International Sea and Air Port Mosquito Surveillance Programme Review 2019

Conducted by

Andrew F. van den Hurk, PhD and JR Gardner

13-22 May 2019

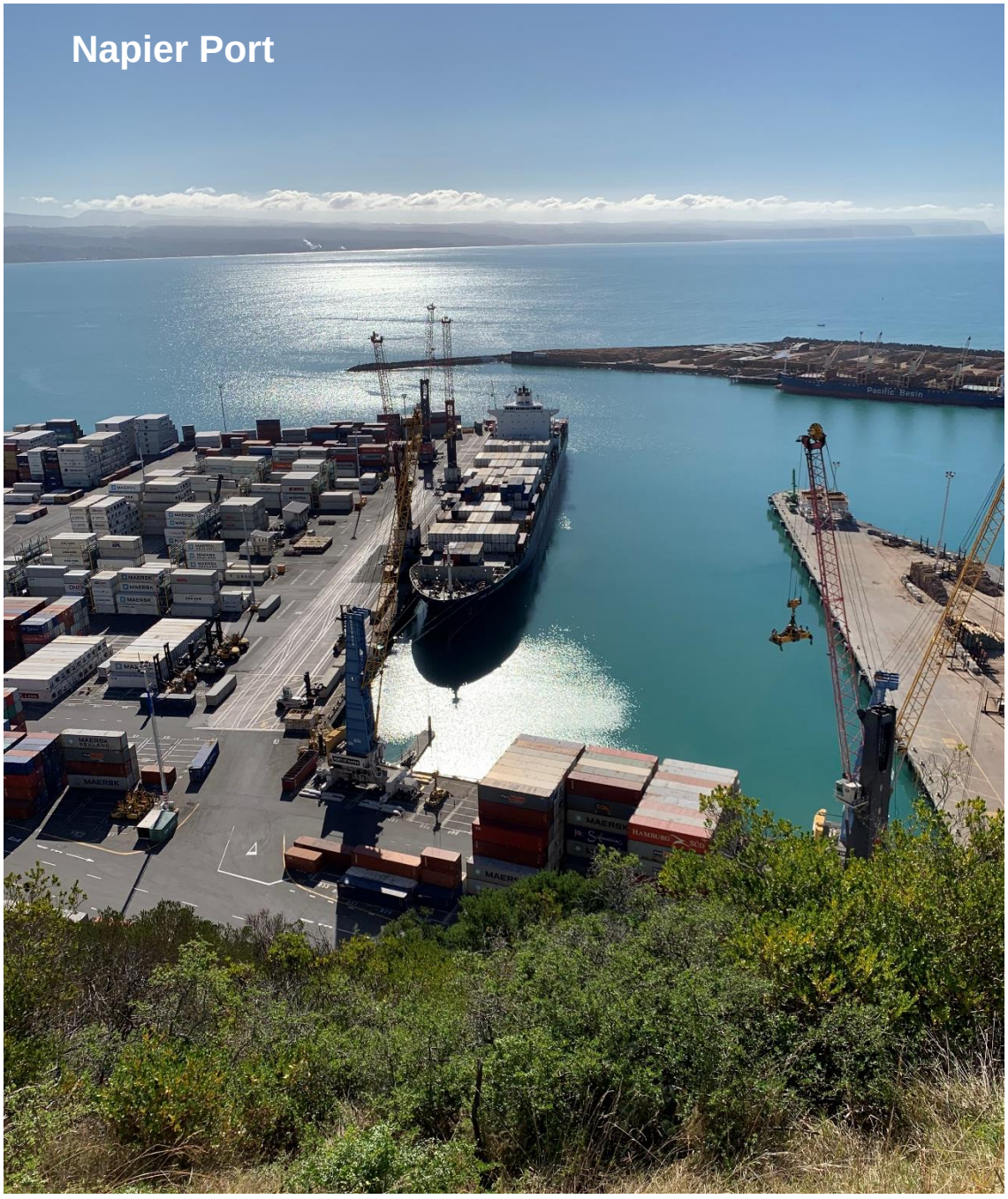

Table of Contents

Background

The intercontinental movement of mosquito species involved in the transmission of pathogens (such as dengue, Zika and yellow fever viruses, and malaria parasites) continues to be of significant concern throughout the world. Two species that are historically invasive and important virus vectors are the container-inhabiting *Aedes aegypti* and *Aedes albopictus*. Females of these species lay desiccation-resistant eggs which facilitate their transport via tyres, machinery components or any other container that can hold water. Mosquitoes can also be transported in aircraft, whether that be in the cabin or cargo hold, or even in luggage or freight. History is littered with examples of mosquito species becoming established in a virgin location and causing significant outbreaks of arboviral disease, such as which occurred with *Ae. albopictus* emerging as a key vector of chikungunya virus in the nations of the western Indian Ocean in the mid-2,000s and the 2014 central Tokyo dengue outbreak, also vectored by this species.

New Zealand possesses 12 native mosquito species and three introduced species that have established, namely *Culex quinquefasciatus*, *Aedes australis* and *Aedes notoscriptus*. Fortunately, these mosquito species are not considered primary vectors of human pathogens in the New Zealand context. The NZ Ministry of Health, (MoH) and the Ministry of Primary Industries (MPI) has formulated a list of exotic mosquitoes species classified as unwanted organisms (refer to https://www.smsl.co.nz/NZBEL/Exotic+Mosquitoes.html). In 1998, the southern saltmarsh mosquito, *Aedes camptorhynchus*, was introduced from Australia. A major vector of RRV, the establishment of this species, coupled with an immunologically naive human and animal population, rendered New Zealand receptive to epidemics of this virus. A ten-year resource-intensive and costly programme eradicated this species. Despite the success of the *Ae. camptorhynchus* eradication campaign, this episode highlighted the vulnerability of New Zealand to the introduction and establishment of exotic mosquito species. Although there is no evidence that any exotic species of public health significance have become established in New Zealand since 2008, this does not decrease the threat that exotic mosquitoes still pose. Indeed, the threat is ever increasing due to (but not limited to) greater volumes of international air and sea traffic, new points of origin where mosquitoes can arrive from and the ever-present threat of climate change making areas more receptive to the proliferation of pests, that were once thought unable to survive in temperate climates.

New Zealand maintains a comprehensive surveillance and response programme at international ports of entry to ensure that unwanted exotic mosquito species are intercepted before they become established. The programme is overseen by the Ministry of Health, administered by the District Health Boards (DHBs) public health units (PHUs). A number of other key stakeholders are involved in the programmes, including the Ministry for Primary Industries, air- and seaport authorities and private contractors, whilst technical expertise is provided by New Zealand BioSecure.

The legislative framework is provided in one Treaty, two Acts and several sets of regulations and rules. The principle documents are:

- The World Health Organization's, (WHO) International Health Regulations 2005, (IHR 2005) which New Zealand is signatory to. Note: The IHR 2005 does not have a compliance function.
- The Health Act 1956 and the Health Quarantine Regulations 1983

- The Biosecurity Act 1993, (BSA 1993)

To ensure the ongoing relevance and whether current surveillance activities are best practice, the programme is reviewed approximately every 5 years, with the last review being conducted in 2013 by Profs Richard Russell and Scott Ritchie. In May 2019, the programme was again reviewed and the following report documents the observations and recommendations of the review team.

Acknowledgements

The review team wishes to thank the following people for their assistance in conducting the review:

NZ BioSecure Entomology Laboratory: Dr Mariana Musicante

Hutt Valley DHB Regional Public Health: Dr Annette Nesdale, Keith Lewis, Suzie McQuoid

Toi Te Ora - Public Health Service: Stephen Layne, Michael Martin

Auckland Regional Public Health Services: Jane McEntee, Neil Silver, Lionel Ng, Kevin Zhang

Northland DHB, Public and Population Health Unit: Warren Moetara, Gavin de Klerk, Debbie Anderson

Canterbury Community Public Health: Helen Graham, Laura Bruce, Bruce Waddleton, Debbie Smith

Hawkes Bay DHB, Population Health: Maree Rohleder, Noel Watson, Ian Jarvis, Dr Rachel Eyre

MPI: Steve Gay, Lora Peacock, Chris Gumley

MoH Environmental and Border Health Team: Sally Gilbert, Sally Giles and Suz Halligan

Southern Monitoring Services: Allison Graham

Executive Summary

Upon conducting site visits and meeting with Public Health Unit, (PHU) staff, airport and seaport operators, and MPI staff, a number of concerns which had the potential to impact the operations of the International Sea and Air Port Mosquito Surveillance Programme were identified. Whilst some issues had more of a local impact, a number of themes were consistent across the districts and were related to capacity, stakeholder and MPI engagement, lack of clarity of legislative framework, occupational health and safety, management of transitional facilities, and implementation of trapping protocols. The reviewers have formulated recommendations which should increase the efficacy of strategies and methodology employed across the districts and potentially provide some level of "future-proofing" of the programme:

- Current capacity needs to be maintained, and, potentially, increased to allow for future growth in the risks associated with the importation of exotic mosquitoes. This needs to occur against a background of competing priorities, which can limit personnel and resources available to conduct routine operations and respond to concurrent or consecutive biosecurity incidents. In PHUs where capability or capacity is a concern, MoH needs to communicate processes for accessing appropriate technical support and additional resources from other PHUs or NZ BioSecure and this needs to be done as soon as possible. Finally, a strategy needs to be put in place to ensure that the institutional knowledge at each PHU is not lost when key personnel involved in the programme leave the organisation.
- The level of PHU engagement with key stakeholders (air- and sea- port operators, contractors and lessees) needs to be maintained, and in some cases, improved considerably. Some locations were clearly aware of the risks that exotic mosquitoes pose, whilst other could not see the relevance, especially when there are so many other perceived priorities. Thus, the importance of excluding exotic mosquitoes and the priorities of the programme needs to be clearly articulated across all Points of Entry (POEs). In consultation with stakeholders, a number of operational strategies were identified to increase awareness. This included incorporating mosquito risk mitigation into POE environmental management plans and contracts with external contractor site inductions. In addition, various forums could be utilised to convey the message, such as including the topic in site inductions, environmental management and OSH committees, newsletters, and getting the importance of mitigating mosquito risk on the agenda of high-level (executive) management.
- MPI plays a critical role in the programme by intercepting exotic mosquitoes associated with freight, cargo and passenger arrivals at airports. In most cases, the level of operational engagement between the PHUs and MPI staff appeared inadequate. Given the key role they play in the programme, there needs to be a concerted effort to re-engage with MPI at both the operational and strategic levels.
- Transitional facilities (TFs) continue to be a significant gateway for the introduction of exotic mosquitoes. For the most part, there was little knowledge of the scale of the risk, including the number of TFs in each district, their operations, sanitation status with regard to mosquito habitat, and how MPI integrates mosquito risk into their regular auditing. It is recommended that, at a minimum, each PHU should identify the number of TFs in their regions, map their location, and possibly categorise those that might be a significant risk. Categorisation of risk should be based on the mode of business conducted, point/s of origin of freight, and the presence of suitable habitat. Finally, the way that MPI audits facilities regarding

mosquito mitigation needs to be established. Fortunately, the number of TFs is set to decrease in the future, as small operators find it increasingly difficult to operate.

- Different modes of mosquito trapping continue to be used at each POE. All locations used a combination of tyre traps, CO_2-baited light traps and Biogents Sentinel (BG) traps, although the number used, and location of deployment varied considerably between DHBs. Furthermore, detailed knowledge on how different traps are designed to collect specific species, and the most efficient way to deploy traps seemed to be lacking – there is no "one size fits all" when it comes to a comprehensive trapping strategy. In agreement with Russell and Ritchie (2013), it is recommended that a standardised trapping strategy be used, with all traps obtained from and serviced by a single supplier (i.e. NZ BioSecure). As part of this strategy, more BG traps should be deployed, particularly in the locations where there is greater risk of interception. These traps have been rigorously tested and shown to be the most effective for collecting *Ae. aegypti* and *Ae. albopictus*. Despite their perceived limitations, CO_2-baited light traps should continue to be deployed, as they target other unwanted species, such as *Ae. vigilax*, *Ae. camptorhynchus*, *Anopheles* spp. and *Culex* spp. Finally, it is recommended that commercially-available traps based on UV light (ie. Dominator and Terminator traps) should cease to be used, as their efficacy in peer-reviewed scientific studies has not been demonstrated.
- The current training system involves residential courses (National Border Health Course and the Medical Vectors Workshop) where students are taught the basic principles of medical vectors, their risk, surveillance and control. It is important that this training, especially for designated officers remains current. Therefore, these courses should be completed at least every 3 years. To increase the technical competency of PHU personnel, particularly with regard to trap deployment in the context of their particular district, it is recommended that a subject matter expert visit the POEs. The frequency of visits should depend on the risk level of the POE, previous demonstration of competency, staff turnover, among other things. Placements at NZBiosecure Entomology Laboratory (NZBEL) are another training format that can increase the knowledge base.
- Both PHUs and stakeholders expressed their concern that the current policy and legislative framework did not provide clear direction on responsibilities as they apply to mitigating the risk of exotic mosquitoes. The PHUs identified that they possessed no statutory powers to force operators, contractors or lessees to mitigate habitat outside of a biosecurity incident. Thus, MoH needs to address the applicability of the current health legislation and regulations to meet the stakeholder's concerns for clarity or if new regulations need to be developed. In addition, the MoH officials need to actively participate in the current review of the BSA 1993 with the intention of providing authorised officers with the powers to mitigate potential mosquito habitat at areas of risk.
- Occupational safety and health (OSH), and security issues had the potential to limit the scope of the surveillance programme. CO_2 is an essential attractant for light traps which target some unwanted species (i.e. saltmarsh species, *Culex annulirostris*, *Anopheles* spp.), so OSH concerns with using compressed gas cylinders as a CO_2 source need to be addressed to ensure their continual use. Another problem identified by PHUs and POE operators was the difficulty in accessing certain areas within the port or airport. It is critical that processes be enacted that enable PHU staff to access these restricted areas to conduct routine surveillance, site inspections, and, in the event of an event, undertake mitigation.

- Some PHUs had adopted technology or procedures that have enhanced their surveillance operations. This innovation should be encouraged, although it is important that any adoption of technology or procedure aligns with the priorities of the programme. In terms of horizon scanning, there are a number of technological advances that are being developed overseas and which could have application to the programme. This includes (but is not limited to) rapid diagnostic assays for unwanted species identification, novel insecticides and modes of application, and genetic analysis of intercepted specimens to ascertain introduction pathways.

Introduction

New Zealand is a signatory to the International Health Regulations (2005) (IHR). The IHR includes obligations on implementing vector surveillance and control at designated points of entry. Annex 5 of the IHR states that State Parties shall establish programmes to control vectors that may transport infectious agents constituting a public health risk. The IHR also stipulates that competent authorities are required to ensure facilities used at points of entry are maintained in a sanitary condition and are kept free of sources of infection and contamination, including vectors and reservoirs; and conveyance operators are so tasked for conveyances (Articles 22, 24, 27 and Annex 4). It should also be noted that Article 2 of the Treaty states that public health responses "...avoid unnecessary interference with international traffic and trade".

In order to fulfil New Zealand's IHR obligations, and to prevent the establishment in New Zealand of mosquitoes of public health significance, the Ministry of Health funds a national mosquito surveillance programme at international sea and air ports. The programme is delivered by DHB public health units with entomology support from Southern Monitoring Services Ltd (trading as New Zealand Biosecure). DHB public health units may undertake surveillance directly, and/or may audit surveillance undertaken or contracted by port operators. Since establishment, the national programme has been periodically reviewed, with the most recent reviews completed in 2002, 2008 and 2013.

Between 13 and 22 May 2019, the authors of the current report visited a number of PHUs to review their surveillance activities. This review involved meetings with PHU staff and other stakeholders, site visits, observation of surveillance activities, including type and availability of equipment (such as traps, response kits etc.). In addition, A. van den Hurk conducted a peer review of the New Zealand BioSecure Laboratory (NZBEL). The current report follows a similar format to the Russell and Ritchie (2013) and outlines key findings, including implementation of previous recommendations, current practices, stakeholder engagements, impediments to the efficiency and efficacy of the activities and identifies possible opportunities for continual improvement. Importantly, the report contains key recommendations that will further align the programme's activities with its overarching objectives.

Methodology

The current review built on methods used by Russell and Ritchie (2013). The DHBs visited were based on the risk matrix which integrated factors such as number of international flights, amount of goods imported through seaports, origin of cargo, origin of flights, local environmental conditions and history of interceptions. The review team met with MoH PHU staff, airport and seaport operators, and MPI quarantine staff (when present) associated with the local air- and/or seaport surveillance activities. The

review team first met with NZ BioSecure personnel in Wellington and A. van den Hurk conducted a peer review of the NZBEL facility and activities, before meeting with Hutt Valley PHU. The review team then travelled to the following regional centres to meet with PHU staff from the respective DHBs: Tauranga, Auckland, Whangarei, Christchurch and Napier. Although MPI staff may detect mosquito larvae or adults on a vessel, or on cargo or sundry receptacles within the confines of a port, advise the local PHU and collect the specimens for handing on to PHU staff, it is the MoH PHUs that are responsible for auditing the port companies' performance on medical vector surveillance at the border in larger regions or by undertaking the surveillance themselves in smaller regions.

It was emphasised to the review team and the local PHU staff that this review was to be simply a review of port surveillance activities and not an audit of the procedures. The review team also did not engage with any of the contractors on any level. At each centre, a meeting was first held at the PHU where documentation relating to first porting craft and imported cargo, and previous surveillance results, was provided. The documentation and discussion provided an overview of the local strategies and technologies that constituted the local for medical vector surveillance programme. The local surveillance equipment and procedures were discussed and inspected, tours of the ports (both sea- and air-, where applicable) were undertaken, and, on limited occasions, local MPI personnel were met and engaged in similar discussion.

Overall findings

Capacity

The different PHUs had varied capacity to service the surveillance programme and manage the need to respond to an interception or incursion. For the most part, each PHU had at least one Health Protection Officer (HPO) or Technical Officer (TO), who had oversight of the operational components of the biosecurity portfolio as it related to mosquitoes. Other HPOs and TOs had various roles in the programme, although, in some cases, it did not appear that these officers were routinely involved in the day-to-day operations. Instead, operation of surveillance activities only formed a component of the HPO's duties, which was even the case for those with responsibility for the programme. The review team also acknowledged that there was much institutional knowledge retained by these officers and when an HPO was on leave or when they left the position, then this knowledge would not be available or would be lost. Each of the PHUs possessed personnel who could play a role in after hours or on-call duties or form part of the surge capacity. It was identified that most of these staff had attended the various training courses, but their training currency varied considerably. PHUs were concerned at the limited number of places available for staff to visit some training courses. Another issue identified by PHUs was competing priorities, which have the potential to divert staff and resources away from conducting the routine surveillance. Indeed, most PHUs would be stretched if they had to deal with two Public Health emergencies concurrently. Only Auckland would appear to have the resources to respond to two (or potentially more) mosquito interceptions at the one time. The other PHUs would need to be supplemented with staff, equipment and materials if they were required to respond to simultaneous biosecurity events.

Training

Current training is conducted as residential courses (National Border Health and Ship Sanitation Course and the Medical Vectors Workshop) and students are taught the

basic principles of medical vectors, their risk, surveillance and control. The course also teaches the student's the skills and knowledge required to use the equipment that is provided for surveillance and the necessary administrative processes. From the PHU visits it was clear that most staff had a fundamental knowledge of the theories and principals related to conducting their respective surveillance programmes. However, it was clear that a detailed knowledge of the biology of different mosquito species and how this can impact the surveillance methodology in the day-to-day activities was lacking in some cases. For example, not appreciating that environmental conditions vary between locations which can influence the mode of surveillance, not understanding that different traps are designed to collect different mosquito species and the importance of trap placement to ensure efficacy.

The two key training resources, Procedure 5.6 (and relevant appendices) of the Border Health section of the *Environmental Health Protection Manual,* and the *Medical Vector Handbook 2018* are very comprehensive documents. Procedure 5.6 details the relevant legislation, role delegations of officers appointed under the BSA 1993, activities aimed at excluding pests, response pathways for interceptions or incursions, surveillance methodology and control options. The *Medical Vector Handbook 2018* contains thorough information on mosquito biology and taxonomy, transmission cycles and epidemiology of vector-borne diseases, the risk posed by exotic mosquitoes, surveillance and control methodology, information on database management and response pathways for interceptions or incursions.

Engagement with MPI

The Ministry for Primary Industries (MPI) has a key role in detecting all unwanted organisms at the border. The health services are heavily reliant on this being delivered efficiently and in a timely manner. It was noticeable that, in general, there was only a limited amount of engagement between PHU staff and MPI staff at the operational level. The suggested reasons for this include the limited numbers of MPI operational staff and their heavy workloads meaning they have limited opportunity to establish relationships. Conversely, PHU staff spend most of their time away from the operational POEs so do not have the opportunity to become familiar with their counterparts and so establish good working relationships. This is an issue, as interceptions often occur outside of work hours, and, in such circumstances, the more familiar the MPI staff are with the PHU staff, the better the prospects are of executing an effective response.

The overall impression was that the relationship between MPI and MoH could be strengthened, both locally and nationally, especially regarding operational response. When the Biosecurity responsibilities were originally concentrated at MPI in 2005, there was provision for public health officials to be embedded in MPI to provide advice on human issues as they relate to biosecurity. It would seem these positions are no longer being filled, so the opportunity to sustain a direct connection with MPI has been lost. However, there is one work stream when MPI and the MoH work well together, which is the aircraft disinsection programme administered by Steve Gay of MPI at Auckland International Airport.

Disinsection procedures

The aircraft disinsection programme administered by MPI according to the Schedule of Aircraft Disinsection Procedures for Flights into Australia and New Zealand (Version 4.2) plays an important role in reducing the risk of establishment of exotic insects,

including mosquitoes. Two chemicals are currently recommended by the World Health Organisation (WHO) for aircraft disinsection: permethrin (a residual pyrethroid) and d-phenothrin (a non-residual pyrethroid). One of the key issues regarding aircraft disinsection is the development of resistance in key arbovirus vectors to different classes of insecticides, including pyrethroids. Indeed, many populations of *Ae. aegypti* residing near ports of origin for flights and sea traffic into New Zealand are displaying different rates of pyrethroid resistance. Steve Gay from MPI is a member of a working group examining ways to expedite the WHO assessment of new active ingredients for insecticides. Several other issues were identified that will impact the application of disinsection procedures, including environmental concerns with propellants used in aerosol cans and efficient assays to detect insecticide concentrations.

The maritime pathway is protected somewhat by the mandatory fumigation of specific risk goods, such as used tyres, which provide an ideal mechanism for movement of *Ae. albopictus*. Without aircraft disinsection and fumigation of at-risk goods, the potential for the introduction of unwanted mosquitoes into New Zealand would increase considerably, leading to the probable establishment of an exotic species.

Policy and legislative framework

Without exception, the stakeholders that we met were resolute in their opinion that they needed to have unambiguous rules to comply with. It was asserted that if they had a clarity of direction, then they would be far more able to conform with the requirements of the programme. The Health Act 1956 is an example of legacy legislation designed to meet the requirements of the mid-20th century. It does not reflect the revolution in the latter part of the 20th century of supply chain logistics and recreational travel. This occurred with the introduction in the of the wide body jet, the introduction of shipping containers, the growth in air freight and the emergence of "globalisation". This phenomenon has exponentially increased international commerce on a variety of platforms which brings an associated increased risk of the movement of unwanted organisms.

Currently there is not a clear legislative requirement for POE operators to maintain sanitary conditions (e.g. mitigating potential reservoirs) or undertake surveillance for unwanted organisms.

Documentation

Each PHU visited by the Review Team provided examples of the documentation they had that supported their surveillance programmes. These documents also included local plans for interception responses.

The Biosecurity Act 1993 (BSA) is a relatively new legislation with a single focus. The review team noted that there could be more attention to providing for the identification and remediation of organism "reservoirs" (habitat) that should be eliminated. The BSA 1993 is understood to be under review. It is suggested that the MoH in its submissions to any such review should press for the ability of officials to identify and remediate these risks.

In this setting there is a critical need for the MoH to formulate a clear set of rules or regulations.

Stakeholder engagement

There appeared to be relatively good engagement between key stakeholders, although the level of engagement did vary considerably between PHUs and between operators within these PHUs. Some stakeholders viewed preclusion of unwanted species an integral component of their operations (i.e. Environmental Management Plans), whilst other organisations did not appear to understand the importance of the issue or even view it as an issue of importance, especially given competing priorities.

Ground surveys to identify and mitigate mosquito habitat

It was previously recommended by Russell and Ritchie (2013) that pre-planned ground surveys (referred to as mega surveys) to identify larval habitats be conducted on a regular basis (potentially 3 times per year). The current reviewers identified that for the most part, each of the PHUs was conducting these surveys, with "mega surveys" over a wider geographical area undertaken typically twice per year. In addition, ad-hoc (environmental) surveys were also conducted when accumulated materials or rubbish were identified. Surveys were conducted by teams which in most cases, contained at least one skilled officer. Surveys aimed to identify standing water, either in containers or ground pools and map their position, as well as undertake some form of mitigation, such as informing authorities that the item/s needed to be removed (refer to section on policy and legislative framework regarding regulatory constraints associated with this), or in the case of fixed habitat (gulley traps etc.), treated with *s*-methoprene. All larvae collected were entered into the national database and forwarded to NZBEL for identification. There were several key containers observed at some POEs, highlighting the need for continual surveys to identify larval habitats (Figure 1).

Figure 1. Examples of larval habitat encountered during site visits: a) water-filled tyre inside storage shed; b) accumulated items which could serve as larval habitat near a POE.

Innovation

It was observed that several PHUs had integrated different technology and methodology to enhance and compliment their surveillance efforts. For instance, late model smartphones not only provided better quality images, but different applications enabled georeferencing of larval habitats during surveys. Furthermore, the addition of macro-lenses to the smartphone camera facilitated the taking of photos of sufficient quality to allow NZBEL to make a preliminary identification of a sample well before any specimens arrive (Figure 2). This has the potential to enable enhanced surveillance and control activities when a suspicious species is intercepted. Another location had adapted a simple method to ensure the amount of CO_2 gas released by the compressed gas cylinder via the regulator was set at the optimal flow rate. Finally, the adoption of a centralised database (the Online National Mosquito Surveillance Database) has facilitated the tracking of samples from point of collection through to the output of results from NZBEL. To ensure a comprehensive dataset it is important that samples from all air and sea port surveillance are entered.

Figure 2. Image of *Maorigoeldia argyropus* larvae captured using a late model smart phone (iPhone XS) fitted with a macro lens. Despite the inexperience of the user, the image is of sufficient quality so that some key taxonomic features are visible.

Trapping methodology

Overall, the PHUs possessed equipment commensurate with what would expected to conduct surveillance of exotic mosquitoes, although the quantity and type of equipment differed between locations. Each PHU had enough tyre traps to provide adequate geographical coverage. As recommended by Russell and Ritchie (2013) ovitraps were no longer deployed for surveillance. The majority of tyre traps were deployed using rabbit (Lucerne) pellets to create an infusion to attract mosquitoes and

s-methoprene to prevent the emergence of any adults. The length of time of deployment varied between PHUs, with some servicing traps weekly, whilst others checked them fortnightly. Some also varied their servicing time depending on the season, with more frequent servicing in summer. Finally, the cleaning/scrubbing treatment of traps varied between locations.

The number and type of adult traps used for surveillance varied between each PHU. For the most part, the activities involve the deployment of a variety of adult traps at each location. The traps used were the BG traps and CO_2-baited light trap (the so-called "Bland" trap of the Russell and Ritchie 2002 review), as well as several other traps. Almost without exception, it did not appear that staff were aware that the different trap types varied in their efficiency at collecting different mosquito species. For instance, the BG trap was designed specifically to collect *Ae. aegypti* but also collects *Ae. albopictus*, whilst CO_2-baited light traps collect unwanted species, such as *Ae. camptorhynchus*, *Culex annulirostris* and *Anopheles* spp. Several PHUs continued to use "over the counter" traps, such as the Dominator and Terminator, which purport to use a combination of UV light, heat, lures and CO_2 to collect mosquitoes. Upon perusal of key scientific literature search databases (PubMed and Web of Science), no published evidence existed citing rigorous studies showing that these traps are effective at collecting mosquitoes, particularly with reference to *Ae. aegypti* and *Ae. albopictus*.

Another important observation was the positioning of traps. Generally, mosquitoes prefer to harbor in sheltered locations, such amongst foliage, or, in the case of *Ae. aegypti*, in and around buildings, so traps should be set to exploit this requirement. In several cases, traps were set in locations that potentially reduced the efficacy of the traps, such as unsheltered sites which receive high winds. Furthermore, some mosquito species do not fly far (< 100 m for *Ae. aegypti*) nor traverse geographical barriers (such as roads), so the location of some traps some distance from a risk area could have compromised their efficacy. Finally, the traps themselves were not deployed in the most efficient manner. For instance, some BG traps were set suspended at shoulder height and not on the ground, whilst the CO_2 outlet for the light traps was directly next to the trap body inlet and not above or beside the trap.

Occupational safety and health issues

Several PHUs identified occupational health and safety issues, which had the potential to impact the surveillance operations. One of these issues related to the transport and deployment of compressed gas CO_2 cylinders used as bait for the light traps. Some staff found moving the cylinders from the vehicle to the trap location be difficult due to their weight. Another problem with the cylinders was the lack of suitable vehicles required for their transport, such as an open tray with a means of restraining the cylinder.

Access to POEs is also becoming difficult. Increased security requirements and health and safety requirements are inhibiting the ability of PHU staff to access sites for:

- Conducting surveys to identify potential reservoirs as well as places for installing detection systems;
- Routine servicing of detection systems and;
- When detection of mosquitoes occurs the ability to conduct detailed de-limitation surveys and the subsequent servicing of the interception traps.

It was noted that Ports of Auckland are to introduce autonomous mechanical handling equipment, (MHE). The ability of staff to operate in an environment with autonomous MHE is problematic given the requirements of Article 2 of the IHR 2005.

Transitional facilities

Without exception, TFs, which are managed by MPI in terms of biosecurity and audits, were viewed as a high-risk point of entry for exotic species. The risk of these facilities was identified by Russell and Ritchie (2013) with good reason, given their role in previous interceptions. Unfortunately, there was also universal agreement that monitoring and mitigating this risk was a difficult undertaking. The sheer number of TFs makes them a significant challenge for PHUs to assess them, let alone deploy any surveillance measures. Some PHUs had mapped their transitional facilities, which could vary from a relatively low number through to 100s and 1,000s, and some PHUs conduct occasional surveys to assess their risk. Commentary from an MPI official was that they are continuing to discourage small operators from operating these businesses with the long-term goal to reduce numbers significantly.

Conclusions

In general, it was clear to the review team that all PHUs understood the strategy that underwrites the programme and the risks associated with it. The staff delivering the surveillance programmes showed that they understood the general principles of how to carry out their duties in the field. Following is a list of recommendations that could enhance the overall effectiveness of the national mosquito surveillance programme and help to mitigate the risk of establishment of an exotic mosquito species in New Zealand.

Recommendations

The review team has formulated numerous recommendations that build upon those of Russell and Ritchie (2013) to ensure that the programme continues to efficiently perform against a background of competing priorities, engagement with multiple stakeholders, increasing global transport of unwanted organisms and projected impacts of climate change. These recommendations are listed below. A prioritised list of key actions arising from these recommendations is provided in Table 1 on page 20.

Capacity

- Each PHU maintain capacity to perform their current routine surveillance activities. PHUs need to ensure that personnel with adequate training are always available to respond to any events, without faltering.
- It is essential to clearly define a succession pathway to ensure that there is not a capability vacuum when the incumbent staff member who holds the portfolio vacates the position. Most NZ PHUs have limited numbers of staff. This coupled with an aging workforce is another challenge for the management of these units. The Review Team noted that most PHUs had existing staff who seemed to be competent in carrying out their duties.
- Perhaps there needs to be a national stocktake of the HPO resources that will provide a clearer picture of when and where the exit of current staff due to attrition will occur. Then planning could be initiated to identify strategies that might meet this gap.
- Processes need to be clarified if PHU capacity is compromised (i.e. during multiple interception events or an unrelated health incident) so that additional personnel

(from another PHU or NZ BioSecure) can be brought in to assist with the response. This includes funding, logistics, travel and HR issues (multiple awards, allowances etc.).

Training

Maintain the current training framework of the two residential courses. It needs to be emphasised in the course content that variation in biology between target species will impact the mode and scale of surveillance undertaken. This framework should be enhanced by implementing continuation training within the PHUs by suitably credentialed instructors (such as the NZBEL entomologist). This could be delivered by a variety of initiatives, including site visits, assessment of surveillance and response activities, and provision of on-the-ground-training on best practice within the context of the extant environment. The frequency of these training events should be aligned with the relative risk of the given POE (i.e. ports considered higher risk should be visited more frequently). In line with this, the PHUs should consider introducing a programme of assessing the knowledge and skills of any of the staff with the potential to be involved in a biosecurity response. Collective training exercises are events which allows staff to show that they can work collegially to demonstrate that they can deliver the desired outcomes. Mega surveys also provide an excellent opportunity for onsite training because each survey team contains a skilled HPO.

Like any document, the key training resources should be periodically reviewed and updated, especially to capture legislative or policy changes, the adoption of new procedures and the changing global vector risk. Some suggested amendments to the *Medical Vector Handbook 2018* are provided in recommendations section in Appendix 2.

Stakeholder engagement

Maintain the current level of engagement where PHUs have a productive relationship with stakeholders, whilst efforts should be made to increase engagement in locations where it was perceived as inadequate. Promisingly, stakeholders who were not as engaged in the programme identified various channels that could improve their level of engagement, such as integrating biosecurity training into port user inductions, articles in current site periodicals and bringing it to the attention of chief executives through their various forums. It is important that the PHUs play an integral part in increasing stakeholder engagement and, where possible, be a lead facilitator. Stakeholders must be encouraged not to view mosquito surveillance as a separate programme. Instead mosquito surveillance should be an integral part of the POEs environmental management plans.

Although the POEs and the PHUs have developed response plans for managing interceptions these need to be exercised regularly to ensure they are fit for purpose and to maintain staff awareness of their roles and responsibilities at all levels.

Surveillance for mosquitoes is not the only tool for detecting mosquitoes. Sightings by members of the public are an important channel of communication. At POEs the staff that work inside the “wire” are an important detection asset. There it is seen as being crucial to have an “informed” workforce with an “awareness” of their role at the POEs on matters such as:

- the public health threat of exotic mosquitoes,

- what they look like
- where you might find them
- how to discourage them establishing themselves
- how to capture and keep them
- who to contact if you find them

There are several ways to educate the POE personnel. At the management level it is by personal engagement and involvement in the POE emergency management plans. For frontline staff the very least that could be done is the development of informative and durable signage that can be deployed at key sites in the POE such as devanning areas, rest areas, baggage handling areas and so on (i.e. Figure 3).

Figure 3. Example of the type of signage which could be used to educate stakeholders.

Engagement with MPI

Re-establishing a strong working relationship with MPI at both the operational and strategic levels is an imperative if the program is to have any enduring success. To achieve effective coordination between the agencies there will need to be energetic leadership to ensure that the necessary level of engagement is reached and sustained. The initiatives to achieve this include but are not limited to:

- Use of memoranda of understanding or operational agreements to delineate areas of interest, responsibilities and accountabilities along with robust reporting channels
- Delineating the processes whereby the agencies and their staff interact, for example through agreed business processes
- Sharing of data and information at all levels
- Offering training opportunities to selected staff where appropriate
- Establishing regular forums for staff to meet their counterparts where they can interact, share experiences and establish confidence
- Engage in joint training events such as Desktops, Briefings, walk throughs and field exercises

Occupational Safety and Health

Several of the OSH issues identified by the reviewers have the potential to impact on aspects of the programme. The addition of CO_2 with light traps is essential, as it significantly increases collections of species that these traps target. Whilst CO_2 gas can be produced by the sublimation of dry ice, the best way to provide continual supply of CO_2 gas is via a compressed gas cylinder. Consequently, PHUs need to find a solution to the OSHOSH issues associated with their use. This could possibly include access to appropriately ventilated vehicles (such as tray-back vehicles) with adequate fastening mechanisms, the bulk delivery of cylinders and storage of them on site, and the provision of trolleys or carts to move cylinders.

The inability to access certain areas at POEs poses a risk to surveillance and response operations. It is critical that PHUs liaise with POE operators to establish processes which allow PHU staff to access these restricted areas to undertake routine surveillance (regular habitat surveys as the very minimum), habitat mitigation and direction for mitigation, and respond to interceptions. This may require a memorandum of understanding between the PHU and the POE operators, and other stakeholders (such as contractors and lessees).

Disinsection procedures

Current air craft (residual and non-residual pesticide application) and maritime disinsection (fumigation of tyre shipments) procedures need to be maintained. Support should continue to be given to MPI and their input into the working group expediting the WHO assessment of new chemicals for disinsection. This is particularly relevant given the increasing spread of resistance amongst medically important exotic species to the class of insecticides used for aircraft disinsection.

Policy and legislative framework

To improve the clarity of direction for POE operators and to provide a direct framework for remediation of mosquito risk habitats, in the absence of a specific interception response by PHU designated officers, there needs to be a better policy and legislative framework. To help achieve this, it is recommended:

- That the MoH scrutinise the applicability of the current health legislation and determine whether appropriate amendments can be introduced within current regulations that will meet the stakeholder's concerns for clarity or if new regulations need to be developed.
- That MoH officials take active steps to participate in the current review of the Biosecurity Act 1993 with the intention of providing authorised officers with the powers to mitigate potential mosquito habitat at POEs and Transitional Facilities and their environs.
- That MoH officials, in consultation with MPI work with the EPA to expedite approvals of control agents.

Trapping methodology and larval surveys

As recommended by Russell and Ritchie (2013) there should be a concerted effort to have a national standardised protocol for conducting surveillance:

- Trapping conducted at each POE should involve a combination of tyre traps, CO_2-baited light traps and BG-traps. This will ensure that the range of unwanted mosquito species is being targeted by at least one of these traps. For instance, the tyre traps and BG traps will readily collect *Ae. aegypti* and *Ae. albopictus*, whilst the CO_2-baited light trap will collect *Anopheles* spp., *Culex* spp. (such as *Cx. annulirostris*) and saltmarsh *Aedes* spp. (*Ae. camptorhynchus* and *Ae. vigilax*).
- Whilst CO_2-baited light traps and BG traps will be effective without addition of attractants, consideration should be given to using octenol with CO_2-baited light traps and the BG lure with BG traps to enhance their effectiveness.
- It is imperative that all traps used for surveillance have been rigorously scientifically tested for their efficacy in collecting the target species. Given the lack of evidence in the scientific literature for their efficacy in collecting mosquitoes, the use of "over-the-counter" UV-based traps is discouraged and should cease. This will allow for the deployment of scientifically-proven traps in their place.
- As part of any training module, the complexities of deploying traps for collecting different mosquitoes needs to be emphasized and that one trap will not collect all species. Furthermore, where possible, traps should be operated in sheltered locations away from high winds. When setting CO_2-baited light traps, the outflow from the cylinder should be located above the trap and not next to the trap entrance.
- Surveys should be conducted regularly to identify and mitigate larval habitats. Broadscale (mega) surveys should be conducted at least twice per year. To assure some degree of quality assurance, at least one trained officer should be included in every survey team.

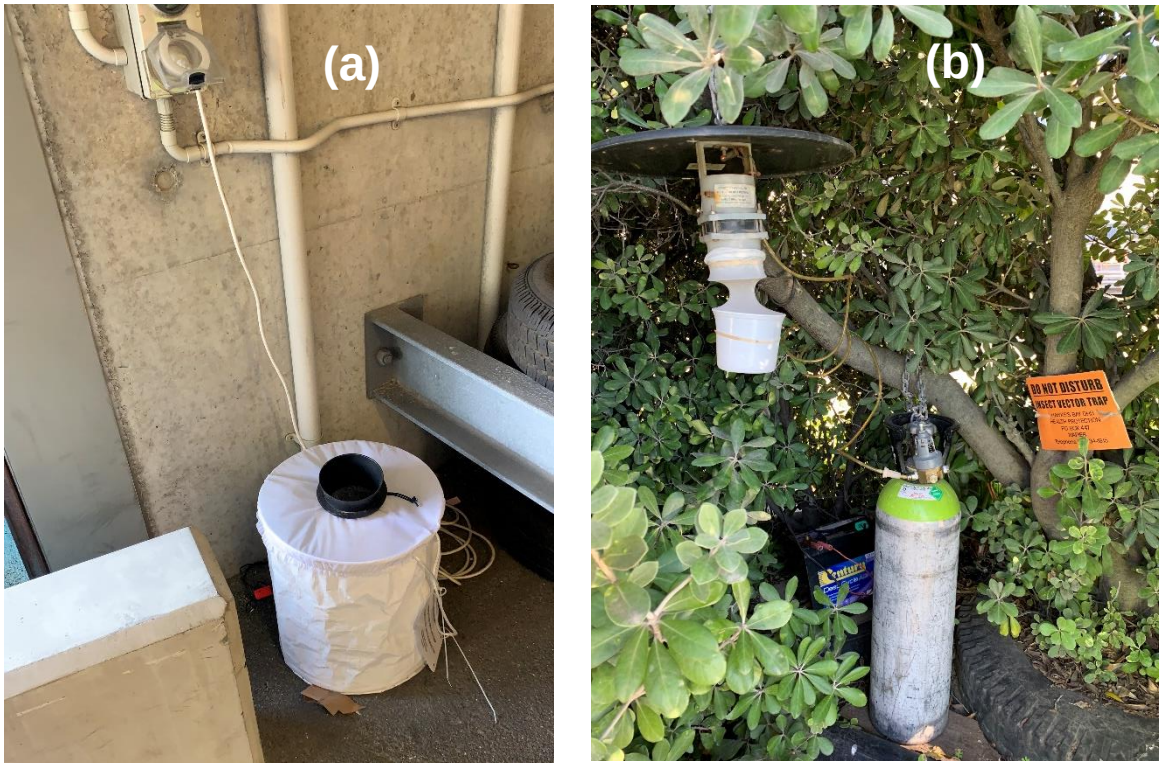

Figure 4. Examples of suitable locations for deployment of a BG Trap (a) and a CO_2-baited light trap (b). These types of sites should maximise the chances of collecting target species

Transitional facilities

Transitional facilities continue to remain a considerable risk as a final pathway for the introduction of exotic mosquitoes. The role of MPI in the auditing of these facilities with reference to excluding mosquito vectors needs to be established. In particular, the requirements for maintaining these sites free of suitable larval habitats, and how they are monitored by MPI need to be clarified. The MoH has advised that, as a minimum PHUs should identify the number of TFs in their regions, map their location, and possibly categorise those that might be a significant risk. Sites need to be prioritised based on the mode of business conducted, point/s of origin of freight, and the presence of suitable habitat surrounding it.

Innovation

Innovation within the PHUs should be encouraged. However, it is imperative that adoption of new methodology or technology aligns with the priorities and procedures of the surveillance programme. Furthermore, the adoption of new technology or methods that enhances any activities should be shared with other PHUs, for instance, the use of late model smart phones fitted with macro lenses to capture the image of intercepted specimens has direct applicability for enhancing response capabilities. Intercepted samples, particularly *Ae. aegypti* and *Ae. albopictus* should continue to be submitted to colleagues in Australia for genetic analysis, so that inferences can be made regarding their point of origin and insecticide resistance status.

Apart from the innovation that is being embraced in some PHUs and via NZ BioSecure, there is technology that is being developed and optimised overseas that may have application to the International Sea and Air Port Mosquito Surveillance Programme. Some examples of this include:

- Simple point-of-care tests, such as loop-mediated isothermal amplification (LAMP) assays that can rapidly identify some of the unwanted species without the need for sophisticated equipment (i.e. Bhadra et al. 2018)
- Alternative systems for ovitrap deployment to facilitate rapid turnaround from sample collection to identification (i.e. Rapid Surveillance for Vector Presence (RSVP; Montgomery et al. 2017)).
- Citizen Science programmes, which are empowering the community to undertake a component of the sampling (i.e. Walther and Kampen 2017). A project being led by the Museum of New Zealand Te Papa Tongarewa is aiming to use citizen science to help catalogue the mosquito fauna of New Zealand.
- Genetic analysis of intercepted mosquitoes, so that inferences as to their point of origin and pathways of introduction can be made (i.e. Schmidt et al. 2019). Some New Zealand material have previously been included in a regional study by Australian researchers on the movement and insecticide resistance status of *Ae. aegypti*. In future studies, it is important that New Zealand staff who provide specimens for projects are duly acknowledged on any publications.
- Alternative chemicals and modes of application. An example of this is autodissemination of the insect growth regulator, pyriproxyfen (i.e. Unlu et al. 2017). In this system, ultra-low doses of pyriproxyfen are applied to water-filled containers where it is picked up by ovipositing female mosquito. These mosquitoes then transfer the chemical to other containers during subsequent ovipositions.

Given the rapid pace of innovation globally, it is recommended that MoH keeps up-to-date with developments and establish processes for the adoption of applicable technology.

Table 1. Summary and prioritisation of actions arising from key review recommendations.

Recommendation	Action	Agencies responsible	Priority
Policy and legislative framework	Assess applicability of current health legislation and determine whether it can be amended to meet stakeholder's concerns for clarity or if new regulations need to be developed.	MoH	High
	MoH officials participate in the current review of the Biosecurity Act 1993 with the intention of providing authorised officers with the powers to mitigate potential mosquito habitat at POEs and TFs and their environs.	MoH	High
	MoH officials, in consultation with MPI work with the EPA to expedite approvals of control agents.	MoH	High
Capacity	Maintain capacity to conduct routine surveillance activities and to respond to biosecurity events.	PHUs	High
	Clarify pathways and processes to increase capacity if a given PHU is overwhelmed by multiple interceptions or competing priorities.	MoH, PHUs	High
	Define succession pathways to ensure that capable staff can maintain continuity of the programme when the incumbent staff member who holds the portfolio vacates the position.	PHUs	Low
	Conduct a national stocktake of HPO resources to assess the rate of attrition of senior staff and identify strategies that could limit its impact.	MoH, PHUs	Low

Transitional facilities	Identify the number of TFs in each health district, map their location, and possibly categorise them based on risk.	PHUs	Medium
	Clarify the role of MPI in the auditing of TFs with reference to excluding mosquito vectors.	MoH, PHUs, MPI	Medium
Disinsection procedures	Maintain current aircraft (residual and non-residual pesticide application) and maritime disinsection (fumigation of tyre shipments) procedures.	MPI	High
Stakeholder engagement	Maintain engagement in PHUs who have a good relationship with stakeholders.	PHUs, POEs, MPI	Medium
	Identify pathways and processes to improve engagement with stakeholders.	PHUs, POEs, MPI	Medium
	Ensure that response plans remain relevant and clearly articulate the roles and responsibilities of key agencies.	PHUs, POEs, MPI	Medium
	Identify opportunities to involve POE operational staff in surveillance activities.	PHUs, POEs, MPI	Low
Occupational Safety and Health	Establish processes which allow PHU staff to access restricted areas at POEs to undertake routine surveillance, habitat mitigation, direction for mitigation, and respond to interceptions.	PHUs, POEs	High
	Ensure that PHUs have access to a reliable and safe method to dispense CO_2 for mosquito traps.	PHUs	Medium
Engagement with MPI	Re-establish a strong working relationship with MPI at both the operational and strategic levels.	MoH, PHUs, MPI	Medium

Training	Maintain the current training framework of the two residential courses.	MoH, NZBEL	Medium
	Provide continuation training at each PHU.	MoH, NZBEL	Medium
	Periodically assess competency of staff who could potentially be involved in a biosecurity response.	PHUs, NZBEL	Medium
	Periodically review and update training resources.	NZBEL	Low
Trapping methodology and larval surveys	Ensure there is a national standardised protocol for conducting surveillance for unwanted mosquito species	MoH, PHUs, NZBEL	High
Innovation	Encourage innovation within PHUs providing it adheres to the programme's objectives	MoH, PHUs, NZBEL	Medium
	Develop a process to ensure the programme's key agencies stay up-to-date with technological developments and establish processes for the adoption of applicable technology	MoH, PHUs, NZBEL	Low

References

Bhandra, S et al. 2018. Direct nucleic acid analysis of mosquitoes for high fidelity species identification and detection of *Wolbachia* using a cellphone. PLoS Negl. Trop. Dis. 12: e0006671.

McGinn, D. 2008. *Mosquito Surveillance Review 2008*. Undertaken for the Ministry of Agriculture and Forestry, and the Ministry of Health, 22pp.

Montgomery, BL et al. 2017. Rapid Surveillance for Vector Presence (RSVP): Development of a novel system for detecting *Aedes aegypti* and *Aedes albopictus*. PLoS Negl. Trop. Dis. 11(3): e0005505.

Ritchie, SA and Russell, RC. 2002. *A Review of the New Zealand Mosquito Surveillance Programme*. A report prepared for the New Zealand Ministry of Health, 47pp.

Russell, RC and Ritchie, SA. 2013. Review of New Zealand Mosquito Surveillance:

Ports (Sea- and Air-) Mosquito Surveillance Review. 11pp.

Schmidt, TL et al. 2019. Tracking genetic invasions: Genome-wide single nucleotide polymorphisms reveal the source of pyrethroid-resistant *Aedes aegypti* (yellow fever mosquito) incursions at international ports. Evol Appl. 00: 1–11.

Unlu I et al. 2017. Effectiveness of autodissemination stations containing pyriproxyfen in reducing immature Aedes albopictus populations. Parasites and Vectors. 10: 139.

Walther D and Kampen H. 2017. The citizen science project 'Mueckenatlas' helps monitor the distribution and spread of invasive mosquito species in Germany. J. Med. Entomol. 54:1790-1794.

WHO 2005. *International Health Regulations*. World Health Organization, Geneva.

Appendix 1 - Site-Specific Observations and Recommendations for Each Public Health Unit

These recommendations are in addition to those in the main report document regarding the nature and siting of traps

Appendix 1.1

Site-Specific Observations and Recommendations - Hutt Valley DHB

Visited 13/5/2019

Appendix 1.2

Site-Specific Observations and Recommendations – Bay of Plenty DHB

Visited 14/5/2019

Appendix 1.3

Site-Specific Observations and Recommendations – Auckland DHB

Visited 15-16/5/2019

Appendix 1.4

Site-Specific Observations and Recommendations – Northland DHB

Visited 17/5/2019

Appendix 1.5

Site-Specific Observations and Recommendations – Canterbury DHB

Visited 20/5/2019

Appendix 1.6

Site-Specific Observations and Recommendations – Hawkes Bay DHB

Visited 21/5/2019

Appendix 2 - Peer Review of New Zealand BioSecure Entomology Laboratory

Conducted by Andrew F. van den Hurk, PhD

Appendix 3 - Terms of Reference

Point of Entry Mosquito Surveillance Review 2019

Background

New Zealand is a signatory to the International Health Regulations (2005) (IHR). The IHR includes obligations on implementing vector surveillance and control at designated points of entry. Annex 5 of the IHR states that State Parties shall establish programmes to control vectors that may transport infectious agents constituting a public health risk. The IHR also stipulates that competent authorities are required to ensure facilities used at points of entry are maintained in a sanitary condition and are kept free of sources of infection and contamination, including vectors and reservoirs; and conveyance operators are so tasked for conveyances (Articles 22, 24, 27 and Annex 4).

In order to fulfil New Zealand's IHR obligations, and to prevent the establishment in New Zealand of mosquitoes of public health significance, the Ministry of Health funds a national mosquito surveillance programme at international sea and air ports. The programme is delivered by DHB public health units with entomology support from Southern Monitoring Services Ltd (trading as New Zealand Biosecure). DHB public health units may undertake surveillance directly, and/or may audit surveillance undertaken or contracted by port operators. Since establishment, the national programme has been periodically reviewed, with the most recent reviews completed in 2002, 2008 and 2013.

Ministry of Health has contracted experts to undertake a review of the Ministry's and DHB public health units' mosquito audit and surveillance programmes in 2019.

Purpose

The purpose of the review is:

- to assess the appropriateness and effectiveness of the current Ministry and public health units' audit and surveillance programmes for excluding and detecting exotic mosquitoes of public health significance (e.g. *Ae. aegypti* and *Ae. albopictus*) at selected international sea and air ports;
- to assess the appropriateness and effectiveness of the current Ministry and public health units' responses to suspected interceptions of exotic mosquitoes of public health significance at selected international sea and air ports;
- to provide recommendations for programme improvement; and
- to provide advice on options for the continuous review of the national mosquito surveillance programme.

Scope of the review

The review will include:

- an assessment of DHB public health units' mosquito audit, surveillance and response programmes at selected New Zealand sea and air ports;
- an assessment of audit, surveillance and response techniques, equipment and data management;
- a review of relevant national and local documentation;

- interviews with key informants;
- a peer review of the advisory material, national database, service and facilities provided by New Zealand Biosecure.

For sites where public health units undertake mosquito surveillance the review will include a site visit and assessment of trap location and clearance procedures. For sites where public health units audit the surveillance programme, the review will focus on the audit role and processes undertaken by the public health unit. At all selected sites, the review will assess public health unit responses to suspected interceptions.

Out of scope: Ministry of Health officials will visit New Zealand Defence Force (NZDF) sites at RNZAF Whenuapai and Devonport Naval Base. Ministry of Health officials will be seeking information on how the IHR capacities for vector control are being achieved, general information about the vector surveillance and response programme, the relationships with key agencies and discuss how Ministry of Health officials might better support NZDF. The management of wider border risks at NZDF sites is out of scope of this mosquito surveillance review but will be part of ongoing discussions between the Ministry of Health and NZDF.

Roles and responsibilities

The reviewers are expected to lead, co-ordinate and deliver the review. The reviewers will:

- develop a threat assessment framework for exotic mosquitoes at New Zealand's points of entry and apply the framework to establish prioritise international sea and air ports for assessment
- review the previous surveillance reports (particularly those conducted by Scott Ritchie and Richard Russell) to ensure consistency with these previous reviews and to identify recommendations that were made in these reviews;
- assess current and expected mosquito threats for New Zealand including those on the unwanted organism list (especially *Culex sitiens)*
- develop interview forms, assessment and data gathering templates for the site visits including assessing the implementation of relevant recommendations from previous reviews;
- interview key informants, in particular the Ministry of Health Environmental and Border Health staff, and Ministry for Primary Industries national saltmarsh surveillance contract manager staff, but also key staff in public health units and at sea and air ports;
- undertake site visits to international air and sea ports agreed with us. The ports have been selected based on the application of a threat assessment model to establish a ranking for each of the New Zealand points of entry;
- assess and make recommendations on audit, surveillance and responses including appropriateness for target species, trapping techniques, laboratory processes, plans and procedures, data management, use of emerging technology, communications, implementation of previous recommendations, and training. Recommendations should consider requirements for future proofing the programme;
- review national operational guidance including Procedure 5.6 (and relevant appendices) of the Border Health section of the *Environmental Health Protection Manual,* and the *Medical Vector Handbook 2018*;

- provide recommendations on a process for continuous review for the national surveillance programme within the Ministry's wider border health protection programme;
- provide a draft report to the Ministry of Health that outlines the review process, findings and recommendations and consider any comments made by Ministry of Health officials in finalising the report;
- provide a final report outlining the review process and findings (including commenting on the implementation of recommendations raised in the previous reviews where relevant).

Andrew van den Hurk will also peer review the service and facilities provided by New Zealand BioSecure, and will interview New Zealand BioSecure scientists to provide advice and recommendations on any improvements to the identification, advice, national database, and other services provided by New Zealand BioSecure to support the national mosquito and border health protection programmes.

Ministry of Health officials will support the review by:
- providing copies of relevant documentation;
- establishing and enabling communication pathways with public health units;
- establishing a document management repository;
- attending site visits and providing the introduction to the review;
- reviewing the draft report and recommendations.

Review team
The review team must include persons with operational as well as academic expertise and will include at least one international expert. Ministry of Health representatives will accompany the reviewers to introduce the review team and the objectives and expectations of the review.

Timing
The review will be completed by 30 June 2019. The site visits are likely to be undertaken over a ten-day working period in May 2019.

Conflict of Interest
The review team members must do their best to avoid situations that may lead to a Conflict of Interest. They must tell the Ministry of Health immediately, and in writing, if any Conflict of Interest arises in relation to the Services. If a Conflict of Interest does arise Ministry of Health officials will discuss, agree and record in writing with the reviewer(s) whether it can be managed and, if so, how it will be managed.

Intellectual property
All physical and intellectual outputs produced for the purposes of providing and completing the services shall be the property of the Crown (for the avoidance of doubt this includes, without limitation, all reports, papers, electronic documents (including computer software), and recordings).

Professional care and diligence
The reviewers will exercise all due professional care and diligence in undertaking the review in accordance with the standards of skill, care, and diligence normally practised by suitably qualified and experienced experts performing services of a similar nature.

Confidentiality
The reviewers have agreed that they will not at any time disclose to any person otherwise than is necessary for undertaking the review, or as required by law, any information they acquire for the purposes of undertaking the review.