

Vectors and vector-borne disease: Ecological research and surveillance development for New Zealand

Project overview

The outcome of this project will be a targeted, risk-based surveillance capability for vectors and vector-borne diseases for New Zealand. Once developed through this research project, the capability will become a component of New Zealand's biosecurity surveillance programme.

Risk-based biosecurity surveillance systems maximise the utility of information derived from the available resource through:

- Targeting highest risk organisms (determined by consideration of both likelihood of arrival and establishment in New Zealand AND impact to biosecurity values)
- Employing sampling strategies which maximise detection probability.

Determining the organisms to target has been addressed through a risk assessment taking into account the spectrum of accountabilities for MAF, Department of Conservation (DoC) and Ministry of Health (MoH). A multi-disciplinary project team has completed the assessment, and this has been made available on the Biosecurity New Zealand (BNZ) website as a written report, a spreadsheet database, and a reference library. Ross River virus (RRV), West Nile virus (WNV), and avian malaria, and their respective vectors, are considered the highest priorities.

Vectors and vector-borne diseases have complex ecology. Understanding vectoring capability and the means by which sampling methods can maximise detection probability requires an understanding of the interactions between mosquitoes, disease agents, animal hosts and environmental factors. Our proposal includes two studies into these interactions. A repeated cross-sectional field study at multiple locations around New Zealand will identify vectors and agents present at these locations at particular times of the year. Animal hosts for vectors will be identified from blood-fed mosquitoes and ticks. Environmental data will also be collected from each site. A laboratory and ecological study on vector competence is proposed involving two endemic mosquitoes and RRV and WNV.

The laboratory diagnostic assays required to support surveillance for arboviruses have been identified, and the proposal involves establishing these at IDC Wallaceville in the PC3+ laboratory, in conjunction with our National Centre for Biosecurity and Infectious Disease (NCBID) partner the Institute of Environmental and Scientific Research (ESR).

The surveillance system to be developed will comprise passive and active components. A pilot study has been undertaken to identify adjustments required to existing mosquito surveillance systems to enable efficient and sensitive detection of arboviruses. The study has identified that minor adjustments to existing systems would ensure an effective and efficient passive surveillance capability for arboviruses, centred around testing of mosquito samples. We plan to continue to identify agencies that could potentially supply mosquito and animal samples for a vector-borne disease surveillance system as an adjunct function to existing systems. Active surveillance systems will be required to complement passive systems. Both systems will be designed and specified to the point of contracting services, at which time they will be incorporated into departmental programmes and budgets.

Project methodology

The proposal comprises a series of sub-projects within four work-streams.

1. Assessing the risk of entry, establishment and spread for vectors and vector-borne diseases

Objective: Identify the vectors and vector-borne diseases that should be the priority for ecological research and surveillance capability development.

Study design: The study has been undertaken as a literature review, with additional components of expert elicitation. There have been several iterations of review involving the project team and an expert panel.

The key technical components of risk considered are:

Vectors

- Presence/absence/emergence in New Zealand
- Entry risk (for exotics)
- Establishment potential (climate, habitat, host)
- Competence for vectoring disease agents

Vector-borne diseases

- Presence/absence/emergence in NZ
- Importance to human health, animal health and conservation
- Entry risk (for exotics)
- Establishment potential (vector presence, hosts)

Outputs: A summary report. Tables identifying vectors and vector borne diseases and their risks, research questions and surveillance requirements. Bibliography. All three outputs are available on the BNZ website. Awareness of the risk assessment will be raised through presentation and publication in targeted conferences and conference proceedings.

Status: Essentially complete.

2. Ecological research into vectors and vector-borne disease in New Zealand

2.1. A field study into the ecology of vectors and vector-borne diseases in New Zealand

Objective: To ascertain the current status of the vector-borne disease agents and the ecology of their vectors at targeted locations in New Zealand:

- Identifies the hosts for vectors at targeted locations
- Identifies the hosts for disease agents at targeted locations
- Identifies the presence of disease agents and vectors at targeted locations
- Identifies what vectors are vectoring specific agents at these targeted locations

This information can be used to develop efficient targeted surveillance.

Study design: A cross-sectional study at four study sites, repeated four times over two years. The four study sites are:

- Cape Kidnappers: seabird colony; native birds
- Mokoia Island (Lake Rotorua): native birds (DoC transitional site for translocation of birds)
- Kaikoura: seabird colony
- Whataroa, Westland: seabird colony

At each study site there will be four visits of one week duration over the course of two years. During the visits samples of ticks, mosquitoes (adults by light-trapping), fleas, and serum and whole-blood smears from birds and mammals will be collected.

The following tests will be conducted on samples collected:

- Tests for host-type for mosquitoes (blood-fed)
- Haemoparasites in blood smears
- Arbovirus serology
- Arbovirus isolation from vectors

Outputs: A research report for each study site, compiled into a final report for the study. A publication in a peer-reviewed journal.

Status: Detailed study plan complete. Potential suppliers identified.

2.2. A laboratory and ecological study of the vector competence of two endemic mosquitoes for the exotic Ross River and West Nile viruses.

Objective: Establish the laboratory competence of *Culex pervigilans* and *Opifex fuscus* for RRV and WNV and determine if the ecology of these mosquitoes would support transmission. *Cx. pervigilans* and *Op. fuscus* are identified in the risk assessment as potential vectors of these diseases. Both mosquitoes have a widespread distribution throughout New Zealand and encounter a wide variety of host species including people. *Cx.pervigilans* is a close relation of *Culex quinquefasciatus*, an efficient vector of WNV in the United States.

Study design: Mosquito arbovirus infection study to determine laboratory competence performed in an overseas laboratory using proven methods. Laboratory competence will be determined by exposing colonies of mosquitoes to infected blood, and every few days selecting a portion of the exposed mosquitoes and assaying gut and salivary glands for virus. If laboratory competence is demonstrated, a cross-sectional survey for blood-fed female mosquitoes at six sites throughout New Zealand will proceed, with host ranges and preferences of selected mosquitoes determined by laboratory assay. Field study sites will be selected in order to trap fed females of *Cx. pervigilans* and *Op. fuscus* and introduced mosquitoes of known competence (*Ochlerotatus notoscriptus* and *Cx quinquefasciatus*). The blood in the mosquitoes will be tested to determine the host.

Outputs: Publication/s in a peer-reviewed journal describing the laboratory competence for two high risk endemic mosquitoes for two serious exotic viral disease agents, and the host range and preference for two mosquito vectors in New Zealand.

Status: Detailed study plan complete.

3. Surveillance systems development

3.1 Pilot study – passive surveillance

Objective: To examine current practice and systems for the collection, identification, storage and testing of vectors and determine how this could be enhanced to support surveillance for vectors and vector borne disease.

Study design: Phone survey of entomology laboratories and animal health laboratories. Pilot field study involving the collection of mosquitoes and bird ticks, taxonomy, storage at -70C, and submission to overseas laboratory for virus testing.

Outputs: Identify improvements to methods of collection (trapping systems), taxonomy (cold table for sorting and identification), and storage of specimens to preserve arbovirus (-70C freezer).

Status: Draft study report available. Final report to be completed in Year 1.

3.2. Passive surveillance development

Objective: To enhance passive surveillance for early detection of arthropod vectors and vector-borne disease agents affecting animals and humans by taking advantage of existing surveillance streams and determining the changes and equipment needed to transform current practice into a system for collection, submission, taxonomy and storage of specimens in a manner suitable for vector borne disease surveillance or ecology studies.

Study design: Business system review and re-design for enhanced passive surveillance for vector and vector-borne disease. Design enhancements by expert elicitation and the outputs of the pilot study.

Define the processes for sample submission, testing, reporting and archiving across the network of providers. Establish service level agreements for all providers in the

network. This is likely to involve service provider contracts for specified external laboratories using the BNZ model for Approved Veterinary Diagnostic Laboratories. Implement training to up-skill key roleholders within the network of providers.

Outputs: A project plan for enhanced passive surveillance for vectors (mosquito, ticks) and vector-borne diseases (alphavirus, flavivirus, haemoparasites and selected bacteria). A system design clearly establishing processes and roles, and identifying key service providers. Service level agreements to deliver the requirements of the system for each of the key service providers. Service contracts with non-departmental service providers, to take effect from 1 July 2008. Training of pathologists in conjunction with the New Zealand Society of Veterinary Anatomic Pathologists (NZSVAP) annual seminar in November 2007. Training of key field staff. Implementation of enhanced passive surveillance systems for ticks, mosquitoes and birds.

Status: High level plan complete. Detailed plan to be finalised in Year 1.

3.3. Active surveillance development

Objective: To develop techniques for use in active surveillance for WNV and RRV, the exotic arboviruses of highest risk to New Zealand.

Study design: Business systems review and re-design for active surveillance for vector and vector-borne disease. Design enhancements by evaluation of systems in comparable overseas countries, and by expert elicitation.

Gap analysis:

- Review of active surveillance systems in overseas countries.
- Develop best practice system design appropriate for New Zealand.
- Review existing active surveillance systems (e.g. MAF arbovirus surveillance), and define the enhancements required.

Implementation:

- Pilot study on sentinel surveillance using sentinel birds and animals.
- Design ongoing active surveillance programmes through the development of service level specifications, as required.
- Implement ongoing service contracts using MAF procurement model as appropriate.

Outputs: A report defining a best-practice system design for New Zealand, incorporating a gap analysis. A pilot study on sentinel surveillance systems, as a final report. Service level specifications for the New Zealand arbovirus active surveillance system. Service contracts with providers.

Status: High level plan complete. Detailed plan to be finalised in Year 1.

4. Development of diagnostic capability for arboviruses, particularly alpha and flaviviruses

Objective: Establish and validate virus isolation and group-level serology for alpha and flaviviruses. Development of diagnostic capability will support surveillance, trade, response, and research programmes.

Study design: Diagnostic test establishment and validation. Establish two new cell lines and associated virus isolation capability in PC3+ laboratory. Establish a commercial total antibody blocking (TAB) ELISA for alphaviruses, and identify and establish an appropriate serological test for flaviviruses

Validation for each will follow the process outlined in the OIE Diagnostic Manual i.e. assessment of sensitivity and specificity, repeatability etc. Purchase of freezer for sample storage and mosquito cell line incubator.

Outputs: Establishment of virus isolation and group-level serology at NCBID to meet departmental needs (biosecurity, public health, conservation), as required. Training of staff in diagnostic techniques. Establishment of service provision relationships with targeted diagnostic laboratories overseas.

Status: Detailed plan complete. Purchase of equipment and reagents begun. Employment of laboratory technician initiated. Test development to be completed in Year 2.

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