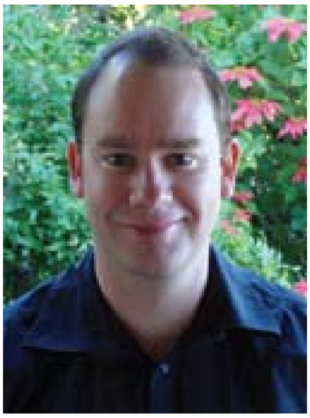
The 'Tiger' on our doorstep: emergence of *Aedes albopictus* as an arbovirus vector in northern Australia



Andrew F van den Hurk

Virology
Forensic and Scientific Services
Queensland Health
PO Box 594
Archerfield QLD 4108
Tel (07) 3274 9135
Fax (07) 3000 9186
Email andrew_hurk@health.qld.gov.au

Introduction

Aedes albopictus **is commonly referred to as the 'Asian Tiger Mosquito', a name that describes its distinctive black and white banding (Figure 1) and its origins in Southeast Asian rainforests. This highly invasive species is a competent vector of dengue viruses (DENVs) and was the primary vector during the recent resurgence of chikungunya virus (CHIKV) in the islands of the western Indian Ocean [1,2].** ***Ae. albopictus*** **is also a vicious biter and can transmit dog heartworm,** ***Dirofilaria immitis*** **[1], between dogs. In the last 30 years, it has colonised many parts of Europe, North and South America and Africa. Until recently, Australia had been spared infestation by** ***Ae. albopictus*****. However, widespread populations were discovered in the Torres Strait in 2005 [3] and genetic analysis suggested that it had been repeatedly introduced from the New Guinea landmass [N.W. Beebe, L.A. Hill and A.F. van den Hurk, unpublished data]. Should** ***Ae. albopictus*** **become established on the mainland, it has the potential to colonise much of coastal Australia, including southern areas [4], thus rendering them receptive to possible DENV and CHIKV transmission.**

Biology of *Ae. albopictus*

The biological traits of *Ae. albopictus* have facilitated a pattern of rapid colonisation following initial introduction into a novel area. Female *Ae. albopictus* lay desiccation-resistant eggs in both

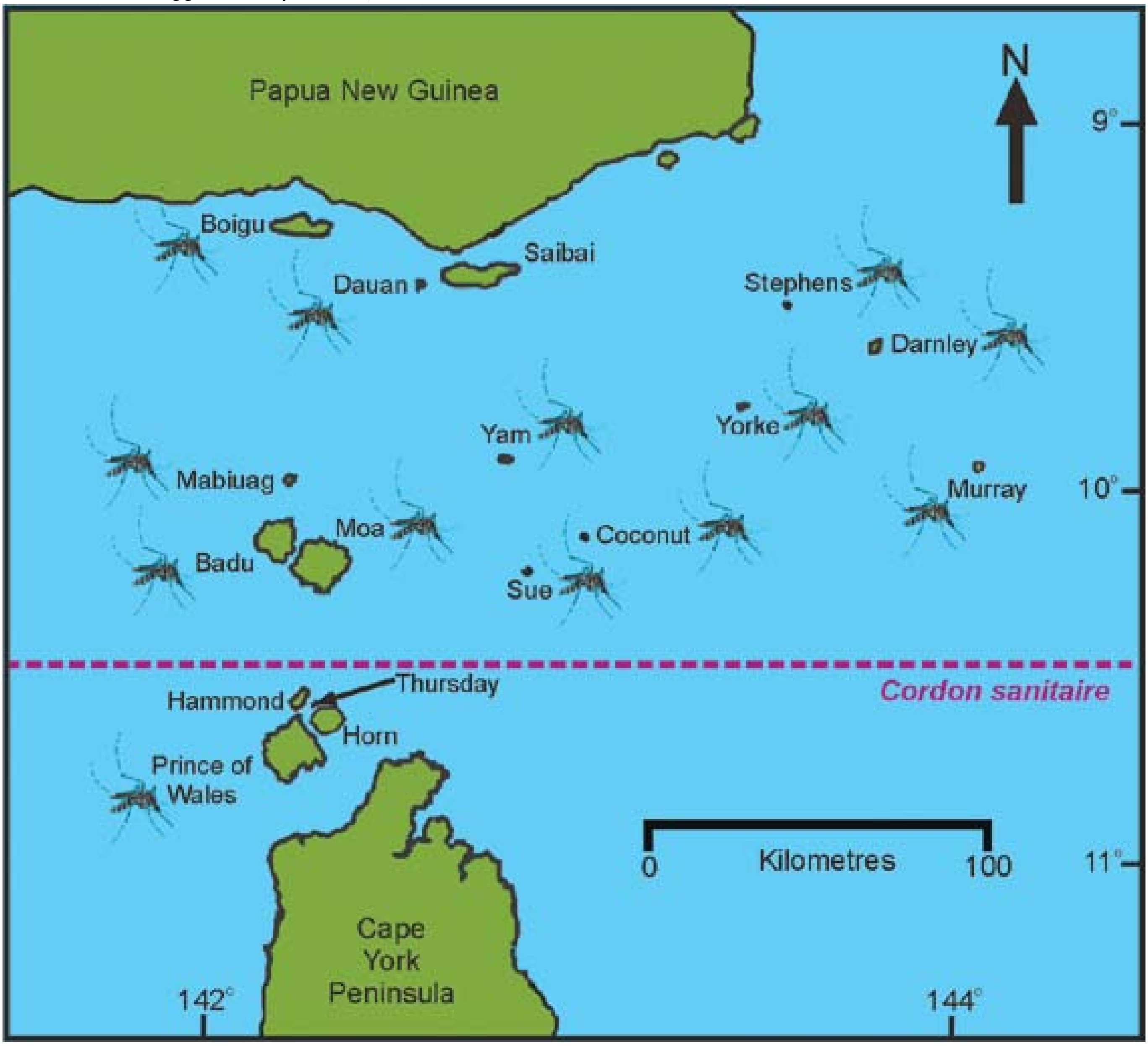
Figure 1. A blood-engorged *Ae. albopictus* mosquito. Photo credit: Paul Zborowski.

natural and artificial, water-filled containers (such as tree holes, tyres, jars, tanks and so on), which may remain viable for up to 6 months [5]. This has facilitated their rapid transport around the world, particularly via the used tyre trade [6]. In temperate latitudes, *Ae. albopictus* are able to survive winter by entering diapause, a period of dormancy triggered by shortened day length [5]. Indeed, in some North American states, the eggs are even able to withstand freezing before hatching when flooded at warmer temperatures [7]. Larvae of *Ae. albopictus* are able to co-exist with endemic mosquitoes, such as *Aedes aegypti* and in some regions they have even displaced this species as the dominant container-inhabiting *Aedes* [8]. Adult *Ae. albopictus* are opportunistic in their blood-feeding habits, readily feeding on humans when available [9]. The ability to utilise a variety of blood meal hosts further contributes to the invasive ability of this species.

Ae. albopictus in northern Australia

Despite the regular interception of *Ae. albopictus* by quarantine personnel at various mainland ports, it had not become established on Australian territory until recently [4]. This all changed in April 2005, when populations of *Ae. albopictus* were discovered on 10 of the 17 inhabited islands of the Torres Strait [3] (Figure 2). Analysis of the mitochondrial cytochrome oxidase I gene from 19 sample locations in the Torres Strait islands and Papua New Guinea (PNG) revealed that at least eight haplotypes occur in the Torres Strait and multiple haplotypes are present on many islands [N.W. Beebe, L.A. Hill and A.F. van den Hurk, unpublished data]. This suggests that *Ae. albopictus* has been introduced numerous times and haplotypes shared with villages in southern PNG indicate that this may be the primary source of the incursions. Indeed, freshwater present

Figure 2. Map of the Torres Strait showing a) islands where *Aedes albopictus* was collected from between 2005 and 2009; and b) the islands below approximately 10˚30'S, which are included in the *cordon sanitaire*.



onboard small boats travelling from these PNG villages to Torres Strait islands does provide an ideal vehicle for the repeated introduction of *Ae. albopictus.*

In response to the discovery of *Ae. albopictus* in the Torres Strait, an eradication program was implemented in late 2005, which focused on surveillance, elimination of larval habitats and application of insecticides [10]. However, due to a myriad of logistical issues, it soon became apparent that eradication of this species would prove extremely difficult. Consequently, a *cordon sanitaire* approach was instituted in 2008, whereby surveillance and control became focused on the inner Torres Strait islands of Thursday, Prince of Wales, Horn and Hammond, the major transport hubs and the most likely staging point for introduction of *Ae. albopictus* onto the mainland.

Ae. albopictus as a vector of arboviruses

Experiments on overseas populations have demonstrated that, despite being a competent laboratory vector of at least 25 arboviruses, the role that *Ae. albopictus* plays as a vector in the field appears to be that of a secondary or supplemental nature [1]. However, *Ae. albopictus* has been an important DENV vector during outbreaks where *Ae. aegypti,* the primary vector, was either absent or unlikely to be responsible for transmission, due to low population density [11,12]. The status of *Ae. albopictus* as an arbovirus vector changed dramatically during CHIKV outbreaks on the islands of the western Indian Ocean from 2004 to 2006, where over 260,000 cases occurred on Réunion Island alone [13]. In the summer of 2007, a European outbreak of CHIKV occurred for the first time in northeastern Italy, from which 205 cases were reported [14]. In both of these instances, *Ae. albopictus* was incriminated as the epidemic vector, due to high population densities in these regions and its enhanced vector competence for the strain of CHIKV that was circulating [2].

The recent addition of *Ae. albopictus* to Australia's mosquito fauna has necessitated research into the ability for this species to serve as a local vector of endemic and exotic arboviruses. Recent vector competence experiments using a Torres Strait strain of *Ae. albopictus,* originating from Yorke Island, revealed that it was an inefficient vector of DENV-2 and the three encephalitic flaviviruses (Murray Valley encephalitis virus, Japanese encephalitis virus and Kunjin virus) especially when compared with proven local vectors [15,16]. Conversely, recent experiments have revealed that the Yorke Island strain of *Ae. albopictus* was highly susceptible to a Réunion Island CHIKV strain and readily transmitted the virus [17]. Similarly, *Ae. albopictus* was able to transmit the related alphaviruses, Ross River and Barmah Forest viruses, albeit at slightly lower rates than the established vector, *Aedes vigilax* [16].

The future

The frequency of air and sea travel from the Torres Strait to the Australian mainland provides numerous opportunities for *Ae. albopictus* to be introduced onto the mainland. A projection model created by Russell and others suggests that, should *Ae. albopictus* become established, it has the potential to survive as far south as Melbourne [4], especially if it evolves the ability to diapause during winter. As *Ae. aegypti* does not occur outside Queensland, this may render these southern areas susceptible to local transmission of DENVs and CHIKV. Furthermore, *Ae. albopictus* is a significant nuisance species, so its presence would impact on the Australian quality of life. Effective quarantine surveillance and the implementation of rapid control measures are imperative to prevent the colonisation of *Ae. albopictus* on mainland Australia.

References

1. Gratz, N.G. (2004) Critical review of the vector status of *Aedes albopictus. Med. Vet. Entomol.* 18, 215-227.
2. Tsetsarkin, K.A. *et al.* (2007) A single mutation in chikungunya virus affects vector specificity and epidemic potential. *PLoS Pathog.* 3, e201.
3. Ritchie, S.A. *et al.* (2006) Discovery of a widespread infestation of *Aedes albopictus* in the Torres Strait, Australia. *J. Am. Mosq. Control Assoc.* 22, 358-365.
4. Russell, R.C. *et al.* (2005) *Aedes (Stegomyia) albopictus* – a dengue threat for southern Australia. *Comm. Dis. Intell.* 29, 296-298.
5. Hawley, W.A. (1988) The biology of *Aedes albopictus. J. Am. Mosq. Control Assoc. Suppl.* 4, 1-39.
6. Reiter, P. & Sprenger, D. (1987) The used tire trade: a mechanism for the worldwide dispersal of container breeding mosquitoes. *J. Am. Mosq. Control Assoc.* 3, 494-501.
7. Hawley, W.A. *et al.* (1989) Overwintering survival of *Aedes albopictus* (Diptera: Culicidae) eggs in Indiana. *J. Med. Entomol.* 26, 122-129.
8. Juliano, S.A. & Lounibos, L.P. (2005) Ecology of invasive species: effects on resident species and on human health. *Ecol. Lett.* 8, 558-574.
9. Richards, S.L. *et al.* (2006) Host-feeding patterns of *Aedes albopictus* (Diptera: Culicidae) in relation to availability of human and domestic animals in suburban landscapes of central North Carolina. *J. Med. Entomol.* 43, 543-551.
10. Hill, L.A. *et al.* (2008) Rapid identification of *Aedes albopictus, Aedes scutellaris* and *Aedes aegypti* life stages using real-time polymerase chain reaction assays. *Am. J. Trop. Med. Hyg.* 79, 866-875.
11. Metselaar, D. *et al.* (1980) An outbreak of type 2 dengue fever in the Seychelles, probably transmitted by *Aedes albopictus* (Skuse). *Bull. World Health Organ.* 58, 937-943.
12. Effler, P.V. *et al.* (2005) Dengue fever, Hawaii, 2001-2002. *Emerg. Infect. Dis.* 11, 742-749.
13. Pialoux, G. *et al.* (2007) Chikungunya, an epidemic arbovirosis. *Lancet Infect. Dis.* 7, 319-327.
14. Rezza, G. *et al.* (2007) Infection with chikungunya virus in Italy: an outbreak in a temperate region. *Lancet* 370, 1840-1846.
15. Moore, P.R. *et al.* (2007) Infection and dissemination of dengue virus type 2 in *Aedes aegypti, Aedes albopictus* and *Aedes scutellaris* from the Torres Strait, Australia. *J. Am. Mosq. Control Assoc.* 23, 383-388.
16. Nicholson, J.N. *et al.* (2009) *Aedes albopictus* in Australia: how low can it go? *Arbovirus Res. Aust.* 10, In press
17. van den Hurk, A.F. *et al.* (2009) Vector competence of Australian mosquitoes for chikungunya virus. *Vector-borne Zoonotic Dis.* In press.

Andrew van den Hurk is a Research Entomologist in the Virology Section of Forensic and Scientific Services, Queensland Health, Brisbane, Australia. His research interests are focussed on the entomology, ecology and surveillance of mosquito-borne pathogens, with an emphasis on arboviruses and their vectors.