MINISTRY OF HEALTH
MANATU HAUORA

Exclusion and Control of Exotic Mosquitoes of Public Health Significance

Report to the Minister for Biosecurity

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Summary of Key Issues

Potentially the most significant mosquito-borne diseases to New Zealand are the arboviral diseases Ross River Fever (Epidemic Polyarthritis), Dengue Fever, Barmah Forest virus and Japanese Encephalitis.

The establishment and maintenance of a nationally co-ordinated approach to exclude and control exotic mosquitoes of public health significance is crucial to protect the public health.

There are number of species of mosquitoes that should be of concern to New Zealand. The species of greatest concern is *Aedes albopictus*, the Asian Tiger Mosquito, a competent vector for Ross River Virus and Dengue.

The risk of an outbreak of an arboviral disease or malaria in New Zealand is real and is likely to increase with time.

In terms of potential entry of exotic mosquitoes, North Island port cities, such as those in Auckland and Northland, are more important than cities without either major international airports or shipping.

The likely consequences of a major outbreak of arboviral disease are so serious that all reasonable steps should be taken to prevent such an occurrence.

Enhancements are required to existing border control, surveillance and ready reaction systems to the extent they will enable an early, effective and economic response to the introduction of a new species of exotic mosquito.

To ensure active and routine monitoring for exotic mosquitoes there must be:

- clear responsibilities and nationally uniform directions for service providers
- publication of national guidelines
- risk-based protocol, designed by the relevant authority specifically for each locality
- records and audits on quality
- education and specialist training for those responsible.

The elimination of mosquitoes and their habitats about ports should be enforced by designated officers who undertake routine surveillance of international airports and seaports of arrival.

Mosquito traps, such as water filled tyres, should be set and checked at the border so exotic mosquitoes may be detected and eradicated before becoming established.

The Memorandum of Agreement between the Ministries of Health and Agriculture should be reviewed with a view to extending the agreement to include matters relating to:

- mosquito species other than *Aedes albopictus*
- inspection of first port of call yachts
- aircraft disinsection procedures, possibly including airbridges and baggage handling facilities
- health audit of fumigation and other mosquito-related border activities
- training, reporting and maintenance of specialist services.

Crown public health service providers should submit six-monthly surveillance reports. The funding and contracting agency should audit and collate these reports. After analysis of the reports the appropriate body should produce an annual report.

Surveillance methodology should be standardised throughout New Zealand, with the level of surveillance graded according to the risk of introduction.

Surveillance activities should be intensified through the summer and scaled down in winter (Kay 1997). They should be continuous and not intermittent like the current 10-year plan.

It is recommended that funding is allocated on an at-risk basis, with a 60:20:20 split: 60 percent Auckland and Northland; 20 percent all other North Island ports and Christchurch; 20 percent elsewhere.

The public view of mosquitoes must be changed from ‘just a nuisance’ to ‘potential health risk’.

Training for border control and surveillance is essential. National courses for designated officers and port authority personnel are appropriate. Also, education of general practitioners and the public is desirable, in particular:

- in the short term – information releases to increase general awareness
- in the longer term – development of appropriate health education resources.

The nuisance provisions of the Health Act may be useful for ad hoc interventions where small-scale concerns are encountered.

Issues relating to funding, compensation and co-ordination are not covered in any detail by the Health Act.

On balance, it seems that a Biosecurity Act National Pest Management Strategy (NPMS) is the most appropriate option for the exclusion, eradication and management of exotic mosquitoes of public health significance. In developing the NPMS careful consideration must be given to the need for:

- carefully developed pest management strategies and contingency plans
- effective community consultation
- adequate science and expert input
- good information flows and interactions between departments with clear accountabilities and lines of interaction established in advance
- a generic decision-making framework for dealing with pest incursions
- operational assumptions to be well informed
- improved processes for quality assurance and risk management.

Until an NPMS is in place, biosecurity and other legislative powers do provide a means of responding to a border incursion. Public health service contracts are thought to maintain a basic capacity to eradicate a small-scale mosquito colony and this is likely to be enhanced as a result of increasing awareness.

To avoid duplication of resources and activities, intersectoral collaboration is important. Formation of a working party with all relevant agencies and expertise is vital to formulate appropriate protocols for border control, surveillance, emergency response, and contingency planning.

Attention must be given to establishing mosquito control options, especially those proven effective in other countries with minimal side effects or negative consequences.

There is an identified need for a higher level of expertise in New Zealand with respect to mosquitoes and mosquito-borne disease. Also, there are a number of issues that warrant research.

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1 Introduction

This report arises from a Cabinet directive that the Ministry of Health report back to the Government on exotic mosquitoes of public health significance to New Zealand. Specifically, consideration given to the development of a national pest management strategy for exotic mosquitoes of public health significance and alternative methods of providing for the eradication of such mosquitoes.

It encompasses submissions on the Ministry's November 1996 discussion document '*Exclusion and Control of Exotic Mosquitoes of Public Health Significance*' and the views of Dr Brian Kay as expressed in his February 1997 report '*Review of New Zealand Programme for Exclusion and Surveillance of Exotic Mosquitoes of Public Health Significance*'. Dr Kay was commissioned in December 1996 by the Ministry of Health to assess New Zealand's border control and surveillance arrangements for exotic mosquitoes.

The worldwide spread of mosquitoes and the danger of mosquito-borne diseases is a threat to public health. The New Zealand environment is conducive to the survival of mosquitoes. It is possible that exotic mosquitoes, capable of transmitting very serious diseases could establish in New Zealand. In addition to border control measures, early detection and eradication action will be necessary to avert a substantial threat to public health.

New Zealand has no record of outbreaks of mosquito-borne diseases, such as arboviruses, malaria or filariasis. Internationally, the re-emergence of such diseases is of public health significance. It is possible that New Zealand could experience an outbreak of one of these disabling or life threatening diseases. Arboviruses pose the greatest threat to New Zealand. The human population in New Zealand is non-immune and susceptible. Susceptibility can be exacerbated by the fact that the population knows little about mosquito-borne diseases and how to minimise the risks of infection. The establishment and maintenance of a nationally co-ordinated approach to exclude and control exotic mosquitoes of public health significance is crucial to protect the public health.

In 1993, the *Aedes albopictus* species and three other exotic species were detected at New Zealand's border. *Aedes albopictus* were then found at a used tyre importer's yard and were eradicated. These occurrences highlight the fact that accidental introduction to this country is possible.

There are many ways mosquitoes can be introduced into New Zealand. Interventions that occur now include insecticide treatment of aircraft, ongoing surveillance around ports of entry, fumigation of used tyre imports and the examination of larval habitats on ships. These interventions greatly reduce risks but do not absolutely guarantee that new mosquitoes will be excluded.

The Institute of Environmental Science and Research Limited (ESR) subcontracted Dr Philip Weinstein to undertake a study and in 1994 he produced a report entitled '*Real And Potential Risks of Arboviral Disease In New Zealand*'. The report recommended maintaining regular surveys for introduced mosquito species and production of contingency plans. Early detection of any new species of mosquito of public health significance will help to enable an effective and economic control response.

2 Background

2.1 Public Health Significance of Mosquito-borne Disease

New Zealand has no record of any outbreak of mosquito-borne diseases, such as arboviruses, malaria or filariasis. Internationally, the re-emergence of such diseases is of public health significance. It is possible that New Zealand could experience an outbreak of one of these disabling or life threatening diseases. Arboviruses pose the greatest threat to New Zealand.

The human population in New Zealand is non-immune and susceptible. Susceptibility is exacerbated by the fact that the population knows little about mosquito-borne disease and how to minimise the risks of infection.

Potentially the most significant mosquito-borne diseases to New Zealand are the arboviral diseases Ross River Fever (Epidemic Polyarthritis), Dengue Fever, Barmah Forest virus (Kay 1997) and Japanese Encephalitis. The significance of these diseases was recognised by submitters to the discussion document. Affecting more people than ever, these viral diseases are widely distributed overseas. Yellow fever, malaria and filariasis warrant consideration, but are thought to present a much lower level of risk to New Zealand.

New Zealand presently has four known arboviruses: Whataroa (Maguire et al 1967) isolated from the indigenous mosquitoes *Culiseta tonnoriri* and *Culex pervigilans*; Johnston Atoll (Austin 1978) from *Ornithodoros caensis* ticks off seabirds; Saumarez Reff virus from *Ixodes eudyptidis* ticks off seabirds; and an unidentified Hughes group virus from *Ornithodoros capensis* from seabirds (Austin 1984).

Each year a number of Dengue Fever and Ross River viraemic travellers enter New Zealand. Antibody to Ross River virus has been detected from people with a travel history. Recently, at least one to two cases of imported Dengue Fever have been reported each year. During 1995, 12 cases of Dengue Fever were treated in New Zealand. However, locally acquired antibody has not yet been demonstrated for either of these viruses.

Ross River Fever occurs in Australia as well as many South Pacific islands. In 1979 a major outbreak of Ross River Fever occurred in Fiji and spread to other Pacific Islands, including Tonga and the Cook Islands, with 15,000 cases in American Samoa in 1979–80 (Benenson 1995). In the first four months of 1996, 5081 cases of Ross

River Fever were notified to Australian health authorities (Commonwealth Department of Health and Family Services 1996).

Dengue Fever and Dengue Haemorrhagic Fever are prevalent in the tropics of Africa and the Americas. Occurring in epidemics, these diseases have become increasingly important internationally. A recent epidemic in Queensland, Australia, affected over 2000 people and lasted more than a year.

Barmah Forest virus is found in both *Aedes* and *Culicine* mosquitoes and around 200 cases of illness are reported each year in Australia.

Japanese Encephalitis is common in the Far East, especially Japan. It is known to cause frequent epidemics.

Yellow Fever occurs in the tropics. For nearly half a century Yellow Fever has been considered a rural disease, but today many cities around the world are at risk because they have become infested with the mosquito responsible for transmitting the disease.

Malaria is not an arboviral disease. It is caused by any one of four parasitic protozoans that may be transmitted by mosquitoes. It occurs commonly in the tropics and less frequently in the temperate zones of the world. This, coupled with the fact that the mosquito vector for the causative agent is not found in New Zealand, makes it less of a threat than arboviral disease. New Zealand has no or little risk of becoming malarious, now or in the foreseeable future (Boyd and Weinstein 1996; Kay 1997). However it is noted that exceptions to this may occur and the risk must be continuously reassessed (Boyd and Weinstein 1996).

Filariasis is not considered a potential threat due to a competent vector being present in New Zealand for over 160 years without causing concern and the availability of suitable disease control methods which are expected to decrease the incidence of filariasis worldwide (Kay 1997).

An outbreak of arboviral disease is primarily dependent on the presence of viraemic individuals in a population and vector mosquitoes. Auckland and other large population centres could experience a massive outbreak if sufficient numbers of viraemic individuals and vector mosquitoes are present.

General practitioners lacking awareness of symptoms of arboviral illness, coupled with the lack of rapid diagnostic services for these illnesses means that if an arboviral outbreak did occur in humans, it could be some time before this was recognised, enabling the infection to spread widely.

Potentially the most significant mosquito-borne diseases to New Zealand are the arboviral diseases Ross River Fever (Epidemic Polyarthritis), Dengue Fever, Barmah Forest virus and Japanese Encephalitis. The establishment and maintenance of a nationally co-ordinated approach to exclude and control exotic mosquitoes of public health significance is crucial to protect the public health.

2.2 Exotic (Introduced) Mosquitoes

There are three species of exotic mosquitoes in New Zealand that are well established and have proven arbovirus vector competence (Weinstein 1995; Weinstein et al 1997). These species are *Aedes notoscriptus*, *Culex quinquefaciatu*s and *Aedes australi*s.

Both *Aedes notoscriptus* and *Culex quinquefaciatus* are competent vectors for Ross River Virus (RRV) and Murray Valley Encephalitis Virus (MVEV). Both species are found in the warmer climates of the North Island and have been reported in Nelson.

Aedes australis is a species adapted to temperate climates and has been found as far south as Invercargill. It has the potential to transmit RRV.

It is recognised that little is known about the vector competence, host feeding patterns and general bionomics of New Zealand mosquitoes. However, with regard to RRV, eight populations of *Culex quinquefaciatus* from Tonga, Florida and Australia have been found to either be refractory or poorly susceptible to infection (Kay et al 1982). To some extent, the lack of definitive information about New Zealand mosquitoes makes risk assessment more tenuous (Kay 1997).

The possibility of other exotic species of mosquito establishing in New Zealand is also of concern. *Aedes albopictus,* the Asian tiger mosquito, has spread from South East Asia to many countries, including temperate countries. It is capable of transmitting RRV and Dengue Fever (Weinstein 1994). It could easily survive in New Zealand's range of climatic conditions.

Aedes aegypti, the Yellow Fever mosquito, is also recognised as the primary vector of Dengue (Dengue Haemorrhagic Fever) and a capable vector of RRV. It has a wide distribution in the tropics and subtropics but the likelihood of this species establishing itself in New Zealand is limited to the far north because it is not known to survive in temperatures of less than 10^{o}C (Collett et al 1972).

The potential for the introduction of *Aedes* into this country was demonstrated in 1993 when it was detected at the border. *Aedes albopictus* was found inland at a used tyre importer's yard and was eradicated (Laird et al 1994). *Aedes aegypti* has also been previously intercepted in New Zealand (Laird 1995).

The introduction and generalised spread of Japanese *Aedes japonicus*, which transmits Japanese encephalitis virus, is possible as it has been intercepted on three occasions at New Zealand ports (Laird et al 1994). Its role in natural cycling, including virus over-wintering, has yet to be studied.

*Culex annulirostri*s from Australia is recognised as a major vector of RRV, Barmah Forest and Murray Valley and Japanese Encephalitis (Weinstein et al 1995). *Culex annulirostris* has been previously intercepted in New Zealand (Laird 1995) and is abundant in many parts of the Pacific, including Fiji.

Aedes vigilax, a primary vector of RRV and Barmah Forest Virus, and *Aedes camptorhynchus*, also a vector for RRV, have the potential to colonise the Northland-Coromandel intertidal zones of New Zealand.

The establishment of *Aedes polynesiensis* into New Zealand may be limited by cool temperatures. *Aedes polynesiensis* is a recognised vector of Dengue, RRV and filariasis in the South Pacific.

Anopheline mosquitoes are the exclusive vectors for the agents of malaria. Anophelines also transmit filariasis and several viral diseases. Common in tropical and subtropical regions, anophelines are also found throughout most temperate areas.

There is merit in applying the principles of the International Health Regulations 1969 (WHO 1983) to the introduction of vectors (including biting midges of the genus *Culicoides*) or pathogens (bovine ephemeral fever, bluetongue, Rift Valley fever etc) likely to cause serious damage to the livestock industry. Rift Valley fever is also a major human pathogen. It seems incongruous to protect airports and seaports from human pathogens and from exotic agricultural pests and to neglect vectors which could devastate the livestock industry (Kay 1997).

A mosquito survey, commissioned by the Ministry of Health in 1993–94, sampled 9408 larval mosquito habitats. The survey provided no evidence of new exotic mosquito establishments (Laird 1996). No new exotic mosquitoes are known to have established in New Zealand since the early 1960s when *Aedes australis* was reported. Most recent annual 'spot check' surveys have been conducted as indicated below:

- 1996/97 Gisborne
- 1995/96 Waikato/Taranaki

However, the fact that exotic mosquitoes have evaded the New Zealand border highlights the fact that accidental introduction is possible.

There are number of species of mosquitoes that should be of concern to New Zealand. The species of greatest concern is *Aedes albopictus*, the Asian Tiger Mosquito, a competent vector for Ross River Virus and Dengue.

2.3 Future Risk

It is not possible to accurately quantify the risk of an outbreak of an arboviral disease or malaria in New Zealand. However the risk is real and is likely to increase with time. It is assumed that international travel and shipping movements are increasing in volume and may be occurring more quickly. This increases the virus and protozoan pool available for local mosquitoes to ingest (Weinstein et al 1995).

Similarly, the risk of importing new mosquito vectors, some of which may already carry arboviruses, will also increase. New Zealand mosquito habitats are under-exploited, so introduced mosquitoes might establish themselves widely and rapidly. New Zealand is subject to increasing urbanisation and population growth. This provides larger concentrations of susceptible individuals, most of whom will be unaware of the public health significance of anti-mosquito measures (Weinstein et al 1995).

Global warming would reduce mosquito development time and the incubation period required for arboviruses to become infective in these vectors. Global warming would also increase the number and ability of established mosquitoes to transmit arboviral diseases. It is also possible that an unusually warm season, coinciding with mosquito introduction, could result in an otherwise unlikely establishment of a mosquito population.

Key factors affecting the risk of introducing vectors and associated diseases are covered in Kay's (1997) report to the Ministry of Health. They are as follows:

- demography
  - population growth
  - population density

- climate
  - temperature
  - rainfall
  - climate change

- international visitors
  - country of origin
  - length of stay
  - risk

- international air services
  - arrivals
  - trade cargo

- shipping
  - number of cargo entries
  - port of loading
  - imported used tyres

- marsupials
  - with respect to Ross River Virus.

In terms of potential entry of exotic mosquitoes, Kay concluded North Island port cities, such as those in Auckland and Northland, are more important than cities without either major international airports or shipping. The area of highest risk is Auckland. Auckland has:

- the largest population
- the second highest population growth
- a suitable climate with the highest annual temperature
- international air and sea ports, resulting in:
  - 74.9 percent of passenger arrivals
  - 74.0 percent of bulk shipping cargo
  - 34.5 percent of direct overseas vessels (including yachts)
  - 50 percent of retreaded or used pneumatic imported tyres
- a large Pacific Island community in South Auckland.

Northland rates second in terms of risk. Wellington and Christchurch are categorised as medium risk. However, lower annual average temperatures (and high wind in Wellington) would reduce risk in these later two cities compared with other medium risk cities: Tauranga, Napier and Gisborne.

Apart from Christchurch, it is difficult to rate other major South Island localities, mainly because low temperatures, especially in winter, will reduce the likelihood of establishment to some extent.

Tourist venues such as Rotorua, Taupo and the Coromandel warrant some surveillance because of tourist earnings.

Kay accentuates that these rankings are not meant to imply that border inspection can be neglected at any air or sea port receiving international traffic. Rather, he uses them to provide a guide as to how finite resources should be apportioned.

The Ministry of Health considers that the likely consequences of a major outbreak of arboviral disease are so serious that all reasonable steps should be taken to prevent such an occurrence. These serious consequences would be compounded if an outbreak led to arboviral disease becoming endemic in New Zealand.

2.4 Estimate of Costs

The cost of any particular outbreak of arboviral disease is very difficult to calculate. However, the Ministry of Health has estimated costs to New Zealand in the order of $250 million in the event of the hypothetical Dengue Fever outbreak detailed below.

- Assumptions:
  - 100,000 people exposed
  - 1000 clinical cases of classical Dengue
  - 10 cases Dengue Haemorrhagic Fever
- Medical costs
  - 100 hospitalisations @ 1 week
  - 10 intensive care cases @ 1 week + further 2 weeks in hospital
- Time off work/normal duties
  - 900 cases off for 1 week
  - 100 cases off for 2 weeks
  - 9 cases off for 4 weeks
  - 1 death
- Cost to tourism and business (eg, conference bookings cancelled)
  - 5 percent of total foreign exchange earnings for one year lost

These assumptions are considered by the Ministry of Health to be conservative. They were derived in light of the consequences of actual outbreaks of arboviral disease in other countries. Outbreaks given particular consideration included Dengue in Malaysia 1996, in Charters Towers, Australia 1993, and in Puerto Rico 1977. Reference was also made to a Ross River Fever outbreak in Riverland, South Australia, 1992/93.

When looking at outbreaks in other countries it is easy to see that preventative action is more cost-effective than curative strategies.

The risk of an outbreak of an arboviral disease or malaria in New Zealand is real and is likely to increase with time.

In terms of potential entry of exotic mosquitoes, North Island port cities, such as those in Auckland and Northland, are more important than cities without either major international airports or shipping.

The likely consequences of a major outbreak of arboviral disease are so serious that all reasonable steps should be taken to prevent such an occurrence.

Enhancements are required to existing border control, surveillance and ready reaction systems to the extent they will enable an early, effective and economic response to the introduction of a new species of exotic mosquito.

3 Surveillance, Surveys and Spot Checks

3.1 Public Health Service Requirements

The *Public Health Services Handbook 1997–1998* (Ministry of Health, 1996) includes a reference that indicates that Crown public health service providers should be contracted to provide services as recommended in the *Public Health Protection and Regulatory Service Guidelines* (pages 9 to 16), including:

- *maintaining sufficient staff and resources at all times to ensure:*
  - *identification of the presence of animal and insect vectors at all ports, including airports*
  - *maintenance of an intersectoral contingency plan for international airports which addresses imported illness*
  - *prompt response to requests for pratique, inspections and anthrax clearances*
  - *inspection of all first port of call international ships not granted pratique*

- *providing a disease control service which includes investigation and surveillance of cases, provision of advice to cases and contacts, and international travel health advice*

- *conducting routine surveillance and evaluation of the performance of controlling authority management of public health aspects of the service area with reference to statute, guidelines, standards, resource consent conditions and accepted public health practice, in respect of quarantine, vector control, potable water and safe food at all shipping ports and international airport facilities.*

In 1996, with very few exceptions, Crown public health service providers were not carrying out active and routine monitoring for exotic mosquitoes. Three factors were attributed to causing this lack of activity (Kay 1997):

- absence of clear and nationally uniform directions for providers
- absence of records and audits on quality
- insufficient education and specialist training of those responsible.

To ensure active and routine monitoring for exotic mosquitoes there must be:

- **clear responsibilities and nationally uniform directions for service providers**
- **publication of national guidelines**
- **risk-based protocol designed by, and specifically for, each locality by the relevant authority**
- **records and audits on quality**
- **education and specialist training for those responsible.**

3.2 Border Control and Surveillance

Mosquitoes are most likely to enter New Zealand by way of:

- international aircraft
- deck cargo on international ships
- water storage and open containers on fishing boats, refugee vessels and yachts
- used tyres and other imported goods.

The principle of border control as laid out in the International Health Regulations 1969 (WHO 1983) is to ensure that vessels, passengers and vectors are separated, thus preventing importation or exportation of either pathogen or vector. New Zealand is signatory to this agreement and compliance with the following article.

International Health Regulations – Article 19

"1. Every port and the area within the perimeter of every airport shall be kept free from *Aedes aegypti* in its immature and adult stages and the mosquito vectors of malaria and other diseases of epidemiological significance in international traffic. For this purpose active anti-mosquito measures shall be maintained within a protective area extending for a distance of at least 400 metres around the perimeter.

2. Within a direct transit area provided at any airport situated in or adjacent to an area where the vectors referred to in paragraph 1 of this Article exist, any building used as accommodation for persons or animals shall be kept mosquito-proof.

3. For the purposes of this Article, the perimeter of an airport means a line enclosing the area containing the airport buildings and any land or water used or intended to be used for the parking of aircraft.

4. Each health administration should furnish data to the Organization once a year on the extent to which its ports and airports are kept free from vectors of epidemiological significance in international traffic."

In some ports the 400 metre zone of active anti-mosquito measures is not currently occurring. Port Chalmers in Dunedin, and many Bay of Island sea ports are identified as special cases where first port of entry yachts, residential areas and natural vegetation may all co-exist within the 400 metre zone. In these cases this discrepancy may not be suitable to change, which means it is even more vital that border control measures are successful.

Disinsection (insecticide treatment) of all international aircraft is an essential measure to help prevent new mosquitoes, or infected individuals of existing species of mosquitoes, entering New Zealand. An aircraft disinsection review was undertaken in 1987 and accepted by Cabinet in 1988. The review recommended, "aircraft disinsection must remain for New Zealand to maintain its pest free status". Residual permethrin disinsection for aircraft cabins and holds was advanced as the preferred treatment, and was extended to air-bridges and baggage unloading areas (Laird 1994). It is doubted whether this extension has been carried out (Kay 1997). A range of other approved aircraft disinsection techniques are also available.

The elimination of mosquitoes and their habitats about ports should be enforced by designated officers undertaking routine surveillance of international air and sea ports. Section 29(q) of the Health Act 1956 provides that a nuisance is deemed to be created where there is *"any condition giving rise or capable of giving rise to the breeding of flies or mosquitoes . . ."*. It follows that subsequent sections of the Act apply to the extent that port owners and occupiers are, in the first instance, responsible for abating such a nuisance.

A responsible port authority would almost certainly operate its own surveillance and management programme as a precursor to abatement action or, more sensibly, to avoid the need for such action. However, there is no explicit requirement for this type of programme and in default, public health service providers will need to carry out surveillance commensurate with the risk.

Article 19 of the *International Health Regulations 1969* makes specific requirements relating to keeping ports free of mosquito disease vectors and to *"each health administration"* furnishing data to the World Health Organization. These requirements, and possibly the more serious implications of this particular nuisance, where it occurs at a port, mean that public health service providers should take an active role in monitoring for compliance.

The inclusion in the *Public Health Services Handbook* (Ministry of Health, 1996) of this service component was intended to ensure that providers would undertake some active surveillance and sampling. This would serve at least as an audit of any more substantial surveillance programme the port authorities would be expected to have. Precisely what is needed locally will depend, inter alia, on the relative risks of the locality and the available expertise and resources allocated by respective stakeholders (including territorial authorities).

In addition to measures at the border, early detection and eradication of any new species of exotic mosquito will be necessary to avert a substantial threat to public health. Surveillance, undertaken by port authorities and designated officers, is viewed as the second line of defence and is enhanced by border control by the Ministry of Agriculture Quarantine Service. Early detection will help to enable an effective and economic control response.

However, in the vicinity of some ports there has been little active or routine mosquito surveillance work. This increases the risk of the introduction and establishment of exotic mosquitoes. Funding and contracting agencies should monitor service providers through contracts which require regular reporting on surveillance undertaken with respect to insect vectors and habitat control. Information received should be conveyed to the Ministry of Health as appropriate.

There is real potential for mosquitoes to enter New Zealand through sea ports. Shipping may present a risk due to on-board mosquito breeding or introduction via cargo. Surveillance of international vessels and inspection of deck cargo for mosquitoes is thought to be carried out in an erratic and inconsistent manner nationally. Yachts are exempt from health quarantine requirements. It is of interest to note that a yacht entered Darwin, Australia, in 1984 carrying *Aedes aegypti* (Whelan 1995).

Breeding of mosquitoes inside used vehicle tyres is treated separately to cargo. While no large-scale tyre surveys are known to have been undertaken recently, checking and fumigating used tyres appears to be effective as no further exotic mosquito larvae have been reported since the *Aedes albopictus* finding in 1993 (Laird 1995). An annex to a memorandum of agreement between the Ministries of Health and Agriculture outlines procedures for checking and fumigating used tyres.

Kay (1997) believes the problem of importation of exotic mosquitoes lies with the ships rather than the cargo, if:

- evidence can be found that methyl bromide actually is effective at killing egg and aquatic stages of mosquitoes
- fumigations are effectively carried out
- other cargo items within containers are not oviposition sites for *Aedes* mosquitoes.

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Mosquito traps, such as water filled tyres, should be set and checked at the border so exotic mosquitoes may be detected and eradicated before becoming established.

The Memorandum of Agreement between the Ministries of Health and Agriculture should be reviewed with a view to extending the agreement to include matters relating to:

- **mosquito species other than *Aedes albopictus***
- **inspection of first port of call yachts**
- **aircraft disinsection procedures, possibly including airbridges and baggage handling facilities**
- **health audit of fumigation and other mosquito-related border activities**
- **training, reporting and maintenance of specialist services.**

Crown public health service providers should submit six-monthly surveillance reports. The funding and contracting agency should audit and collate these reports. After analysis of the reports the appropriate body should produce an annual report.

3.3 Surveys and Spot Checks to Date

Surveys and spot checks undertaken nationally can provide useful information, such as the identification of any new species of mosquito, and monitoring the geographic spread and preferred habitats of established mosquitoes. This is important as several established species have the potential to be vectors of arboviral diseases (Maguire 1994).

Surveys were conducted by the Ministry (previously Department) of Health in 1978/79, 1988/89, 1993/94, 1995/96 and 1996/97. The first two were broad in that all types of larval habitats were sampled. The latter three were more focused, concentrating primarily on used tyres, because water lying in tyres is attractive to *Aedes albopictus* and the particular risk posed by that species.

Started in 1995/96, the Ministry's 10-year plan for mosquito surveillance consists of two surveys and eight spot checks. This plan is now seen as an ineffective means of excluding and detecting new species of exotic mosquitoes. With this plan, if a new species is found, the mosquito may have been established for several years before detection.

The apparent inconsistency of surveillance by the public health service nationally, and the limited geographic coverage of spot checks, endorses the need for review and change.

3.4 Future Surveillance

Surveillance methodology should be standardised throughout New Zealand, with the level of surveillance graded according to the risk of introduction. A minimal programme for sea ports with low numbers of vessels, eg, Timaru, Bluff, Dunedin, could be as follows:

- inspection of all first port of call vessels
- fumigation of all containers with tyres
- dockside surveillance using 10 tyres as monitoring devices throughout all months with an average temperature above 10°C.

For a programme at the opposite end of the spectrum, activities would be year-round, involving surveillance at the sea and air ports, and other areas of perceived high receptivity. Thus, the greatest resources are committed to areas of greatest risk.

Surveillance activities should be intensified through the summer and scaled down in winter (Kay 1997). They should be continuous and not intermittent like the current 10-year plan.

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Surveillance activities should be intensified through the summer and scaled down in winter (Kay 1997). They should be continuous and not intermittent like the current 10-year plan.

3.5 Biosecurity Costs Associated with Exotic Mosquitoes

In line with surveillance and border control, it is recommended that funding is allocated on an at-risk basis with a 60:20:20 split:

- 60 percent Auckland and Northland
- 20 percent all other North Island ports and Christchurch
- 20 percent elsewhere.

Kay (1997) believes the current allowance of NZ$140,000 over 10 years for taxonomic and other specialist services to support mosquito surveillance and training is gross under-budgeting. He proposes that New Zealand spends $1-2 million per annum to effectively exclude and control mosquitoes. This would potentially fund enhancement of existing border control, surveillance and ready reaction systems to the extent they will enable an early, effective and economic response to the introduction of a new species of exotic mosquito, rather than facing the potential cost of tens to hundreds of millions of dollars if an outbreak did occur.

It is anticipated this expenditure will also enable more training opportunities and provisioning for designated officers and others with biosecurity responsibilities. It would also support provisioning for routine control and emergency response, and education for general practitioners and the public. It may also stimulate and assist research, and assist the setting up and running of a National Mosquito Surveillance and Control Laboratory.

However, it is important to put into perspective the competing demands for finite public health resources, both human and financial, and the need to prioritise health protection activities. Fiscally neutral transfers from Vote:Health to the new Vote: Biosecurity show a total of $21,000 per annum for Ministry of Health mosquito activities. This includes biosecurity policy advice, air facilitation commitments and mosquito identification contracts. It is also important to consider:

- other science service contracts
- public health services relating to border control and surveillance
- border activities undertaken by other agencies (eg, fumigation of tyres and aircraft disinsection)
- training of designated officers, general practitioners and public information
- spending by port authorities and other non-governmental agencies.

It is recommended that funding is allocated on an at-risk basis, with a 60:20:20 split:

- **60 percent Auckland and Northland**
- **20 percent all other North Island ports and Christchurch**
- **20 percent elsewhere.**

3.6 Training and Public Information

Limited training is provided by the Ministry of Health to designated officers as a prerequisite to participation in the 10-year plan survey and spot check work. All submitters felt current training was inadequate. They believed more comprehensive training should cover the risks associated with exotic mosquitoes, identification and habitats. Submitters suggested that training should target designated officers, territorial local authorities, sea and air port authority personnel, general practitioners, yachties and the public. A compulsory section in the Bachelor of Applied Science (Environmental Health) course offered by the Wellington Polytechnic was advocated by some.

Kay (1997) recommends the following training topics for designated officers:

- International Health Regulations 1969
- basic identification and biology of *Aedes (albopictus, aegypti, notoscriptus)* and *Culex (pervigilans, quinquefaciatus, annulirostris)* and *Anopheles*
- health risks to New Zealand
- practical mosquito control
- design of risk-based surveillance programmes – including costing and auditing procedures.

To discern training opportunities and available expertise, it would be beneficial to canvass individuals and institutions, in New Zealand and overseas. Linkages with mosquito control agencies in Australia and possibly the United States were strongly supported.

New Zealand specialists in arboviruses and their vectors are scarce. It is vital that a core cadre of such specialists are maintained as a national resource, or appropriate alternatives are sought.

New Zealand personnel could benefit considerably by visiting Australian specialists and attending the training courses and conferences run by the Mosquito Control Association of Australia. Another option is the USA with its well-structured Mosquito Abatement District system and American Mosquito Control Association. There seems to be greater advantage in developing working linkages with Australian personnel with possible practical enactment of emergency responses, timeliness, lower cost and greater similarity of the potential or actual vectors involved. First-hand experience is priceless (Kay 1997).

By raising general practitioners' (GPs) awareness of arboviral disease, malaria and filariasis, GPs are more likely to recognise symptoms associated with these diseases. It is considered possible that arbovirus infections may go undiagnosed and be listed as pyrexia of unknown origin (PUOs), flu, etc, in the absence of specific knowledge and complementary serological testing. Notification of arboviral disease and malaria is compulsory in New Zealand. Education of GPs, coupled with notification, may provide better information on the origin and potential spread of mosquito-borne illness in New Zealand.

It is important to raise public awareness generally to dispel the misconception that mosquitoes present no risk to New Zealand. The public should be made aware of the potential risk of mosquito-borne diseases, their cost and health implications and new environmentally-friendly methods of control (Kay 1997). The development of health education resources to articulate national policy would be helpful. The Ministry of Health publication *Health Advice for Travellers* contains information on disease risks associated with mosquitoes and preventative measures.

> *"The single most important determinant of the scale of an outbreak is community awareness of, and involvement in, mosquito control including everything from personal measures (avoiding exposure, use of repellents, house screening) to source reduction (minimising urban water holding containers, insecticiding natural water bodies in and near population centres). The New Zealand population is largely ignorant of these measure and their potential public health significance, further compounding the risk of a major arboviral disease outbreak at some time."* (Weinstein et al, 1995)

The public view of mosquitoes must be changed from 'just a nuisance' to 'potential health risk'.

Training for border control and surveillance is essential. National courses for designated officers and port authority personnel are appropriate.

Education of general practitioners (GPs) and the public is desirable:

- **in the short term – information releases to increase general awareness**
- **in the longer term – development of appropriate health education resources**

4.0 Legislative Options for Mosquito Control

4.1 Strategy Options

No formal national strategy exists to eradicate a colony of exotic mosquitoes. In considering the development of a strategy, several options are available. Options include:

- ad hoc interventions based on ***contingency plans*** (Part II – Nuisances, or Part III – Infectious and Notifiable Diseases, Health Act 1956)
- ***national pest management strategy*** (section 55, Biosecurity Act 1993)
- ***regional pest management strategy*** (section 84, Biosecurity Act 1993)
- ***small-scale management programme*** (section 144, Biosecurity Act 1993)
- ***biosecurity emergency*** (section 144, Biosecurity Act 1993)
- ***provisional control programme*** (section 152, Biosecurity Act 1993).

4.2 Legislation

Effective mosquito vector control requires legislative backing to:

- mandate the responsible agency
- specify the functions and powers of the agency
- enable enforced compliance
- identify appropriate funding arrangements for operations and compensation.

Legislation identified as enabling in terms of mosquito control includes:

- Health Act 1956, administered by the Ministry of Health
- Biosecurity Act 1993, administered by the Ministry of Agriculture.

Health Act 1956

The Health Act 1956 is the principal legislation for securing public health in New Zealand. Provisions of the Act which provide potential for mosquito control include the nuisance provisions in Part II and the infectious and notifiable disease provisions in Part III.

Nuisances

Without limiting the meaning of the term nuisance, section 29 of the Act defines conditions that are considered offensive or likely to be injurious to health. Paragraph (q) of section 29 (*reproduced below*) is especially relevant:

> *Where there exists on any land or premises any condition giving rise or capable of giving rise to the breeding of flies or* ***mosquitoes*** *or suitable for the breeding of other insects, or of mites and ticks, which are capable of causing or transmitting disease.*

If satisfied that a nuisance exists, a District Court Judge may order the abatement and prohibit the recurrence of the nuisance. The local authority or medical officer of health has powers to abate the nuisance if the owner or occupier defaults in carrying out the court order. Where immediate action for the abatement is considered necessary, an engineer or environmental health officer of the local authority may (with such assistance as they may require) enter the premises and abate the nuisance.

The nuisance provisions of the Health Act may be useful for ad hoc interventions where small-scale concerns are encountered. However, such provisions do not seem to assist with planning and implementing a national strategy for exotic mosquitoes of public health significance.

The emphasis is more on eliminating or controlling conditions that may support the breeding of an unwanted organism, rather than the eradication of the organism itself. Issues relating to funding, compensation and co-ordination are not covered in any detail by the Health Act. Territorial authorities may be reluctant to become involved in implementing strategies which are likely to make heavy demands on resources.

Infectious and Notifiable Diseases

Subject to certain qualifying provisions, Part III of the Health Act 1956 provides special powers to the medical officer of health (MOH) in preventing an outbreak or spread of any infectious disease. Section 128 of the Health Act 1956 authorises the medical officer of health or health protection officer, or any other person authorised in writing by any local authority, to enter any dwelling house, building, land, ship or other premises and inspect and execute any work authorised under the Health Act.

The MOH can eradicate infected animals (including insects) in such a manner as they think fit. Part II of the Act is largely dependent on territorial authorities for enforcement. A MOH has special powers under Part III of the Health Act to control an infectious disease. However, powers under Part III are focused on the control of an infectious disease and are not necessarily appropriate for the eradication of vectors of those diseases. Ministerial (delegated to the Director-General of Health) prior approval would be required to enable the use of such powers.

The usefulness of the Health Act is limited because of its emphasis on 'conditions' and the prevention and control of infectious diseases, rather than the detail of planning and implementing vector control programmes.

The nuisance provisions of the Health Act may be useful for ad hoc interventions where small scale concerns are encountered.

Issues relating to funding, compensation and co-ordination are not covered in any detail by the Health Act

Biosecurity Act 1993

The Biosecurity Act 1993 provides for the exclusion, eradication and management of unwanted organisms. Provisions of the Act may be used by a range of agencies. The Act allows for the discretionary control of exotic pests and enables a range of actions from one-off responses through to long-term, sustained control programmes.

Part VI of the Act prescribes a range of options and specifies related powers that may be exercised to control and eradicate pests and exotic diseases, and to undertake associated surveillance. Powers must be exercised as part of a recognised programme once sustained control action is required (Ministry of Agriculture 1995).

Specifically the Biosecurity Act provides the following five options for mosquito control. These are:

- national pest management strategy (NPMS)
- regional pest management strategy (RPMS)
- small-scale management programme (SSMP)
- biosecurity emergency declaration
- provisional control programme.

The Biosecurity Act 1993 was enacted, inter alia, to provide for the exclusion, eradication and management of unwanted organisms. Accordingly, the Government might expect agencies to adopt strategies under the Act when biosecurity issues arise. For instance, an NPMS or RPMS empowers a Government department, regional council or other interested agencies to prepare a management programme for eradicating an unwanted organism. The intention of the strategy is to provide a planned approach to dealing with the organism. The strategy identifies the powers and matters associated with funding and compensation in respect to implementing the plan.

An SSMP seems most appropriate where there is a sudden concern or unexpected occurrence of an unwanted organism and the agency concerned needs to deal with it rapidly. There would be no national or regional strategy in place.

A biosecurity emergency declaration is made in an extreme case that requires immediate action where sufficient powers are otherwise not available for the effective management of the organism.

A Minister may declare a provisional control action to contain a suspect organism until the identity or existence of the organism has been confirmed. Such confirmation means that the options of provisional control action are no longer available.

On balance, it seems that a Biosecurity Act NPMS is the most appropriate option for the exclusion, eradication and management of exotic mosquitoes of public health significance.

The Biosecurity Act concentrates on prevention and exclusion of unwanted organisms. Strategies relating to SSMP and biosecurity emergency declarations could be seen as a fallback position and should not be considered as a substitute to developing a long-term pest management strategy.

Biosecurity is a developing field, with further amendments being proposed to the Biosecurity Act, the appointment of a Minister for Biosecurity, creation of Votes: Biosecurity and the formation of a Biosecurity Council. *Pest Incursion Management – A Review of the White Spotted Tussock Moth Eradication Programme, with Recommendations for Future Biosecurity Practice* (Sinclair et al 1997) includes a number of matters directly relevant to the issue of exotic mosquitoes. For example, the need for:

- carefully developed pest management strategies and contingency plans
- effective community consultation
- adequate science and expert input
- good information flows and interactions between departments with clear accountabilities and lines of interaction established in advance
- a generic decision-making framework for dealing with pest incursions
- operational assumptions to be well informed
- improved processes for quality assurance and risk management.

On balance, it seems that a Biosecurity Act NPMS is the most appropriate option for the exclusion, eradication and management of exotic mosquitoes of public health significance. In developing the NPMS careful consideration must be given to the need for:

- **carefully developed pest management strategies and contingency plans**
- **effective community consultation**
- **adequate science and expert input**
- **good information flows and interactions between departments with clear accountabilities and lines of interaction established in advance**
- **a generic decision-making framework for dealing with pest incursions**
- **operational assumptions to be well informed**
- **improved processes for quality assurance and risk management.**

5 National Pest Management Strategy

5.1 The Value of a National Strategy

Submissions overwhelmingly supported preparation of a National Pest Management Strategy (NPMS) for exotic mosquitoes of public health significance. An NPMS seems appropriate when sustained control action is needed over a longer period of time and when costs may exceed what is permitted under a small-scale management programme.

Extensive consultation is required when developing an NPMS. Powers that may be used to eradicate or bring the pest under control need to be identified. Such powers arise from Part VI of the Act and become part of the strategy. Funding arrangements must be detailed in the NPMS. The strategy must address whether compensation will be paid and the principles on which it will be paid. Compensation may not be as substantial an issue for mosquito eradication compared to the destruction of crops or livestock that may be necessary in the case of other biosecurity actions.

The process of developing an NPMS is useful in itself as a response to a perceived biosecurity threat. Necessary consultation and information-seeking raises awareness and the overall level of specialist knowledge. Consequently, the level of preparedness and the chance of early detection may be raised. The strategy and the associated operational plan provide the basis for an appropriate and effective response. Another key advantage is advance knowledge and probably support for action on the part of all interested individuals and groups.

An NPMS affords a number of advantages over other options, including:

- more explicit powers for managing unwanted organisms than under the Health Act 1956
- benefits of intervention are considered in advance of the event
- planning and consultation help to ensure acceptance of the strategy
- endorsement of the strategy by the Government and status as regulations through Order in Council
- opportunity to formalise arrangements for intersectoral collaboration
- matters relating to costs and compensation (if applicable) are resolved before the event
- a clear mandate to act when border incursion occurs

- a comprehensive and current operational plan for immediate implementation
- the possible stimulation of research on prevention and control technology
- a nationally-consistent approach is assured
- successful implementation represents savings to future generations.

An NPMS does have some disadvantages. In particular, considerable planning and consultation is required to prepare the NPMS and the associated operational plan. Also an NPMS may lead to a focus on control of vectors and outbreaks at the expense of improvements in prevention programmes.

5.2 Responsibility for the Proposal of an NPMS

In preparing for an NPMS there is a need for intersectional collaboration with one agency taking the lead role. Because the principal effect of introduced exotic mosquitoes will be on public health, it would be most appropriate for the Minister of Health to propose the NPMS. The development of the strategy would be the responsibility of the Public Health Group within the Ministry of Health.

5.3 Financial Implications

Sections 60 and 61 of the Biosecurity Act require information on costs arising from:

- implementation of the NPMS
- compensation payments (eg, destruction of valued insects or contamination of organic farms and drinking water with pesticides).

In comparison to the exclusion and eradication of some agricultural pests, the compensation costs associated with eradicating exotic mosquitoes are likely to be minor. This is because there is no anticipated need to destroy cash crops, livestock or other private property as part of a mosquito control programme.

An NPMS for mosquitoes would most likely be implemented as a ‘public good’. Levying industry, communities or local authorities does not seem to be appropriate. It would be difficult to isolate industries that may have contributed to the introduction of the mosquito. It would be equally difficult to identify discrete groups that are likely to gain from any eradication programme.

Considerable information has been accumulated by the Ministries of Forestry and Agriculture on costs for the exclusion, control and eradication of pests. MAF maintain a fruit fly surveillance system of 7000 bat traps and staff to service them to guard against a potential loss of NZ$1800 million per annum.

The Ministry of Forestry's operational costs for Operation Evergreen, a spraying programme to eradicate the tussock moth from the eastern suburbs of Auckland in 1996, was initially estimated at $5.7 million. The Ministry of Health understands that now $8.2 million will have been spent on Operation Evergreen. Should this emergency response under the Biosecurity Act prove to be unsuccessful in the short term, this expenditure will escalate considerably.

Kay (1997) thus recommends that development and reasonable expenditure on border inspection and surveillance for exotic mosquito (and arboviruses) should be viewed as an essential insurance policy.

The economic and health impacts of Ross River Virus in Queensland are difficult to estimate but are at least AU$6 million in diagnostic tests annually. During 1983–84, a Ross River epidemic in New South Wales was costed at AU$10 million (Hawkes et al 1986).

5.4 Notification of Proposal

Section 62 of the Biosecurity Act 1993 requires the Minister to publicly notify the NPMS by publishing in the *Gazette* a summary of the purpose and extent of the proposed NPMS and places where a complete description of the proposed strategy may be obtained or inspected.

Section 63 of the Biosecurity Act 1993 provides that unless satisfied on reasonable grounds that there is no significant opposition to the strategy from persons likely to be affected by its implementation, the Minister shall appoint a board of inquiry to inquire into and report on the proposed NPMS. To avoid the need to appoint such a board, a process of extensive consultation should occur before proposing the NPMS.

5.5 Operational Plan

Section 85 of the Biosecurity Act 1993 provides that the management agency for every NPMS is required to prepare an operational plan within three months of the strategy approval. The operational plan is required to be reviewed annually and a report on the review submitted to the Minister within five months after the end of the financial year.

5.6 The NPMS Work Programme

The normal period of time for the development of an NPMS is about two years. Because considerable information is available on mosquito control, the planning cycle, including matters relating to compensation and levies, is not expected to be an especially complicated process. Most of this time is involved in the preparation of documentation and consultation.

The Ministry of Health considers that it should be possible to have a draft NPMS prepared and issued for consultation by November 1998. The NPMS would be co-ordinated by the Ministry of Health in partnership with the Ministry of Agriculture and Crown health funders, contractors and service providers.

The main responsibilities of the Ministry of Health would be to:

- provide policy advice on national policy aspects of NPMS to the Ministers of Health and Biosecurity
- act as the Ministers' agent in the negotiation of the funding agreements with the funders and contractors
- specify the service obligations in relation to the NPMS
- monitor and analyse the state of public health regarding the incidence of introduction of exotic mosquitoes and associated disease in New Zealand and associated risk factors
- monitor and evaluate the NPMS
- develop health education resources which articulate national policy
- manage the NPMS
- liaise and provide advice to local areas.

6 Interim Arrangements

6.1 Continuous Improvement

Until an NPMS is in place, biosecurity and other legislative powers do provide a means of responding to a border incursion. Public health service contracts are thought to maintain a basic capacity to eradicate a small-scale mosquito colony and this is likely to be enhanced as a result of increasing awareness. An NPMS will provide a more comprehensive approach to exclusion, surveillance and control of mosquitoes. Until an NPMS is adopted, the following control procedure prescriptions serve as useful references:

- World Health Organization. 1994. *Chemical Methods for the Control of Arthropod Vectors and Pest of Public Health Importance*. Geneva: World Health Organization.

- World Health Organization. 1995a. *Guidelines for Dengue Surveillance and Mosquito Control*. Manila: World Health Organization.

- World Health Organization. 1995b. *Report of the Informal Consultation on Aircraft Disinsection*. Geneva: World Health Organization.

- World Health Organization. 1996. *Operational Manual on the Application of Insecticides for Control of the Mosquito Vectors of Malaria and other Diseases.* Division of Tropical Diseases. Manila: World Health Organization.

Improvements to border control and surveillance have been discussed in Section 3. Ongoing efforts to raise the awareness of port authorities and their personnel should result in the removal of mosquito habitats such as improperly stored tyres or metal parts. Ports will also be encouraged to establish their own surveillance and control systems for mosquitoes. For example, *Aedes albopictus* surveillance would require appropriately marked, water-filled tyres to be inspected on an at-risk basis.

Contingency planning must be thorough, with well-defined roles for affected parties. A working group is proposed to develop appropriate national guidelines and protocols. This working party would include representatives from biosecurity agencies, ports, local authorities, pest control, science services, and tourism. Development of protocols for routine reporting and audits is essential to assist with information compilation, audit analysis and WHO reporting.

The risk-based approach to exclude, control and eradicate mosquitoes would be followed. With national guidance, local contingency plans would be formulated by the relevant agencies to take into account local circumstances. Funding would reflect risk, but would be flexible. For example, sharing resources for mosquito surveillance and control in Auckland and Northland may be ideal, given that the regional councils and the North Health Division of the Transitional Health Authority have almost contiguous boundaries and are at most risk from exotic mosquitoes.

Until an NPMS is in place, biosecurity and other legislative powers do provide a means of responding to a border incursion. Public health service contracts are thought to maintain a basic capacity to eradicate a small-scale mosquito colony and this is likely to be enhanced as a result of increasing awareness.

To avoid duplication of resources and activities, intersectoral collaboration is important. Formation of a working party with all relevant agencies and expertise is vital to formulate appropriate protocols for border control, surveillance, emergency response, and contingency planning.

6.2 Mosquito Control Tools

Before a pesticide is imported or sold in New Zealand it must first be registered by the Pesticides Board. There are a limited number of mosquito pesticides registered with the Pesticides Board in New Zealand as there is little demand for these products. The discussion document covered pesticide options available for the eradication of mosquitoes. Only 10 of these pesticides are currently registered in New Zealand.

The Pesticides Board is reluctant to ‘fast-track’ applications for registering pesticides except in extreme cases. The speed at which an application can be processed is dependent on supporting information and field trial results. This is applicable when the pesticide is not for general sale or obtained for experimental use permit. In an emergency situation, other legislation (for example, the Biosecurity Act) may supersede the Pesticides Act 1979. The issue of pesticide registration remains to be resolved. The aim is to progress this issue as part of the development of an NPMS.

Submitters asked that attention be given to establishing mosquito control options, especially those proven effective in other countries, with minimal side effects or negative consequences. Submitters favoured *Bacillus thuringiensis israelensis* (Bti). Dr Kay (1997) also suggested Bti, along with s-methoprene for use in New Zealand as they are used in broad-scale mosquito programmes in Australia where considerable effort has gone into evaluating their environmental safety.

Attention must be given to establishing mosquito control options, especially those proven effective in other countries with minimal side effects or negative consequences.

6.3 *Bacillus thuringiensis israelensis (Bti)*

The choice of pesticide to be used in any control or eradication exercise will depend, inter alia, on the target mosquito species. As a biological control agent, *Bacillus thuringiensis israelensis (Bti)* is a highly selective insecticide for use against mosquito, blackfly and fungus gnat larvae. According to WHO, *Bti* has reached the stage of operational control of mosquito immatures (WHO 1995a). *Bti* can be safely used to eradicate mosquito breeding in irrigation ditches, roadside drains, flood water, standing pools, woodland pools, snow melt pools, pastures, storm water retention areas, tidal water, salt marches and polluted water (such as oxidation ponds and animal waste lagoons) (WHO 1995b).

Bti has exceedingly low mammalian toxicity (LD50 values for both acute oral and dermal toxicity are more than 30 000 mg/kg) and is considered one of the safest insecticides in use today (WHO 1995a). No reports of adverse effects to the environment have been documented during several years of commercial use.

Bti is manufactured under the trade name ‘Vectobac’ by Abbott Laboratories.

Bti is not registered for use in New Zealand. However, adequate information is available to the Pesticides Board on *Bacillus thuringiensis* to the extent that *Bti* could be registered with minimal delay. Nufarm Ltd has a licence to undertake *Bti* field trials in New Zealand, but the company are apparently reluctant to proceed because of the cost of trials and of registering the product.

7.0 Establishing a Knowledge Base and Research

There is an identified need for a higher level of expertise in New Zealand with respect to mosquitoes and mosquito-borne disease. The establishment of a Mosquito Surveillance and Control Laboratory was suggested by Kay (1997) with a view to centralising current expertise. Kay envisaged the laboratory offering advice, providing audit and training services, identifying mosquitoes beyond designated officers capabilities, and being the centre for notification and identification of mosquito-borne illness, this to be in addition to being the main centre for research into mosquitoes and mosquito-borne disease. There is a need to identify if any existing laboratories could take up this function or if a new laboratory would need to be established.

There has been little research undertaken in New Zealand on mosquitoes and mosquito-borne disease. Some issues which appear to warrant investigation are:

- the competence of New Zealand mosquito species to transmit and become a reservoir for arbovirus and other mosquito-borne illness, particularly *Culex pervigilans, Culex quinquefaciatus* and *Aedes notoscriptus*
- the competence of possum to be a disease reservoir for arbovirus and other mosquito-borne illness
- serosurvey of the population, both travellers and non-travellers, to provide mosquito-borne disease prevalence and origin information
- extension of former New Zealand studies designed to identify arboviruses.

There is an identified need for a higher level of expertise in New Zealand with respect to mosquitoes and mosquito-borne disease. Also there are a number of issues that warrant research.

Appendix – Summary Information on Certain Mosquito-borne Diseases

Barmah Forest Virus

Infection characterised by fever, arthritis and rash, very similar to Ross River Virus (see below).

Dengue Fever

- Dengue Fever is caused by one of four arboviruses of the Flaviviridae family of viruses. The viruses are transmitted by the bite of vector mosquitoes.

- Dengue Fever or break bone fever is an acute febrile illness characterised by severe headaches, fever , severe joint and muscular pains.

Dengue Haemorrhagic Fever and Dengue Shock Syndrome

- Dengue Haemorrhagic Fever is an arboviral disease caused by the same viruses that cause Dengue Fever. Beginning with a fever, the disease is characterised by abnormal blood clotting that leads to haemorrhagic phenomena such as bleeding of the nose and gums. In some instances, liver enlargement occurs.

- Dengue Haemorrhagic Fever may be followed by Dengue Shock Syndrome where the extremities become cold and the pulse is rapid but weak.

Filariasis

- An infection caused by nematode parasites of the Filariodea family. Filariasis in humans is caused by the nematode *Wuchereria bancrofti* and the infection is spread by mosquitoes. Symptoms include enlargement of the lymph nodes and recurrent lymphangitis.

Japanese Encephalitis

- This arthropod-borne viral disease is caused by the Japanese Encephalitis Virus of the family Flaviviridae. The disease is characterised by inflammation of the brain, spinal cord, and meninges. Headaches, fever, convulsions, and comas are some of the more severe symptoms associated with severe infection.

Malaria

- Also known as Marsh fever or periodic fever. An infectious disease caused by one of four parasitic protozoans: *Plasmodium vivax*, *Plasmodium malariae*, *Plasmodium falciparum* or *Plasmodium ovale*.

- Typical symptoms are species dependent and include fever, chills, sweats and headaches. Prolonged untreated malaria can lead to renal and liver fever, acute encephalitis and coma.

Murray Valley Encephalitis

- Murray Valley Encephalitis is caused by arboviruses of the family Flaviviridae. Infections are usually asymptomatic but can cause acute inflammatory diseases of short duration involving parts of the brain, spinal cord and the meninges.

Ross River Fever

- Also known as epidemic polyarthritis is caused by the Ross River Virus, an arbovirus that is transmitted by a variety of mosquitoes. Symptoms range from a mild flu-like illness to arthritis affecting all the joints (polyarthritis). The onset of arthritis is often followed by a rash and sometimes fever may be present.

Yellow Fever

- This disease is an acute infectious disease caused by the Yellow Fever virus of the family Flaviviridae. Typical symptoms include fever, chills, and muscular pain. Jaundice and a slow weakening pulse may also be present. In more severe cases, haemorrhaging, renal, and liver failure may occur.

Glossary

Anopheline

- Mosquitoes of the genus *Anopheles*. A widely-distributed group which includes species that transmit malarial parasites to humans through the biting of the female Anopheles mosquitoes. Other members of this genus transmit bancroftian filariasis.

Aedes

- Mosquitoes of the genus *Aedes*. A widely-distributed group including species that are vectors for the causative agents of Dengue, yellow fever, filariasis and encephalitis.

Arbovirus

- Arthropod-borne RNA viruses. Certain insects including mosquitoes, lice, ticks and other arthropods (segmented body and jointed limbs) have the potential to carry and transmit viruses thus transmitting the diseases these viruses cause to humans. Arboviral diseases include, Dengue, encephalitis and Ross River Fever.

Arthropod-borne

- Capable of being transmitted by insect vectors.

Febrile

- Characterised by or relating to fever.

Vector

- A carrier such as an arthropod that transfers an infective agent from one host to another.

Viraemic

- Presence of virus in the blood. Potential for disease to be transmitted by certain biting or sucking insects, such as mosquitoes.

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