Aussie Mozzies Invade NZ

Exotic mosquitoes already established in New Zealand pose a significant risk to public health. José Derraik says that new invading mosquito species could seriously aggravate this threat.

As a result of New Zealand's early separation from other large land masses approximately 80 million years ago, the country has a unique fauna characterised by an absence of indigenous terrestrial mammals apart from three species of bats. New Zealand also has an impoverished mosquito fauna comprising only 12 indigenous species.

The arrival of humans about 800 years ago started an invasion of exotic species at a rate that has considerably expanded since European settlement brought an ever-increasing arrival of goods and passengers. The problem of invading species became considerably worse during the 20th century, which brought an exponential rise in the number of ships (and later aircraft) moving around the world, greatly increasing the opportunities for invasive species such as mosquitoes. Commerce became the most important medium for biological invasions, and the volume and frequency of commercial shipments continues to increase, both via sea and air, making the risk of new invasions higher than ever. The interception of important disease vectors has consequently become commonplace, and a large number of exotic invertebrate species are now established in New Zealand, with the count at approximately 2200 species in 1997.

Although the main entrance pathway for invading mosquitoes in the past 75 years has been aircraft, there has been a major shift towards ships and their cargo since the 1990s, which accounted for 82% of 62 described interceptions of exotic mosquitoes in New Zealand borders since January 1990.

Exotic Mosquitoes: A Constant Threat

The cargo on board ships provides a perfect invading medium for mosquitoes. Most interceptions throughout the world involve the aquatic immature stage, as these can hitchhike in a variety of receptacles such as used tyres, the leaves of bromeliads (which form a funnel that holds water) and pretty much any container capable of holding water for a significant length of time. The so-called "container-breeding mosquitoes" are especially efficient in exploiting these larval habitats, and used tyres in particular have probably become the main means worldwide for the spread of exotic mosquito vectors. The Asian tiger mosquito *Aedes albopictus*, listed by the World Conservation Union (IUCN) as one of the world's worst invasive alien species, is a serious disease vector and an efficient bio-invader that has spread to many countries via used tyres.

Four exotic mosquitoes have so far become established in New Zealand. The first exotic mosquito species to settle in New Zealand was the cosmopolitan *Culex quinquefasciatus*, which was recorded for the first time in 1848 and is believed to have arrived on an American whaling vessel. The three remaining established exotic mosquitoes are native to Australia.

The first of the latter to arrive was *Ochlerotatus notoscriptus* in the 1920s, with a second mosquito species (*O. australis*) first reported in the 1960s. The last Australian species to have populations established in New Zealand was the southern salt-marsh mosquito (*O. camptorhynchus*), which was first discovered in 1998 near Napier on North Island's east coast. This mosquito has since spread to several other localities, most recently near Blenheim on the South Island. Eradication programs are currently underway but the areas of suitable habitats are vast. Based on its known

distribution it is unlikely that this species will be completely eliminated.

Apart from these species there is a seemingly never-ending wave of mosquito interceptions at New Zealand's borders. Approximately 30 different exotic species have been intercepted in the past 75 years. This number is likely to have been higher as a large number of specimens were not adequately identified. The list of mosquitoes intercepted includes important disease vectors such as the Australian species *C. annulirostris* and *O. vigilax*.

New Zealand's foremost mosquito expert, Marshal Laird, has been warning Pacific nations for half a century about the dangers arising if foreign mosquito vectors become established in New Zealand and other Pacific Islands. Laird himself has given a detailed account of a close call when shipments of used tyres infested with the Asian tiger mosquito (*A. albopictus*) breached border controls and were delivered to an Auckland suburb in the early 1990s. Fortunately, the discovery was made soon enough to allow for complete eradication before the species was able to spread, but this breach highlighted the elevated biosecurity threat posed by exotic mosquitoes.

The Asian tiger mosquito has been intercepted in New Zealand at least 12 times. It is an efficient biological invader and its establishment could have disastrous consequences. Apart from being a vector of a number of agents that cause disease in humans, it is a significant nuisance and its bites are painful and may produce wheals with a haemorrhagic appearance.

The Disease Threat

There has never been a locally acquired case of mosquito-borne disease in humans in New Zealand. Nonetheless, the consensus among experts is that an outbreak of a mosquito-borne disease is likely to occur sooner rather than later. In other words, it is not a question of "if" but "when". Even if we assume that the improvements in border control procedures put in place by New Zealand authorities in recent years will effectively stop new disease vectors from arriving, the disease threat does not go away.

The four exotic mosquito species already established in New Zealand are all disease vectors. The species of least concern is *O. australis*. While it is a potential disease vector, this species appears to be confined to southern parts of the South Island where it breeds in saline rock pools along the shore.

The distribution of *O. camptorhynchus* seems to be still somewhat limited as a result of the eradication program, but the spread of this species would be a major concern. It is a vicious biter and an important arbovirus vector in Australia. In New Zealand it could become a serious public health hazard as an efficient vector of Ross River virus and Barmah Forest virus.

In contrast to these species, both *O. notoscriptus* and *C. quinquefasciatus* are already abundant and widespread in northern New Zealand. *C. quinquefasciatus* is a vector of several diseases such as West Nile virus and lymphatic filariasis, and it has been suggested that it is the vector involved in an outbreak of avian malaria and avian pox in captive-reared populations of the endangered New Zealand dotterel.

O. notoscriptus is a potential vector of Barmah Forest virus, and several studies have implicated this species as a Ross River virus vector in urban areas in Australia. The most recent evidence indicates that *O. notoscriptus* is still expanding its distribution in New Zealand, and in many habitats it has surpassed the native *C. pervigilans* to become the dominant mosquito species, particularly in highly modified native forest environments.

As a result, the mosquito-borne pathogen most likely to strike New Zealand is Ross River virus. The latter is the most common agent of recognised arboviral disease in Australia. It has been estimated that more than 100 people entered New Zealand from Queensland with clinical or subclinical Ross River virus infection in 2001. Computer models indicate that the climate in northern New Zealand is suitable for the establishment of a Ross River virus cycle.


José Derraik sampling for mosquitoes.

As *O. notoscriptus* is abundant in urban and peri-urban areas (breeding in all types of man-made containers and in the leaf axils of banana palms, bromeliads and other exotic plants), it is a matter of time before a female mosquito bites an infected person. Compounding this situation, the likelihood of a vector mosquito biting a viraemic traveller arriving from Australia would greatly increase if *O. camptorhynchus* manages to become established in the Auckland region, the main point of entry for people arriving from Australia.

Human-induced Environmental Change

New Zealand has undergone extensive

environmental changes since the arrival of humans. It is estimated that only one-quarter of the original forests and woodlands remain, most of which are in mountainous and upland areas. Such change is directly implicated in the emergence of infectious diseases in other parts of the world. Urbanisation in particular is known to benefit exotic vector mosquitoes and other bio-invaders throughout the world.

In the case of New Zealand, populations of native mosquito species are likely to be reduced by the destruction of native habitat. In contrast, exotic mosquitoes that are potential disease vectors should benefit from habitat modification and replace native species, a process observed overseas and directly responsible for outbreaks of mosquito-borne diseases.

For instance, the indigenous mosquito *Maorigoeldia argyropus* seems to have disappeared from most areas modified by humans, and is now only found in or adjacent to large and pristine areas of indigenous forest. In comparison, the Australian mosquito *O. notoscriptus* has become the most widespread and abundant container-breeding mosquito in urban, peri-urban and rural areas in the Auckland region, where it also seems to be the dominant species in small modified patches of native forest. *O. notoscriptus* can reach very high densities in certain habitats, and more than 1000 specimens have been collected overnight from a single adult trap at an exotic plant nursery in the Waitakere Ranges.

Unfortunately, the association of exotic mosquitoes with human-modified areas tends to aid their dispersal. The application of used tyres in New Zealand farms to weigh down polythene sheeting covering farm silage piles and pits has greatly increased the availability of artificial larval mosquito habitats, and according to Marshal Laird was probably one of the main facilitators of the North Island spread of both *C. quinquefasciatus* and *O. notoscriptus*. New invading exotic mosquitoes are likely to utilise a similar pathway.

It is important to highlight the potentially serious consequences to public health of these processes, as human-induced environmental change is leading to the replacement of native mosquito fauna, which feeds primarily on birds, by exotic vector mosquitoes that are highly anthropophilic. As a result, the chances of a disease outbreak occurring is continually increasing with the North Island spread of exotic vectors.

Conclusions

Outbreaks of mosquito-borne diseases caused by the establishment of exotic vectors could indeed happen in New Zealand. There are many such occurrences documented overseas, such as the 17th century introduction of yellow fever and its vector (*A. aegypti*) into South America by slave ships from West Africa.

The scenario for a mosquito-borne disease outbreak in New Zealand is dangerous as it is, and the arrival and establishment of new exotic vectors such as *A. albopictus* could be a

serious public health hazard. It is paramount that New Zealand border control procedures are the most stringent possible. The numerous interceptions of exotic vectors arriving aboard ships mean that every cent spent by biosecurity authorities on border control is worth it. Once an efficient bioinvader such as *A. albopictus* manages to gain a foothold in New Zealand, the costs that the country would incur on eradication attempts would be incredibly higher. Complete eradication would be unlikely.

Auckland is New Zealand's largest city and the main port of arrival for goods and passengers, and it is therefore not surprising that it has been the location of most exotic mosquito interceptions. Moreover, Auckland is also the place where the danger of an outbreak is highest: abundant and widespread exotic vector mosquitoes, a relatively large human population that is likely to be susceptible to exotic pathogens, numerous larval mosquito habitats, the absence of any mosquito control programs, and a lack of public knowledge about mosquito avoidance and control measures.

Based on the number of viraemic people estimated to be arriving in Auckland each year from Australia, one wonders when bad luck will strike and an outbreak will occur. The resulting epidemic may be significant, and containment of the outbreak may be difficult.

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