

# Is New Zealand prepared to deal with arboviral diseases?

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To date, there has not been a confirmed, indigenously acquired arboviral infection in a human within New Zealand. The rapid modern movement of people, the consequent routine arrival of infected humans, and exotic arthropods already present in this country are likely to terminate this blissful state. The absence of indigenously acquired cases appears to be entirely fortuitous,<sup>1</sup> as New Zealand seems to have no particular characteristics that make it intrinsically refractory to the local transmission of arboviruses.<sup>2</sup>

Ross River virus (RRV; family *Togaviridae*, genus *Alphavirus*) is the most common mosquito-borne pathogen affecting humans in Australia, annually causing at least 5,000 illnesses.<sup>3</sup> An outbreak of infections with RRV seems likely to occur, at some time, sooner rather than later in New Zealand,<sup>4,5</sup> the likelihood having greatly increased since the discovery of the southern salt marsh mosquito *Ochlerotatus (Ochlerotatus) camptorhynchus* (Thomson) in the country.<sup>6</sup>

Other arboviruses also pose potential threats to public health in New Zealand, particularly the dengue viruses (family *Flaviviridae*, genus *Flavivirus*)<sup>7</sup>. A climate suitable for *Aedes (Stegomyia) aegypti* Linnaeus, the main vector of the four viruses causing dengue, exists in the northern tip of the country.<sup>8</sup> Establishment of the virus

cycle (human to human via infected mosquitoes) could become a reality if *Ae. aegypti* or another major vector such as *Ae. (Stegomyia) albopictus* Skuse (Asian tiger mosquito) become established here. On several occasions, including post-border detections, *Ae. albopictus* has been intercepted in used tyres.<sup>9</sup> *Aedes aegypti* has also been recently intercepted.<sup>10,11</sup>

In these comments, we question the readiness of the New Zealand health system to deal with cases of arboviral diseases, from detection to response to recognition of infection with an autochthonous virus or an exotic one.

## **Ross River virus and other viruses, and their threat to New Zealand**

Symptoms of RRV infection are not pathognomonic, its main characteristics being fever, rash and polyarthritis.<sup>12</sup> This can be a debilitating illness whose symptoms may persist for months or years.<sup>3</sup> There are a few mosquito species implicated in the transmission of RRV in Australia and, in coastal regions, one of the main vectors of the virus is the southern salt marsh mosquito *Oc. camptorhynchus*.<sup>3</sup>

*Ochlerotatus camptorhynchus* was first discovered in New Zealand, near Napier, in 1998.<sup>13</sup> It has since spread north from there to other areas, such as Kaipara Harbour.<sup>14</sup>

## **Abstract**

To now, New Zealand has been spared arboviral diseases, except for the odd imported infection. However, two exotic vector mosquitoes (*Ochlerotatus camptorhynchus* and *Ochlerotatus notoscriptus*) have become established in New Zealand and the routine arrival of infected people from overseas may soon lead to local arboviral transmission. Large populations of wild wallabies and Brushtail possums could serve as reservoirs of Ross River virus and other arboviruses. Several other exotic mosquito species, including important disease vectors such as *Aedes albopictus* and *Aedes aegypti*, have already been intercepted in New Zealand. It is clear that increased border surveillance is necessary if we are to interdict the establishment of such species. We recommend several measures that should be adopted, including increased training and awareness of public health officials, clinicians and the general public, and taking appropriate steps to make New Zealand self-sustainable in terms of arboviral surveillance, diagnosis, and prevention.

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Larvae were also detected in south-east Auckland,<sup>15</sup> although it is not known whether the species has become established in the area. The New Zealand Government is spending \$NZ30 million over four years in an attempt to eradicate it,<sup>16</sup> but it is unlikely to be successful. In order to eradicate such a pest, an extensive program would have to be carried out throughout the whole region. At present, vector control programs target the areas where the mosquitoes have already been found. No fully comprehensive survey has been carried out to establish the distribution of the species on the North Island. Even if the latter were adequately determined, eradication of all larvae would be extremely difficult because of the vast areas of suitable and often remote habitat.

The presence of *Oc. camptorhynchus* in the Auckland region is reason for significant concern, especially as members of this species have been described as vicious biters that will readily feed on humans.<sup>17</sup> Auckland is New Zealand's largest city, with about 1.25 million people, nearly one-third of the country's population. It is also New Zealand's main entryway for Australian and other tourists and, most importantly, for New Zealanders returning from overseas. Almost 60% of the notified imported cases of dengue in 2001, for instance, occurred in Auckland.<sup>18</sup> Kelly-Hope et al. estimated that each year more than 100 people entered New Zealand from Queensland, Australia, with clinical or subclinical infections of RRV.<sup>19</sup>

The risk of local transmission is greatly increased by the presence of another Australian mosquito well established in New Zealand: *Ochlerotatus (Finlaya) notoscriptus* Skuse. Laboratory transmission studies in New Zealand have indicated that *Oc. notoscriptus* appears to be a poor vector of RRV.<sup>7</sup> Nevertheless, in Australia, the species has been more recently identified as a potential vector of RRV<sup>20,21</sup> and it is most likely a vector of this virus in urban areas.<sup>22-24</sup> *Ochlerotatus notoscriptus* is abundant throughout Auckland, particularly in artificial containers in urban areas, but it is also widespread in rural areas and within natural containers.<sup>25</sup>

It seems, therefore, that it is simply a matter of time before an infected human is fed upon by a vector mosquito inside New Zealand and a transmission cycle is subsequently established. This likelihood is increased by New Zealand's large urban and peri-urban populations of Brushtail possums (*Trichosurus vulpecula*), which are competent intermediate hosts of RRV.<sup>19,26</sup> The population of possums now occupies more than 95% of New Zealand's land area and it is estimated to be as large as 70 million.<sup>27</sup> The presence of wallabies (*Macropus* spp.) in the North Island is also an epidemiologic concern. They could serve as major amplifying hosts of local transmission of RRV, since macropods are the primary vertebrate hosts of RRV in Australia.<sup>3</sup> Dama wallabies (*Macropus eugenii*) have steadily increased their distribution in the central North Island and Bay of Plenty since the 1940s and are now spread over at least 170,000 hectares.<sup>28</sup> According to the Department of Conservation, this population is expanding and may now occupy an area as large as 500,000 ha.<sup>28</sup> That population is close to the sites where *Oc. camptorhynchus* have been found. Consequently, both possums and wallabies, which are clas-

sified as serious threats to New Zealand's conservation estate, may also become a public health hazard. Moreover, the presence of wallabies in zoos located within the urban areas of Wellington and Auckland, allied to the high density of *Oc. notoscriptus* at such sites,<sup>29</sup> could become a focus for the spread of disease where the contact between infected person, vector, and reservoir would be maximised.

Similar to the situation regarding alphaviruses, there are no recognised flaviviruses that affect humans in New Zealand, and consequently it is unlikely that any immunity exists among the general population. As a result, there is little or no natural resistance to other Australian viruses that may enter the country, such as Murray Valley encephalitis virus (family *Flaviviridae*, genus *Flavivirus*) and Barmah Forest virus (an alphavirus closely related to RRV and which can cause an illness clinically indistinguishable from that caused by RRV infection). Again, the presence of *Oc. notoscriptus* is a complicating factor, as it is thought to be an efficient urban vector of Barmah Forest virus<sup>30</sup> and a potential vector of Murray Valley encephalitis virus.<sup>17</sup> In laboratory studies, *Oc. camptorhynchus* has also shown to be a vector of Murray Valley encephalitis virus.<sup>17</sup> Other important viruses include the four viruses causing dengue fever (i.e. dengue viruses, genus *Flavivirus*) and Rift Valley fever virus (family *Bunyaviridae*, genus *Phlebovirus*), for both of which *Oc. notoscriptus* has been shown capable of transmission within laboratory conditions.<sup>7,31</sup>

It is relevant to point out that the risk of transmission is not restricted to northern New Zealand; *Oc. notoscriptus* is widespread in Wellington.<sup>32</sup> On the southern South Island coast, the exotic *Ochlerotatus (Halaedes) australis* (Erichson) is widespread in salt-water pools. Although this species is not anthropophilic, it will feed on humans and it has been shown to be good laboratory vector of dengue viruses and RRV under experimental conditions.<sup>7</sup>

## Border surveillance and mosquito control

Adequate surveillance at all ports of entry is a mandatory activity intended to prevent the arrival of exotic mosquitoes and other arthropods, and consequently to prevent local transmission of arboviruses. Unfortunately, New Zealand's record in this regard is not particularly good. In 1993, for instance, several larvae of *Ae. albopictus* entered the country in used tyres and were later found and destroyed in an Auckland suburb.<sup>9</sup>

Whereas actions taken were timely and appropriate on that occasion, the same did not happen during the spread of *Oc. camptorhynchus*, and recent reports from New Zealand's Audit Office have criticised some government departments.<sup>33,34</sup> The reports highlight failures within the national surveillance program that led to a considerable delay in the identification of *Oc. camptorhynchus*, and pointed out uncertainties and delays in the response process. A significant issue yet to be resolved is whether the incursion of a vector mosquito should be treated as a biosecurity priority or a public health priority. These priorities obviously overlap and government departments must come to an agreement that would enable the necessary immediate response

to an exotic mosquito incursion. If such delays and surveillance failures were to occur under an incursion from a species such as *Ae. albopictus*, which is capable of exploiting artificial containers in urban areas and natural breeding containers in native ecosystems, the consequences would be disastrous. Once such a species becomes established, it is essentially impossible to eradicate it.

Compounding administrative problems, a recent survey of standard container door inspections indicated that approximately 96% of invading insects and spiders are not detected under current procedures.<sup>35</sup> The sea containers pathway has been identified as the least well controlled of all entry ports in New Zealand.<sup>34</sup> It is therefore likely to be the most important means for new species to enter the country, and it has been suggested as the entry way for *Oc. camptorhynchus* into New Zealand.<sup>35</sup>

Ships should be inspected before they dock in order to minimise the arrival on land, and consequent establishment, of any live pests that might be on board. Because of the large number of ships arriving, however, that process is unlikely to be implemented. Nevertheless, surveillance of commercial shipments entering the country should ensure that each container and any other cargo on board, particularly those in the open air, are rigorously examined and/or treated with insecticide. This is feasible if the costs were to be met by importers, which seems fairer than sending the taxpayers multi-million dollar bills for the eradication of pests accidentally imported in commercial goods.

Another important program to establish would be a campaign to teach New Zealanders about adequate means to control mosquitoes in their own backyards. It is ironic that people complain about the nuisance caused by mosquitoes in their homes, when very often they have exacerbated the problem themselves by leaving pots, cans, barrels and other containers with stagnant water in their backyards. One exotic mosquito in particular, *Oc. notoscriptus*, has greatly profited from such breeding grounds, breeding widely in urban and peri-urban areas.<sup>25</sup> The species is highly anthropophilic<sup>30</sup> and such a good domestic container-breeder is the ideal candidate to become an important urban vector of introduced arboviruses in a city such as Auckland.

Problems with mosquito control are not at all restricted to New Zealand; they are worldwide. For instance, in many Australian communities where RRV is an endemic problem, there are no routine vector control programs despite the high annual incidence of the disease.<sup>3</sup> However, apathy elsewhere should not be adopted as the model for New Zealand.

## Detection and diagnosis of arboviral infections

Arboviral diseases are classified as notifiable diseases under New Zealand's Health Act 1956. As a result, medical practitioners are obliged to notify health authorities (in the case of arboviruses the Medical Officer of Health) of the occurrence of any cases.<sup>5</sup> In order to stem the spread of such a disease, one would expect that there would be an immediate and swift response

from biosecurity authorities, a response that would include identifying the potential breeding and transmission sites and the vector and initiating a subsequent intense control program for the vector.

Maguire has stressed the importance of early detection of RRV and dengue viruses in infected patients.<sup>7</sup> He suggested that New Zealand clinicians should be aware of these and other possibilities and should consider such arboviruses in the differential diagnosis of fevers of undetermined origin. The field of infectious diseases is a specialty, one requiring special training. Most New Zealand medical graduates practising in this country would have had minimal or no experience in diagnosing and treating arboviral infections, as certain aspects of training on infectious diseases would not have been emphasised because of the apparent absence of diseases exotic to New Zealand. The few cases they might treat would be related to infected tourists. In 2001, for instance, there were 83 cases of imported dengue (in comparison to an average of 14 a year for 1995 to 2000).<sup>18</sup>

As a consequence, it is unlikely that a general practitioner in New Zealand would be capable of identifying an arboviral infection. It is likely that a specific diagnosis would be unavailable until the person is sick enough to be taken to hospital. In the latter lies the real chance of detection, as every main hospital has an infectious diseases team that would be capable of identifying and perhaps quarantining people who might be infected with exotic viruses. Unfortunately, for every person that goes to hospital with a severe infection, there would be many with moderate, mild or no symptoms. As a result, the greatest chance of detecting infected people would lie with general practitioners.

To make matters worse, one cannot make an accurate and invariably correct clinical diagnosis of arboviral infections. Although no indigenous arbovirus has been shown to cause human illness in New Zealand, there are many viruses related to RRV and Australian experiences have demonstrated that these can cause identical clinical pictures.<sup>12</sup> For RRV, and others, definitive diagnosis relies on detection of virus (isolation and identification), detection of viral RNA, or serological evidence (immunofluorescence or enzyme-linked immunosorbent assays) of IgM and IgG antibodies, the presence of which must be confirmed by neutralisation tests. Confirmation by serodiagnosis relies on observation of at least a fourfold increase or decrease in antibody titre between acute- and convalescent-phase serum samples. A major constraint, therefore, derives from the absence of a New Zealand reference centre that could test samples from suspect cases.

A recent diagnostic exercise involving an Auckland resident stimulated us to consider the availability of reagents and overall expertise in New Zealand. A near misdiagnosis occurred because of the many logistical complications arising from the need to send samples elsewhere for testing and confirmation.

At present in New Zealand, for the most common arboviral diseases such as dengue fever, serum samples are screened for IgG and IgM antibodies at the Institute of Environmental Science and Research (Rabia Khan, personal communication 2003). Despite the fact that tests for dengue are carried out in New Zealand,

significant reporting delays occur. Khan et al. pointed out that median time from laboratory testing to notification of results was seven days, but in 36% of the cases it exceeded 21 days.<sup>18</sup> The fact that one-third of all notifications were not made for more than three weeks is, or should be, unacceptable to attending physicians and to public health authorities.

As a result, one can expect a rather extensive time frame for the whole process to occur, from detection until confirmation of an infection. The patient becomes infected, goes through an incubation period (about 3-4 days) and gets sick. One or two more days might pass before the patient seeks medical assistance and has some blood drawn. If the laboratory test results are positive, the patient then has a second blood sample drawn (7-14 days after the first blood sample was taken), after which the samples are sent to Australia. Independently of how swift the action of the Australian laboratory is, by the time samples are tested and the results returned to New Zealand, an unacceptable interval would have passed. This means anywhere from three to five weeks from the time of infection until the receipt of final results.

It seems to us, therefore, that it is important for New Zealand to develop its own facilities and competence to attempt diagnosis of suspected cases of arboviral and other viral infections. This is especially so when competent research laboratories already are present in the country, such as the Institute of Environmental Science and Research in Porirua. There are unavoidable delays when there is reliance on overseas laboratories for confirmation of tests, delays that may increase the risk of epidemic amplification of a virus. The later one receives confirmation of a case of local arboviral transmission, the more difficult it is to stop its spread. It would be the index case of infection with an exotic virus that would be most worrisome and troubling. The combination of invasive arthropod species and movement of infected people is the predecessor of disease emergence.

## Conclusions and recommendations

The risk of an arboviral outbreak in New Zealand is real and serious. In 1979, an infected Australian tourist introduced RRV to Fiji, which led to a major epidemic of polyarthritis in the Pacific area where as many as half a million people were infected.<sup>36</sup> In the New Zealand scenario, according to Weinstein et al., the amount of virus circulating in the human and other vertebrate animal populations, such as that of Auckland and its surroundings, is likely to be sufficient to sustain an outbreak.<sup>37</sup>

Compounding this situation, the human population in New Zealand is likely non-immune and susceptible.<sup>38,39</sup> This ostensible susceptibility is exacerbated by the lack of public education regarding the need for mosquito control measures.<sup>37,38</sup> The convergence of potential introduction of exotic viruses, lack of adequate testing facilities, and absence of a well-informed public cannot bode well for rapid recognition and response.

We believe that New Zealand has the capability of becoming self-sufficient when it comes to arboviral surveillance and control and we therefore recommend the following courses of action:

1. Increase the capacity for vector surveillance at major entry ports, particularly of ships arriving in Auckland.
2. Study the possibility of establishing a program to control Brushtail possums and wallabies as a public health strategy in certain areas.
3. Establish a rapid response team to act swiftly upon any biosecurity breaches by new exotic vectors.
4. Carry out a long-term public education campaign on mosquito avoidance measures for homes and outdoors, and on ways to control the breeding places of arthropods.
5. Increase training of medical practitioners and other technical staff about both the identification of suspected cases and the need for laboratory diagnosis of viruses exotic to New Zealand.
6. Establish a diagnostic reference centre, one capable of carrying out all necessary laboratory tests for detection and confirmation of autochthonous and exotic arboviral infections.
7. Conduct serological surveys to determine whether antibodies to any recognised arboviruses are present among the general population.
8. Establish adequate response protocols to deal with imported cases of dengue, as well as RRV and other arboviruses, any or all of which could be established in New Zealand by naturally occurring or exotic mosquitoes already established here.

Most of the above recommendations have already been put forward in a report to the Minister of Biosecurity<sup>39</sup> and by Kelly-Hope et al.<sup>19</sup> In these days of international bioterrorism, establishment of a national diagnostic centre would be in the best interests of national security and, should there be a break in the existing barriers to virus introduction, would prevent untold human misery and eliminate or reduce severe economic losses.

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