined lures	Concept being developed further by GIA Fruit Fly Council	Brockerhoff et al. 2013, Stringer et al. 2019
Expert support in real-time biosecurity responses	Knowledge incorporated into Technical Advisory Groups and operational responses	Phillips et al. 2020, Soewarto et al. 2020, Voice et al. 2022

*Citations found in https://www.zotero.org/groups/1595276/better_border_biosecurity_b3/collections/H6NCM36Y

Photo credit: Josie Ford



Theme A: Risk Assessment for Intentional Introductions

Improving tools and methodologies for assessing risk and predicting impacts for intentional introductions

Theme leader:
Barbara Barratt

The purposeful introduction of biological control agents (BCAs) into plant systems continues to be one of the more sustainable and preferred solutions for invasive insect species management. In Aotearoa New Zealand the EPA regulates this process to ensure any proposed release maximizes beneficial outcomes and minimizes non-target impacts such as against indigenous and taonga species.

B3 researchers have now completed two projects focused on better understanding the science behind biosafety for biocontrol release and to support EPA, applicants, and other interested parties including iwi in this process.

- **Improving risk prediction (A17.2)** developed new tools to improve host testing in containment and support pre-release risk assessment of candidate BCAs. These will provide better predictions of potential direct, and where possible, indirect impacts on non-target species and, ultimately, reduce uncertainty.
- **Understanding environmental impacts (A17.3)** analysed previous biocontrol introductions to assist in predicting and evaluating direct and indirect risk from new organism introductions.

These projects developed a substantial knowledge base from which to assess the potential impact of intentionally introduced BCAs on non-target species. B3 capacity or knowledge has underpinned a number of applications to EPA in recent years, including: Samurai wasp for pre-emptive biocontrol of the brown marmorated stink bug (BMSB) (2018), *Eadya daenerys* for biological control of *Paropsis charybdis* (2018), and *Pauesia nigrovaria* for biological control of giant willow aphid (2019).

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Preparedness for priority biosecurity threats

Considered to be a world-first, the pre-emptive approach aims to address a major limitation in biocontrol practice – the lengthy pre-release risk assessment research in containment required for approval by regulators, which gives a pest additional time to establish, build population density and spread. The pre-emptive approach for the BMSB, supported an application by industry and approval (with controls) by the EPA, for the release of the *Trissolcus japonicus* (samurai wasp) in the event of a BMSB incursion. Substantial support for this approach came from the NZ-US Joint Commission on Science and Technology Collaboration and CABI China. A Euphresco project, co-led by B3, was commissioned in 2020 with the aim of establishing a biocontrol network to share knowledge and information on priority threats and BCAs to increase preparedness for incursions of invasive invertebrate species.

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Toni Withers explaining the Biosecurity Adverse Impact Probability Assessment (BAIPA) model to stakeholders.

New tools for biocontrol risk prediction

B3 researchers developed three new prototype tools to assist applicants and regulators predict the risk of new BCAs. The 'Scale-of-Risk' tool compares the relative risk of new BCAs compared to BCAs already introduced. The 'Biosecurity Adverse Impact Probability Assessment' (BAIPA) and 'Threshold' tools use probabilistic modelling of biological and ecological parameters to assess and predict risk to non-target species. Each tool was assessed using New Zealand case studies of previously documented BCA introductions. While showing considerable promise, these prototypes will require further development for uptake and application. Results from this five-year B3 project also demonstrated chemical ecology studies can, in some cases, contribute new knowledge to increase understanding about the potential risk of candidate BCAs and reduce uncertainty that remains after host range testing.

Barbara Barratt made Fellow of Royal Society Te Apārangi

Barbara has been part of B3 for more than 15 years and led and pioneered internationally relevant research into the biosafety of introduced biocontrol agents for insect pests, in close partnership with the EPA, MPI and DOC. Her research is widely applied domestically and internationally. As well as becoming a Royal Society Fellow, Barbara was President of the International Organisation for Biocontrol (IOBC) and was central to the development of IOBC's Global Commission on Biological Control and Access and Benefit Sharing'.

Tom Saunders defended his PhD thesis in March 2022

In his research at the UOA and PFR, Tom studied the samurai wasp, a potential biocontrol agent of BMSB, and how the wasp might behave when presented with indigenous and naturalised New Zealand stink bugs. He also studied the role of chemical ecology to gain better insights into non-target risks associated with classical biocontrol agents.

Photo credit: Plant & Food Research

Theme B: Risk Assessment for Unintentional Introductions

Improving tools and methodologies for identifying hazards, assessing risk, predicting impacts and ascertaining where in the system mitigation measures are best targeted

Theme leader:
John Kean

Xylella fastidiosa (Xf) is an insect-vectored bacterial plant pathogen that infects a wide range of plant species and causes devastating diseases. The pathogen is not present in New Zealand. Two interconnected B3 projects have examined the sentinel plant concept to understand the potential impact of this pathogen on New Zealand indigenous plants such as pōhutukawa, kauri, and karaka:

- **Predicting the risks and impacts of *Xylella* using sentinel plant network (B20.2)**
- **Strategies for determination of biosecurity risk using high throughput sequencing (D17.25)**

A survey of New Zealand indigenous woody plants species growing in Southern California in 2012 revealed several were susceptible to Xf. More recently, over 140 indigenous plants growing in the University of California Botanical Garden at Berkeley were screened for Xf and eight tested positive. Most positive samples came from shrub-like species, unlike the woody species sampled in Southern California in 2012. This research is providing insights into the disease progression of *Xylella* in indigenous species, developing diagnostics tools in the event of an incursion in New Zealand, and assessing the risk of Xf sequence-types to indigenous flora and their potential transfer to crops. Substantial support was provided by Rodrigo Almeida (University of California, Berkeley), and Holly Forbes (University of California Botanical Garden) and their teams.

The New Zealand section of the University of California Botanical Garden at Berkeley. Photo credit: Marion Brenner, UC Botanical Garden at Berkeley

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Karakia by MPI kaihautū (from left) David Teulon, Waitai Petera, Waata Papali'i-Smith, Kapiera Peita and Rob Taylor in the presence of plant taonga. The repatriation ceremony was held in the MPI PHEL containment laboratory under strict quarantine conditions.

B3 and the Biological Heritage National Science Challenge

Theme B is closely linked to the Biological Heritage NSC project SO3: He Tangata, He Taiao, He Ōhanga, which aims to create a biosecurity risk assessment framework inclusive of the rich set of environmental, economic and socio-cultural values that characterise Aotearoa New Zealand. Like B3, SO3 draws on a wide range of skilled researchers from across the CRIs and universities. B3 Theme B leader John Kean co-leads SO3, and B3 Māori Research Lead Alby Marsh is the primary Māori advisor. SO3 draws on the mahi of several B3 researchers, and has linkages with more than seven B3 projects. SO3 supports a Māori biosecurity PhD project through UOA, and three Masters students through the UCBI hub.

For further information see https://bioheritage.nz/goals/stategic-objective/predicting-current-and-future-threats/

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Repatriation of nga tupu taketake ō Tāne

A small but significant ceremony was undertaken to recognise the repatriation of samples of indigenous plant taonga from Aotearoa New Zealand trees growing in California USA. The whakatau acknowledged the special connection people share with nature and expressed that connection according to Te Ao Māori. The ceremony was held in the MPI containment laboratory in Tamaki Makaurau under strict quarantine conditions. The whakatau represents a significant step by B3 in recognising Te Ao Māori and integrating tikanga in its research programme.

The ceremony consisted of an initial set of cultural protocols including karakia, mihimihi, and waiata as well as kai whakanoa. This was followed by further karakia inside the PC2 laboratory in the presence of the descendants of Tāne, or plant samples, then waiata were performed outside the containment laboratory. The ceremony was led by MPI Kaihautū: Waitai Petera, Kapiera Peita, Michelle Nahi and Waata Papali'i-Smith.

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Rebecca Campbell awarded prestigious MBIE Science Whitinga Fellowship

In 2021 Rebecca was awarded this fellowship, administered by The Royal Society Te Apārangi, to study *High-resolution epidemiological models for plant disease prediction and risk management*. She will formulate epidemiological models with direct applications to pre- and post-border biosecurity and bioprotection. Case study examples are European canker in apple, myrtle rust and *Xylella*.

Photo credit: Port of Tauranga

Theme C: Pathway Risk Management

Developing fit-for-purpose tools and methodologies for reducing risks along importation pathways

Theme leader:
Nicolas Meurisse

Novel sensors to sniff out biosecurity threats (C17.13)

With an increase in global trade comes increased biosecurity risk in unwanted pest insect incursions via importation pathways. New technologies that can rapidly and confidently detect pests pre-border and en route are needed. Researchers in this project developed two novel sniffer technologies for the real time detection of pests such as BMSB and fruit flies based on their unique volatile fingerprints. These technologies have the potential to become essential biosecurity tools for detecting key insect pests along importation pathways and at the border.

Queensland Fruit Fly – Bactrocera tryoni. Photo credit: James Niland

The first technology comprises a tuneable sensor that can screen fresh produce and inanimate commodities using an array of powerful insect odorant receptors (iORs), ordinarily located within the olfactory sensilla on an insect's antenna, that detect volatile organic compounds (VOCs). Researchers specifically looked at volatiles emitted from fruit infested with the Queensland fruit fly. iORs have been recombinantly expressed, purified and stabilised in membrane-based liposome and nanodisc formats. These iORs have successfully been coupled to various biosensor platforms and used to detect volatile compounds dissolved in solution. The focus is now on transferring this technology into the gas phase.

The second sensor is a low-cost portable device for detecting hitchhiker pests in containers during shipment or post border. Researchers are targeting tridecane, the major component of the BMSB alarm pheromone. A portable prototype BMSB sensor, combining a specialised polymer-coated sensor with a front-end selectivity filter, has been developed, capable of detecting tridecane at concentrations consistent with expected levels in shipping containers.

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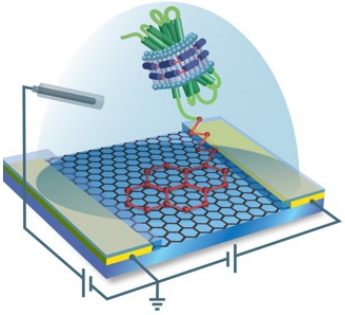
Jamal Cheema defended his PhD thesis in January 2022

Carried out at the UOA and PFR, Jamal's research examined the development of electrochemical biosensors using insect odour receptors (iORs) in nanodiscs for detection of biosecurity threats, such as fruit flies. Nanodiscs have shown superior sensitivity, stability and scale (size) characteristics compared with other sensor approaches. His findings were a critical part of the major B3 project on developing novel sensors (see previous page) and contributed significantly to improvements in sensor design and methodology for nanodisc-based biosensors.



Schematic of the QFF sensor

Cultural Tourism Biosecurity Ambassador Roopu Hui

A roopu of Māori tourist operators are seeking to strengthen biosecurity in the tourism sector, with B3's support. A hui, organised by Simon Phillips (The Piripi Group) in Wellington in June 2022, and attended by Māori tourism operators representing the moana and ngahere and from throughout the motu, examined how mātauranga and their own personal business experiences could elevate the discussion and application of improved biosecurity in the tourism secor. Each identified that biosecurity goes hand-in-hand with their everyday mahi, and as a backdrop for the cultural kōrero of their hapū / iwi. Attendees were keenly aware their observations of the taiao were real and relevent as tohu, as well as being open to the technical side of biosecurity. All agreed there was a major need for a greater focus on biosecurity in the tourism sector and a need for action. Various roles for the roopu were discussed, including the distribution of information and sharing knowledge with visitors and locals, identifying and actioning best-practice, and multi-level communication to influence decisions at the policy level. An agreement to formalise the roopu as actors for change within the tourism industry was reached. B3 will continue to support this initiative as appropriate.

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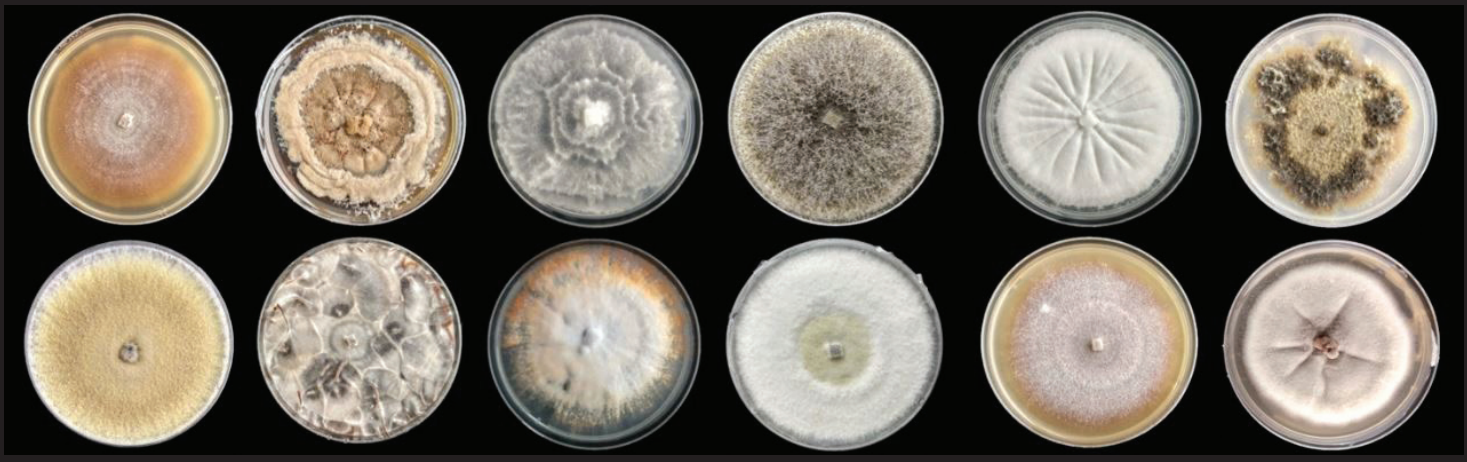
Attedees at the hui: Simon Phillips, Alby Marsh (B3 Pourangahou), Lee-Anne Jago, Kyle Kydd, Kauahi Ngapora, Minnie Clarke, David Teulon (B3 Director), Henare Dewes, Hinewai McManus, Wi Huata. Michael Harbrow (DOC) also attended. Photo credit: Simon Phillips. Photo credit: Simon Phillips

Photo credit: Bioluminescence Superbugs Lab



Theme D: Diagnostics

Fast, cost-effective, robust and accurate diagnostic methods and tools to enable informed biosecurity decisions

Theme leader:
Karen Armstrong

Linking molecular and morphometric diagnostics (D17.22)

This five-year study addressed the crucial issue of misleading species identifications due to inaccurate DNA sequence data. Researchers linked sequence data back to authentically identified specimens from the NZ Arthropod Collection and the NZ Fungarium (PDD) as well as living cultures in the International Collection of Microorganisms from Plants (ICMP). These MWLR specimen databases then provided direct hyperlinks to specimen sequenced data in international depositories for arthropods (BOLD), and for fungi and bacteria (GenBank).

Over the course of the project over 1200 arthropod species in key families of Hemiptera, Coleoptera, Lepidoptera, Hymenoptera and Diptera were sequenced. Specimens sequenced in PDD and ICMP have doubled to more than 8000, including key genera such as *Phoma, Alternaria, Fusarium* and *Verticillium.*

Integral to the project was the development of high throughput methods for more efficient sequencing and obtaining sequences from difficult to handle material such as old specimens of important early records of a pest or pathogen. Researchers worked on pipelines to make more effective use of sequences generated as part of the routine diagnostics in the MPI labs. Data generated through the project are now routinely included in protocols for assessment of biosecurity risk by MPI.

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A tool for early plant pathogen detection (D17.5)

Researchers in this project developed a novel PCR diagnostic approach for distinguishing between disease-causing and non-disease-causing bacterial strains, enabling risk-based decisions to be made more rapidly. MPI now regularly uses this PCR pathogenicity test on imported plant material and is trialling its potential to process bulk samples – as happened with COVID-19 PCR testing – to further speed up the process of determining biosecurity risk.

Researchers focused on pseudomonads, an important group of pathogens containing a number of key biosecurity threats to develop a leaf-based pathogenicity test. They demonstrated the potential of comparative genomics to detect strains of otherwise uncharacterized pathogenicity.

To improve on the efficiency of this approach, short-read and long-read off-the-shelf platforms were explored to simultaneously detect *Pseudomonas* and *Pectobacterium* strains in mixed-inoculated plants and samples from the field. Both platforms were able to detect the pathogens in symptomatic and asymptomatic tissue to the subspecies level when searching for the genetic signatures identified previously in a comparative genomics study. Long-read sequencing had a much faster turnaround and enabled the possibility of metagenome-assembled genomes with longer contigs to allow for better identification.

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B3 researchers and MPI diagnosticians met regularly to debate diagnostics research.

Boosting diagnostic capacity for plant production industries

Initiated through PBRI and managed by Grains Research Development Corporation, B3 has been able to strengthen its research outcomes, access additional expertise and explore additional applications through its involvement with this Australian Rural R&D for Profit programme part funded through the Department of Agriculture, Fisheries and Forestry. B3 is active in two diagnostic projects (1) developing race specific nanopore sequencing protocols for the plant pathogen *Xanthomonas citri pv. malvacearum* to be incorporated into a revised National Diagnostic Protocol, in collaboration with Toni Chapman (NSW DPI), and (2) enhancing the stable isotope B3 programme by investigating lead isotope ratios as a means to improve geographic provenance or origin resolution in high-risk urban areas.

BOOSTING DIAGNOSTICS PLANT BIOSECURITY

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

PLANT BIOSECURITY RESEARCH INITIATIVE

Scholarship enables upskilling in spittlebug identification

Jessica Vereijssen, was successful in obtaining a Margaret Hogg-Stec Memorial Scholarship (2021) to acquire the knowledge and skills for identification of New Zealand spittlebugs, all potential vectors of *Xylella fastidiosa*. The Scholarship will enable Jessica to collaborate with other B3 partners with diagnostic expertise from MPI (Disna Gunawardana) and MWLR (Darren Ward, Murray Dawson) to develop a spittlebug key that can be used by non-experts.

Theme E: Surveillance and Eradication

Tools and strategies for preparedness and response to incursions of invasive plant pest species, including determining their presence or absence

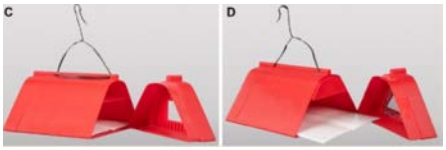
Theme leader:
Jessica Vereijssen

Automated Surveillance for Biosecurity Threats (E17.27)

The deployment of smart sensor traps for biosecurity surveillance could substantially reduce the cost of labour by directing trap visits to locations of insect detection, thereby supporting a sustainable and low-carbon surveillance system.

In this project, a multi-disciplinary team of data scientists, engineers, chemists, and biologists developed prototype smart trapping systems that (1) integrate low power optoelectronic sensor technology within a delta-type trap; (2) records low wing-beat frequencies of Lepidoptera and (3) remotely sends real-time digital detection via wireless communication. Identification of different insect species can be enhanced through machine-learning algorithms that differentiate wing-beat frequencies from different insect species.

Laboratory and field trials showed that moths flying in and out of the new traps can be detected automatically before visual trap catch, thus improving early detection. The battery of current prototype traps can last



3D-printed smart sensor trap with (C) front-end cap hosting the optoelectronic sensor and (D) rear end cap fitted with insect mesh preventing entrance of insects from this end and removable to access the trap to change the sticky base.

for six months when in sleep mode with power consumption decreasing depending on numbers of detection and network connectivity.

Such automated trapping systems could revolutionise biosecurity surveillance by assessing catch from remotely-located traps and transmitting data via wireless communication for real-time biosecurity alerts.

Contact:
Flore.Mas@plantandfood.co.nz

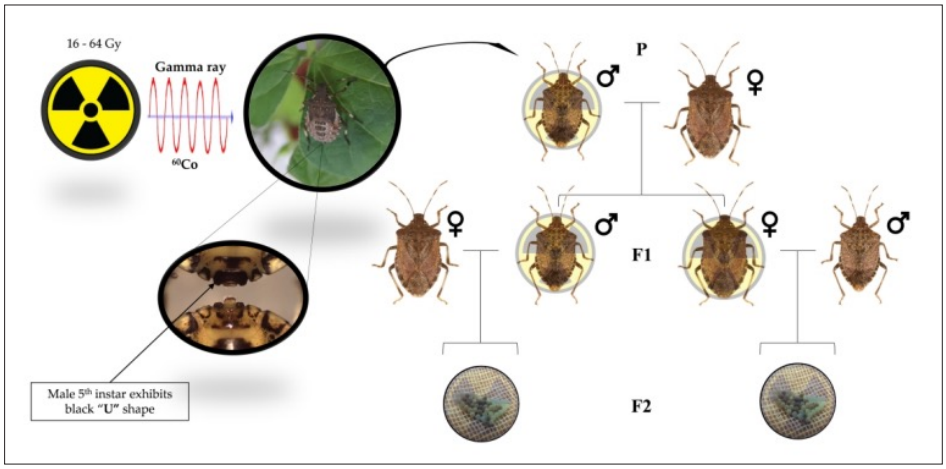
Biosecurity Excellence in Port Communities (17.28)

This project provided science support to the Port of Tauranga Biosecurity Excellence Initiative, a collaboration between industry and government, to promote positive biosecurity awareness and behaviours in port-related communities. Both are closely aligned to the Tauranga Moana Biosecurity Capital (TMBC) initiative.

Biosecurity awareness and behaviours were assessed by B3 social scientists for several different port communities: Horticultural and forestry owners unanimously supported the importance of biosecurity and most claimed to monitor for unwanted pests, but few practiced rigorous orchard hygiene; Port and transitional facility staff rated their knowledge of biosecurity as high, but around half wanted more training; Local residents felt the biggest barriers for them in helping with biosecurity was their lack of knowledge, and not knowing what to do to make a difference; School children were exposed to an educational kit and Invasion Busters board game, which increased their perception of biosecurity as being important, and this effect persisted for at least six months afterwards. It was surprising to find that the COVID-19 pandemic had little apparent effect in raising awareness of biosecurity issues.

Through studying different trapping options, researchers found large light

The B3 research in Port of Tauranga was part of a much wider contribution from several parties working closely together. Photo credit: Port of Tauranga



The Sterile Insect Technique is being investigated by B3 as a potential response tool in the case of a BMSB incursion. Photo credit: Nguyen, Stringer and Hong

traps were the most effective tools for sampling port biodiversity, especially when augmented with pitfall traps for non-flying species. Better tools are required to optimally sort and identify specimens from bulk samples.

Findings from the study are being used to better target biosecurity awareness activities for workers, industries and communities around the Port of Tauranga, and inform budding initiatives at other New Zealand ports.

Contact:
John.Kean@agresearch.co.nz

Feasibility of the Sterile Insect Technique Examined (E17.31)

New, effective and socially-acceptable tools are urgently needed for insect eradication. The Sterile Insect Technique (SIT) is an organically approved, species-specific tool with considerable potential for use in future biosecurity responses. Developing knowledge on the technical feasibility of SIT was a major focus for researchers in this project, using a mix of population modelling, field trials and validation, and focusing on key biosecurity threats such as BMSB, QFF, leafroller moths, and spotted wing drosophila (SWD).

This project developed strong international linkages, and co-funding from some of these sources, which facilitated greater collaboration, broadened the scope, provided access to supplementary knowledge and data, and access to out-of-country field testing sites.

Major findings of this five-year research project indicate SIT is technically feasible for supporting eradication of BMSB and for SWD. However, aspects of pest biology and access to large numbers of insects to irradiate and release still provide challenges to implement this tool for these species. Combining population modelling with trials has greatly improved the understanding of how different tools can suppress population growth as well as provide confidence a species has been eradicated. The modelling approaches are widely transferable to other insect species.

Contact:
Lloyd.Stringer@plantandfood.co.nz

Kiran Horrocks submitted his PhD thesis for examination in July 2022

In his research at the UOA and PFR, Kiran studied the novel approach of using sterile parasitoids for the eradication of invasive species, thereby mitigating the potential risk of non-target impacts. He intended to model the BSMB and its natural enemy, *Trissolcus japonicus* (samurai wasp) but due to COVID-19-related travel restrictions did model validation using green vegetable bug and its parasitoid *Trissolcus basalis*. He found irradiating mated female parasitoids can induce sterility without inhibiting their ability to kill the host. Kiran was recently awarded the biannual best paper prize by *Agricultural and Forest Entomology*.

Photo credit: Ministry for Primary Industries

B3 Steps Up Research to Face Fall Armyworm

Fall armyworm (FAW) (*Spodoptera frugiperda*) is an invasive pest species that has been spreading rapidly around the world. FAW was first recorded in Aotearoa New Zealand in March 2022. Even if does not establish at this time, it is likely to continue to threaten New Zealand as it can be blown across the Tasman Sea from Australia where it has firmly established.

FAW is a sub-topical/tropical insect and it is uncertain to what extent it will overwinter and develop populations in sufficient numbers in New Zealand to cause significant damage to plants.

In expectation of its arrival, and more probable impact in Northland, B3 engaged 2021-22 summer student Taylah Dalton to explore the potential impact of FAW to plants of value to Māori.

Soon after the first recorded cases of the pest in New Zealand, B3 refocussed some of its expertise and intensified activity to support the ongoing response, as it has done in the past for the great white butterfly, kiwifruit vine canker (PSA) and myrtle rust outbreaks. B3 instigated a cross-CRI FAW Biosecurity Science Consultative Group with access to expertise from the local research community, and researchers from Australia (Australian FAW expert Helen Spafford) and Asia, who have had first-hand experience of this pest.

With BNZ and its primary sector partners, B3 identified several research areas of particular interest and was able to work these into its ongoing research programme. Additional funding was provided by MPI / GIA to continue research in two areas: (1) climate modelling to determine where FAW might overwinter and the likely number of generations it might have per year in different localities, and (2) spring assessment of FAW adult flights to provide further evidence of overwintering. B3 researchers are also supporting additional industry FAW initiatives for identification and surveillance. Building on previous initiatives to engage with Māori in Te Tai Tokerau, B3 and MPI plan to support two Māori summer students in 2022-23.

Contact:
David.Teulon@plantandfood.co.nz

Atmospheric modelling in support of the FAW response

In related research not funded by B3, Scion undertook novel atmospheric transport modelling called Lagrangian Coherent Structure (LCS) or 'air-bridge' modelling to assess the potential dates FAW could reach New Zealand. They conducted this work for the period November 2021 to March 2022, as this was the period it was initially believed FAW arrived. They identified three weather events (one each in November and December 2021 and March 2022) where 'air-bridges' connected Australia to either Northland or Taranaki. They found FAW dispersal from New Caledonia was also possible during two cyclone events in January and February 2022.

Contact:
Ilze.Pretorius@scionresearch.com

Synergising National and International Research Co-operation

Plant Science Central Conference, Palmerston North July 2021

B3 sponsored a plant biosecurity session for PhD students from throughout Aotearoa New Zealand to stimulate a network of early career plant biosecurity experts. Students were at different stages in their PhD programmes, with topics ranging from investigating specific potential biosecurity risks, to novel tools for handling incursions, and system wide analysis for science (including mātauranga) solutions across the biosecurity continuum. The students included Tracey Godfery (UA/BHNSC), Madeline Marshall (LU/BPRC), Ned Treacher (VUW/B3), Sandra Savinen (LU/BPRC), and Kiran Horrocks (UA/B3). The B3 Collaboration Council reaffirmed the development of new biosecurity capacity as a priority in 2021-22. Developing a cohort of passionate plant biosecurity students is something B3 will continue to encourage in 2022-23 including developing links to similar initiatives with PBRI in Australia.

BMSB Symposium, Napier August 2021

BMSB continues to be one of the great biosecurity threats to Aotearoa New Zealand. This symposium was hosted by NZ Plant Protection Society and sponsored by B3, PFR, GIA, NZ Fruitgrowers Charitable Trust, Zespri, NZ Apples and Pears and NZ Wine. The Symposium brought together interests from the research, government, industry, and iwi communities and included updates from Dr Tracy Leskey (USA), Prof Claudio Loriatti (Italy), Prof Anne Nielson (USA) and Ilania Astorga (Chile). Participants assessed past activity, identified gaps in current knowledge, prioritized future work, and confirmed and built new collaborations with the aim of stopping BMSB from establishing and/or to mitigate its impact if it does.

Plant Biosecurity Research Initiative Symposium, Adelaide May 2022

B3 and PBRI, Australia continue to co-ordinate their annual conferences and to host each other every alternate year. In 2022, six B3 researchers participated in a trans-Tasman session sharing latest research from B3 projects with particular relevance to Australia. James Buwalda contributed to a 'partnerships panel' and David Teulon and Alby Marsh attended a PBRI 'partnership strategy day' immediately after the symposium.

International Congress on Biological Invasions, Christchurch 1-4 May 2023

ICBI2023 will provide a science forum to explore, share and develop effective responses to the global challenges and threats Invasive Alien Species (IAS) present to biodiversity, ecological systems and food production and security in terrestrial, freshwater and marine ecosystems. It will be the major invasive species event in Australasia in 2023. B3 was chosen by previous Chinese ICBI organisers to host this international event. A one day B3 Conference will be held after ICBI2023.

Summer Students 2021-22

Every year B3 welcomes students from a range of universities to take part in the B3 research programme over the summer.

Summer students provide a valuable contribution to the research programme while giving students professional experience working with senior scientists and the ability to enhance their biosecurity career prospects. Summer students working in B3 in 2021/22:

UOA postgraduate biosecurity and conservation student **Taylah Dalton** studied the potential impact of the FAW on plants of value to Māori in the Te Tai Tokerau rohe.

LU student **George Gibbs** supported an International Plant Sentinel Network (ISPN) pilot study, led by Botanic Gardens Conservation International (BGCI) located at Kew Gardens, on the value of exotic pest and pathogen horizon-scanning. George recorded examples of threats in New Zealand on plants considered iconic in the United Kingdom and refined the sentinel network approach working in partnership with Christchurch Botanic Gardens.

UC student **Rey Dela Cruz** was part of a project to visually identify contaminants on shipping containers. Rey created a large-scale dataset for the AI system to detect contaminants on container outer surfaces under complex weather and lighting conditions. He also assisted in development of machine-learning algorithms to detect container numbers and other details, and types of contaminants.

UC student **Connor Kwon** assisted with production of a smart-trap prototype that will catch insects and identify them through machine learning. Connor was also involved in field and wind tunnels trials of the trap, aimed at catching fruit flies and gypsy moths.

UC data science student **Shraddha Holay** worked on a project to use remote sensing technology (hyperspectral imaging data) to identify biosecurity threats in a range of plant systems.

UO student **Hadley Muller** studied REIMS (Rapid Evaporative Ionisation Mass Spectrometry) fingerprinting of weevils to determine age, sex and other biosecurity relevant attributes. REIMS is an emerging technique that allows rapid characterization of biological tissues or differentiation of species.

Projects Initiated in July 2022

Theme A

Testing the Toolbox: Reducing uncertainty around non-target impacts from biocontrol agents by validating tool predictions (A22.1) 3 years

Validate tools for regulators, decision-makers, applicants, and submitters, that predict the impact of putative biological control agents on non-target organisms.

Jacqui.Todd@plantandfood.co.nz

He Waka Hourua: Mātauranga and Western science navigate a safe course for future biocontrol (A22.3) 3 years

Define mātauranga to establish its equivalence with Western science to support applications for the potential introduction of biocontrol agents to Aotearoa New Zealand.

Waipaina.Awarau-Morris@agresearch.co.nz

Theme B

New risk assessment and detection tools for cereal and grass pathogens on the seed import pathway (B22.5) 1 year

Document issues, establish priorities and develop a research plan with stakeholders for risk assessment and detection tools for pathogens of Poaceae in the seed importation pathway.

Soonie.Chng@plantandfood.co.nz

Predicting the spillover of pests and pathogens into natural ecosystems (B22.6) 5 years

Develop a host plant phylogeny index incorporating biological traits for both insects and pathogens, then assess the impact of this approach for biosecurity risk for indigenous plants.

Wardda@landcareresearch.co.nz (Darren)

Development of the Integrated Biosecurity Risk Assessment Model (IBRAM) for pathogens (B22.7) 4 years

Modify the IBRAM-PEST model and create an IBRAM-PATH model including founder population, dispersal and establishment parameters, to quantify and manage micro-organism biosecurity threats.

Nari.Williams@plantandfood.co.nz

Theme C

Novel sensor approaches to sniff out biosecurity threats (C17.13 extn) 2 years

Develop the sensor platform for a novel sensor technology.

Melissa.Jordan@plantandfood.co.nz

Rapid screening method for optimising commodity treatments (C22.9) 5 years

Develop a physiology-based template to rapidly evaluate phytosanitary treatments for high-risk insects in the commodity trade pathway.

Kambiz.Esfandi@plantandfood.co.nz

De-risking the plant tissue culture pathway (C22.11) 1 year

Document issues, establish priorities and develop a research plan with stakeholders for de-risking the plant tissue culture pathway.

Hayley.Ridgway@plantandfood.co.nz

Accelerated aging of plants to shorten the post-entry quarantine testing period (C22.12) 5 years

Evaluate the development, expression of, and ability to detect high risk pathogens in accelerated plant breeding systems under containment.

Rebekah.Frampton@plantandfood.co.nz

The risk of diapausing pest insects on pathways to Aotearoa New Zealand (C22.13) 4 years

Establish the significance of diapause – a period of suspended development – for the survival in transit and eventual establishment of high-risk invasive insects.

Jessica.Vereijssen@plantandfood.co.nz

Theme D

Mass spectral fingerprinting for rapid biosecurity diagnostics: Evolution from successful pilot studies to operational models (D21.14 extn) 4 years

Examine the use of mass spectral fingerprinting for (1) high throughput sample processing in an incursion and (2) attribution of informative biological characteristics for post-border detections.

Alastair.Ross@agresearch.co.nz

Using images and deep learning for the identification of high-risk insect species (D22.15) 5 years

Adapt and apply existing technology platforms and build image libraries of invasive and related species to underpin automation for rapid and accurate insect identification.

Wardda@landcareresearch.co.nz (Darren)

Metatranscriptomics informing the relevance of pathogen disease biomarkers in plants (D22.16) 5 years

Use dual application of nanopore sequencing technology with microbial communities in plants to detect high risk species from DNA and biomarkers of disease risk from RNA.

Sandra.Visnovsky@plantandfood.co.nz

Beyond soil baiting: Toward application of an eRNA diagnostic tool for *Phytophthora* (D22.17) 3 year

Apply eRNA techniques for rapid identification of living pathogen communities in soils.
Darryl.Herron@scionresearch.com

Theme E

Expanding our eradication toolbox in NZ: Is biocontrol a feasible tool to incorporate in a response? (E22.18) 2 years

Assess the feasibility of using inundative biological control releases, alone or in combination with other tools, to achieve eradication of invasive insects.
Rachael.Horner@plantandfood.co.nz

eDNA for terrestrial biosecurity monitoring (E22.19) 5 years

Develop robust air sampling eDNA protocols for invasive species, including the development of reference libraries, mandates for data sovereignty and mitigation for false positives.
Andrew.Cridge@scionresearch.com

Cross Theme

Empowering Te Ao Māori responses to biosecurity threats to taonga species, native ecosystems, and communities (X22.23) 3 years

Examine Māori priorities and aspirations surrounding biosecurity threats, incursions and responses through two mana whenua case studies.
Waipaina.Awarau-Morris@agresearch.co.nz

Plans to make information on past B3 projects more accessible

Information on completed B3 projects and outputs is being uploaded on the B3 website under Ngā hua / OUTPUTS on an annual basis. Each project is summarised and contacts provided if more information is required. B3 is also working collaboratively with its MOU partner, CEBRA, to develop a 'one stop shop' portal for locating past research on invasive species in the Australasian region. This database is under construction and will initially include research projects from CEBRA, B3, MPI, Australia Department of Agriculture and Fisheries and the former Plant Biosecurity CRC (B3 parties, PFR and LU were members).

cebra
Centre of Excellence for Biosecurity Risk Analysis

https://cebra.unimelb.edu.au/research/a-biosecurity-risk-research-portal-to-inform-decision-making

Research Publications and Outputs, 2021-22

Peer reviewed publications

Buddenhagen CE, Rubenstein JM, Hampton JG, Rolston MP. 2021. The phytosanitary risks posed by seeds for sowing trade networks. PLoS ONE 16(11): e0259912. https://doi.org/10.1371/journal.pone.0259912

Bulman S, Drayton GM, Cameron PJ, Teulon DAJ, Walker GP. 2021. Endemic New Zealand aphids (Hemiptera: Aphididae) parasitised by native Aphidiinae (Hymenoptera: Braconidae), not biological control parasitoids. Austral Entomology 66: 713-721

Cheema JA, Carraher C, Plank NOV, Travas-Sejdic J, Kralicek AV. 2021. Insect odorant receptor-based biosensors: Current status and prospects. Biotechnology Advances 53,107840. ISSN 0734-9750, https://doi.org/10.1016/j.biotechadv.2021.107840.

Hiszczynska-Sawicka E, Li D, Armstrong KF. 2022. Universal mitochondrial multi-locus sequence analysis (mtMLSA) to characterise populations of unanticipated plant pest biosecurity detections. Biology 11: 654. https://doi.org/10.3390/biology11050654

Horrocks KJ, Ward D, Suckling DM. 2020. Can natural enemies of current insect pests provide biotic resistance to future pests? Agricultural and Forest Entomology 22: 20-29. https://doi.org/10.1111/afe.12353

Jamieson LE, Woodbury O, Mascaro S, Meurisse N, Jaksons R, Brown SDJ, Ormsby M. 2021. An integrated biosecurity risk assessment model (IBRAM) for evaluating the risk of import pathways for the establishment of invasive species. Risk Analysis 42: 1325-1345.

Johnston PR, Park D, Ho WW, Alexander BJ. Genetic validation of historical plant pathology records–a case study based on the fungal genus *Phoma* from the ICMP culture collection. Plant Pathology 66 (9):1424-31.

Kramer RT, Kinaston RL, Holder PW, Armstrong KF, King CL, Sipple WD, Martin AP, Pradel G, Turnbull RE, Rogers KM, Reid M. 2022. A bioavailable strontium (87Sr/86Sr) isoscape for Aotearoa New Zealand: Implications for food forensics and biosecurity. PloS ONE. 2022 17(3):e0264458.

Lopez-Reyes K, Armstrong KF, Teulon DAJ, Butler RC, van Dooremalen C, Roher M, van Tol RWHM. 2022. Colour response in western flower thrips varies intraspecifically. Insects, 13, 538. https://doi.org/10.3390/insects13060538.

Mackay M, Henwood R, Nelson T, Perkins HC, Wilson J. 2021. Tourism and biosecurity: a content analysis of Aotearoa New Zealand news media reporting 2009–2019, Tourism Recreation Research. DOI:10.1080/02508281.2021.1981072.

Mas F, Manning L-A, Alavi M, Osborne T, Reynolds O, Kralicek A. 2021. Early detection of fruit infested with *Bactrocera tryoni*, Postharvest Biology and Technology 175: 111496, ISSN 0925-5214, https://doi.org/10.1016/j.postharvbio.2021.111496.

Meurisse N, Marcot BG, Woodberry O, Barratt BIP, Todd J. 2021. Risk analysis frameworks used in biological control and introduction of a novel Bayesian network tool. Risk Analysis https://doi.org/10.1111/risa.13812

Nixon L, Morrison III WR, Rice KB, Goldson S, Brockerhoff EG, Khrimian A, Rostas M, Leskey TC. 2022. Behavioural responses of diapausing *Halyomorpha halys* (Hemiptera: Pentatomidae) to conspecific volatile organic compounds. Journal of Applied Entomology 146(3): 319-327.

Paynter Q, Barton DM, Ferguson CM, Barratt BIP 2022. Relative risk scores generated from laboratory specificity tests predict non-target impacts of *Microctonus* spp. parasitoids in the field. Biological Control 170 https://doi.org/10.1016/j.biocontrol.2022.104927

Robinson AP, McNeill MR. 2022. Biosecurity and post-arrival pathways in New Zealand: relating alien organism detections to tourism indicators. NeoBiota 71: 51-69. https://doi.org/10.3897/neobiota.71.64618

Rubenstein JM, Hulme PE, Buddenhagen CE, Rolston MP, Hampton, JG. 2021. Weed seed contamination in imported seed lots entering New Zealand. PloS ONE 16 (8): https://doi.org/10.1371/journal.pone.0256623

Saunders TE, Avila GA, Holwell GI. 2022. Retrospective host-specificity testing shows *Trissolcus basalis* (Wollaston) and the native *Trissolcus oenone* (Dodd) (Hymenoptera: Scelionidae) have overlapping physiological host ranges in New Zealand. Biological Control 170. https://doi.org/10.1016/j.biocontrol.2022.104926

Teulon DAJ. 2022. Distribution and population trends of two New Zealand endemic aphids (Hemiptera, Aphididae, Aphidinae). New Zealand Entomologist 44 (2): 81-87. DOI:10.1080/00779962.2022.2063779

Vangaa BR, Panda P, Shah AS, Thompson S, Woolley RH, Ridgway HJ, Mundy DC, Bulman S. 2022. DNA metabarcoding reveals high relative abundance of trunk disease fungi in grapevines from Marlborough, New Zealand. BMC Microbiology 22 126. https://doi.org/10.1186/s12866-022-02520-2

Voice DG, MacLellan R, Russell A, Goulden D, Lawrie I, Baker G, Teulon DAJ, Kean JM. 2022. The eradication of pea weevil *Bruchus pisorum* (L.) (Coleoptera: Chrysomelidae) from New Zealand. CABI Agriculture and Bioscience 3: 31. https://doi.org/10.1186/s43170-022-00093-8

Watt MS, Leonardo EM, Estarija HJ, Massam P, de Silva D, O'Neill R, Lane D, McDougal R, Buddenbaum H, Zarco-Tejada PJ. 2021. Long-term effects of water stress on hyperspectral remote sensing indicators in young radiata pine. Forest Ecology and Management 502: 119707.

Williams HE, Brockerhoff EG, Liebhold AM, Ward DF. 2021. Mechanisms driving component Allee effects during invasions: using a biological control agent as model invader. Ecological Entomology 46 (5):1205-14.

Xu B, Teulon DAJ. 2022. Combined searches of Chinese language and English language databases provide more comprehensive data on the distribution of five pest thrips species in China for use in pest risk assessment. Sustainability 15: 2920. https://doi.org/10.3390/su14052920.

Books or book chapters

Barratt BIP, Colmanarez Y, Day MD, Ivey P, Klapwijk JN, Loomans AJM, Mason PG, Palmer W, Sankaran KV, Zhang F. 2021. Regulatory challenges for biological control. In: Mason PG (Ed.). Biological Control: Global Impacts, Challenges and Future Directions of Pest Management. CSIRO Publishing, Melbourne, pp. 166-196.

Pureswaran DS, Meurisse N, Rassati D, Liebhold AM, Faccoli M. 2022. Climate change and invasions by non-native bark and ambrosia beetles. In: Hofstetter RW & Gandhi KJK (eds). Bark beetle management, ecology, and climate change. London: Academic Press, pp. 3-30.

Other publications (not abstracts)

Mackay M, Wilson J, Nelson T, Perkins HC. 2021. Frontline professionals' knowledge and awareness of biosecurity risks in nature-based tourism and outdoor recreation. In: CAUTHE 2021 Conference Online: Transformations in Uncertain Times: Future Perfect in Tourism, Hospitality and Events: Proceedings of the 31st Annual Conference: CAUTHE, 2021: 346-349. https://search.informit.org/doi/10.3316/informit.686867238117479

Taylor R, Armstrong KF. 2021 Science Collaboration with B3. PHELosophies MPI Newsletter. Issue 7 December.

Teulon DAJ, Robertson N. 2021. Preface to BMSB Symposium. Abstracts book. Brown Marmorated Stink Bug (BMSB) Symposium, 9 August 2021, Napier.

Reports

Armstrong KF, Holder PW. 2021 Distinguishing New Zealand's stable isotope signature from potential Qfly origins. Fruit Fly Council (NZ) Contract Report Project #26, 11th August. 28 pp

Esfandi K, Jamieson L, Bellamy D. 2021. Current status and prospects for phytosanitary treatments. Plant & Food Research. PFR SPTS No. 21042

Groenteman R. 2021. Predicting the risk of *Xylella*. Contract Report LC3984. MWLR, Lincoln. 8 pp.

Horner R, Cristofaro M, Sasso R. 2022. Aerodynamic traps for brown marmorated stink bug. PFR SPTS No. 22595 PI22056 June 2022.

O'Donnell-Fluit I. 2021. Protecting our plants by future proofing plant health. Summer Scholarship Report. LU.

Phillips CB, Ward D, Todd J, Ferguson CM, Barratt BIP. 2022. Attributes of NZ non-native aphids. B3 Project B19.2 report, AgResearch Ltd. 27 pp.

Phillips CB. 2021. Distinguishing attributes of NZ non-native arthropods in NZ native habitats. AgResearch. Report for B3 Project B19.2. 13 pp.

Vereijssen J, Bellamy D, Bulman S, Butler RC, Campbell R, Colhoun K, Drayton G, Ellingham D, Groenteman R, Kean A, Logan D, Nielsen M, Power M, Preddey J, Sachtleben T, Seville J, Sharp J, Taylor T. March 2022. B3 B20.03 *Xylella fastidiosa* and its New Zealand insect vectors — Year 1 research and activities. PFR SPTS No. 22281.

Theses

Cheema JA. 2022. Development of electrochemical biosensors using insect odorant receptors. School of Chemical Sciences. University of Auckland. PhD. 157 pp.

Saunders TE. 2022. Improving pre-release risk assessments for classical biological control agents through the integration of behavioural, electrophysiological, and chemical-ecological methods to host-specificity testing. Department of Biological Sciences, University of Auckland. PhD. 192 pp.

Invited presentations (significant international/ national meetings/seminars)

Holder P, Armstrong K, Murphy D, McComb K, Van Hale R. 2021. Using isotopes to determine provenance of biosecurity risk insect pests. Chemistry Department Seminar Series, University of Otago, 8th December.

Marsh A. 2021. Indigenous responses to Taonga (native treasures) impacted on by new and invasive biosecurity incursions. Australasian Plant Pathology Society. Online, 26 November 2021.

Marsh A. 2022. Indigenous responses to Taonga (native treasures) impacted on by new and invasive biosecurity incursions. PFR All Staff Seminar. Virtual. 24 March 2022.

Stringer LD. 2021. Protecting and

growing market access opportunities while under the threat of fruit fly. Fruit fly ITTC seminar series, Macquarie University Sydney online presentation 15 September 2021.

Teulon D, Groenteman R, Visnovsky S, McNeill M, Papali'i-Smith W, Marsh A. 2022. Sentinel plants, biosecurity risk assessment and tikanga. New Zealand's Biological Heritage National Science Challenge, Crazy and Ambitious Conference, Virtual. 24-27 May 2022.

Teulon DAJ, Marsh A. 2022. Mahi tahi – biosecurity capability. Perspective from B3. Mahi tahi – work together as one to build biosecurity capability. University of Canterbury Biosecurity Innovations Webinar. Virtual. 13 April 2022.

Invited presentations (PBRI Symposium and Forums and Australian programmes)

Armstrong K. 2022. B3 New Zealand Diagnostics Projects, Future Research. PBRI Forum. Detection and Diagnostics Forum RD&E Gaps and Opportunities. Virtual. 21 October 2021.

Armstrong KF, Holder PW. 2021. Determining the geographical origin of priority insect pest detections. RRD4P Programme update for "Boosting diagnostic capacity for plant production industries, 15 September 2021 (virtual).

Armstrong KF, Holder PW. 2022. Determining the geographical origin of priority insect pest detections. RRD4P Programme update for "Boosting diagnostic capacity for plant production industries, 16 February 2021 (virtual).

Buwalda J. 2022. The mission of B3. Plant Biosecurity Research Initiative Symposium. 11-12 May 2022. National Wine Centre of Australia, Adelaide.

Cridge A. 2020. Bees as Biosecurity Biomonitors: exotic plant detection and identification to monitor plant invasions. Plant Biosecurity Research Initiative Symposium. 11-12 May 2022. National Wine Centre of Australia, Adelaide.

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McNeil M. 2022. Sentinel plants from concept to application: the value in the context of biosecurity for Aotearoa New Zealand. Plant Biosecurity Research Initiative Symposium. 11-12 May 2022. National Wine Centre of Australia, Adelaide.

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Tomasetto F. 2022. Remote Sensing Methods for Biosecurity Surveillance, Response and Eradication: NZ Maize crop as a case study. Plant Biosecurity Research Initiative Symposium. 11-12 May 2022. National Wine Centre of Australia, Adelaide.

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Woolf A. 2022. Biosecurity compliance of Samoa taro exports without methyl bromide treatment. Biosecurity RD&E in the Pacific. PBRI Forum (virtual). 20 April 2022.

Presentations to stakeholders

Bulman S. 2021. eDNA for detection of BMSB. Brown Marmorated Stink Bug (BMSB) Symposium, 9 August 2021, Napier.

Frampton R. 2022. Nanopore for biosecurity. Nanopore research and PromethION launch NZ, Bragato Research Institute and the NZ wine industry. Christchurch. 7th June 2022.

Horner RM, Chen S, Strand T, Jermy M. 2021. New aerodynamic design principles for improved brown marmorated stink bug traps. Brown Marmorated Stink Bug (BMSB) Symposium, 9 August 2021, Napier.

Kean JM. Guest lecture. Level 2 Biosecurity course at Toi Ohomai Institute of Technology in Tauranga. 9 August 2021.

Kean JM. 2022. Biosecurity excellence in port communities. Port of Tauranga Biosecurity Excellence Initiative meeting, 17 June 2022.

Marsh A, Ropata HT, Teulon DAJ, Puketapu A. 2021. The threat of the

brown marmorated stink bug to plants of value to Māori. Brown Marmorated Stink Bug (BMSB) Symposium, 9 August 2021, Napier.

Manning L-A, Seon Ah Jeong SA, Oh HW, Park KC. 2021. Developing electrophysiological techniques to measure the antennal responses of the brown marmorated stink bug, *Halyomorpha halys*, to host plant volatiles. Brown Marmorated Stink Bug (BMSB) Symposium, 9 August 2021, Napier.

Mitchell JS, Visagie I, Kralicek A, Jordan M. 2021. Sensing brown marmorated stink bugs at the border. Brown Marmorated Stink Bug (BMSB) Symposium, 9 August 2021, Napier.

Saunders TE, Avila GA, Holwell GI. 2021. Pre-emptive host-specificity testing of *Trissolcus japonicus* (Ashmead) (Hymenoptera: Scelionidae) reveals high parasitism levels against the endemic New Zealand alpine shield bug in laboratory no-choice tests. Brown Marmorated Stink Bug (BMSB) Symposium, 9 August 2021, Napier.

Stringer LD. 2021. Combining lures for multiple unwanted species to improve the efficiency of pest detection & surveillance. Presentation to Quads surveillance lures and protocols managers, online 23 Sept 2021.

Stringer LD. 2021. Innovative approaches to monitor and manage tephritid fruit fly: the ongoing challenges and opportunities. ACIAR-PFR meeting, online 22 Sept 2021.

Stringer LD, Welsh TJ, Suckling DM. 2021. Development of the sterile insect technique to support *Halyomorpha halys* eradication. Brown Marmorated Stink Bug (BMSB) Symposium, 9 August 2021, Napier.

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Teulon DAJ. 2021. B3 Update. Biosecurity Industry Day. KVH/Zespri. Tauranga. 11 November 2021.

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Tomasetto F, Pletnyakov P, Phillips CB. 2022. Remote Sensing Methods for Biosecurity Surveillance, Response and Eradication: NZ maize crop as a case study. Plant Biosecurity Research Initiative Symposium. 11-12 May 2022. National Wine Centre of Australia, Adelaide.

Wood M. 2022. Overview of sensor research and development. Scion-PFR wānanga. Rotorua 4-5 May 2022.

Wood M. 2022. The concept of biosensors in a field setting. Nga Rakau Taketake's Te Whakahononga wānanga on Kaitiaki Surveillance and Montoring Waananga. Tauranga 24- 26 May 2022.

Wood M. 2021. Deployable point of use pathogen bioelectric sensor. Presentation to MPI and DoC, 29 November 2021.

Wood M. 2022. Overview of the POU electrochemical PANI based sensor. PHEL mini workshop MPI, East Tamaki, Auckland 17 June 2022.

Contributions of Parties to B3, 2021-22

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