Micronesica Suppl. 3: 33–39, 1991

Introduced Vector-Borne Diseases in the Pacific

RICHARD C. RUSSELL

University of Sydney, Medical Entomology Unit,
Department of Infectious Diseases and Microbiology
Westmead Hospital, Westmead, NSW 2145, Australia

Abstract—The major vector borne diseases relate to infections with malarial, filarial and arboviral pathogens. Within recent decades the actual or potential movement of these pathogens and/or their vectors into or within the Pacific Region has concerned national and international health authorities. The introduction of vectors of malaria into areas where they do not exist is a major concern; the appearance of exotic *Anopheles* species and instances of local malaria transmission in Guam illustrate this concern, and islands of the southwest Pacific remain vulnerable. Dengue fever has been active in recent years and, although some indigenous mosquitoes are vectors, further dispersal of the efficient exotic vectors *Aedes aegypti* and *Ae. albopictus* in the region should be prevented because of their domestic habits. Other arboviruses also constitute a threat; the introduction of Ross River virus 10 years ago was an instance where local mosquitoes were competent vectors of an exotic pathogen. Filarisasis is not considered an acute problem but efficient *Aedes* vectors (which may also be arbovirus vectors) should not be allowed to spread to areas with less competent indigenous filarial vectors. Vector control can be difficult once exotic pests are established; quarantine provisions, and efficient routine surveillance and control operations can be used to help prevent many of the above concerns.

Increasing air travel within the Pacific is posing an increasing threat of introducing/dispersing mosquito vectors and/or vector-borne disease within the region, particularly that transmitted by mosquitoes. There are two inherent concerns: transport of infectious human carriers of disease pathogens, and transport of insect (mosquito) vectors (with or without the pathogens).

There have been many instances of the former, where travellers have arrived in a country of the region 'incubating' causative agents of exotic disease such as malaria plasmodia, dengue fever and Japanese encephalitis viruses, as well as various filaria.

For a vector-borne disease (as distinct from the pathogen causing such disease) to be introduced to an island in the region, the presence of a local susceptible vector is required to achieve transmission from the infected carrier. This vector may be an indigenous species which is competent to maintain and transmit the pathogen, or it may be an introduced exotic species which is an efficient natural vector and has been transported and become established locally; but a suitable vector available locally when the pathogen is imported with a human carrier is prerequisite for introduction of a disease.

Insect Vectors of Disease

The carriage of insects on international aircraft has been documented over many decades and has been reviewed by Russell et al. (1984). There has been a number of survey reports of exotic insect vectors being found on board aircraft entering countries in the Pacific/Southeast Asian regions, e.g. Japan (Takahashi 1984), Philippines (Basio et al. 1970, Basio 1973), Singapore (Goh et al. 1985) and Australia (Russell et al. 1984). Vector and pest species from the genera *Aedes*, *Anopheles*, *Culex* and *Mansonia* have been recorded in the above-mentioned collections, particularly *Aedes aegypti* and *Ae. albopictus*, important vectors of dengue; *Anopheles sundaicus* and *An. subpictus*, malaria vectors of concern for coastal environments; *Culex tritaeniorhynchus* and *Cx. gelidus*, important vectors of Japanese encephalitis. Not all (e.g. *Cx. quinquefasciatus*) are exotic species for the country of import but may be of concern even so if they are carrying pathogens or introducing genes for insecticide resistance. It is not only the passenger cabin and cargo holds of aircraft that may be important: mosquitoes and other insects have been shown to be able to survive international travel in the wheel bays of large modern passenger aircraft (Russell 1987).

There have been some introductions of vector mosquitoes of major consequence into islands of the Pacific region. *Ae. aegypti* is now widely distributed in the Pacific, where dengue has become virtually endemic, but dispersal is still occurring; it appears to have been only recently introduced to some islands, e.g. Tokelau, and there are still some islands where it has not yet been introduced (Pillai & Ramalingam 1984). There are also some islands from which it is thought to have been eradicated (e.g. Rarotonga and Guam), so its movement into and through the region is still of concern and should be prevented.

Ae. albopictus was introduced to the Carolines and Marshalls during the 1960s or 1970s, probably from Guam or Saipan, and the species was unknown east of PNG until 1980 when it was recorded from the Solomons after introduction probably from PNG; *Ae. vigilax* has been introduced to Fiji and Tonga, *Ae. australis* and *Ae. notoscriptus* into New Zealand, and *Cx. quinquefasciatus* was relatively recently introduced to Tokelau (Pillai & Ramalingam 1984).

There is a valid major concern for the introduction of malaria vectors of the *Anopheles punctulatus* group into the central and eastern parts of the south Pacific where ground pool habitats appear to be eminently suitable for the establishment of *An. farauti* or *An. punctulatus* (Self & Smith 1984).

Concerns remain also for intraregional transportation and establishment of vectors. For instance, if *Ae. aegypti* is currently absent from Guam there is considerable risk of its reintroduction from Asian ports (particularly by air from Manila) but also from neighboring islands in Micronesia. There are risks of inter-island transfers elsewhere, e.g. *Aedes aegypti* occurs in Tonga but not in nearby Rarotonga (Cook Islands), while *Aedes polynesiensis* (a vector of filariasis, dengue and Ross River virus) occurs on Rarotonga but not in Tonga; the night-biting mosquitoes of the *Ae. kochi* group, which are important vectors of filariasis in Samoa and Tonga are absent from neighboring French Polynesia which has day-biting vectors.

The situation on Guam, with its heavy influx of international traffic and consequent establishment of several malaria, dengue and arbo-encephalitis vectors over the years, is a prime illustration of the reality of such transport of insects. At least 18 species of mosquitoes have become established on the island of Guam, 15 through international (primarily aerial) transportation, mostly since WW II; these include 5 *Anopheles* species on a previously anopheline-free island (Ward 1984).

Of course, there is also the potential (and indeed the reality) of sea-transport of mosquitoes, especially for *Aedes* species which can colonize ships' receptacles such as water barrels and water tanks, as well as some cargo such as tires, and can thus survive long sea journeys and be introduced to new ports. *Aedes togoi*, a potential filariasis vector, was introduced from Japan to Malaysia about 1960 by ship; and *Anopheles litoralis*, a malaria vector, was exported from the Philippines to Malaysia by ship in 1970 (Pillai & Ramalingam 1984). The introduction of *Ae. albopictus* to the USA through the agency of tyre imports (Francy et al. 1990) is a more recent illustration.

Aedes aegypti and *Aedes albopictus* are the species of greatest concern potentially most likely to be dispersed and introduced within the region by ship. Prior to this century and the proliferation of air travel, the transport of *Ae. aegypti* via sea trading routes over centuries enabled its dispersal and establishment in many ports of the tropical and subtropical regions of the world, and no doubt this sea-transport continues as illustrated by the occasional recording of *Aedes* eggs and larvae on vessels arriving in northern Australia from Asian ports.

Vector-Borne Disease

From a disease perspective, a major concern in the region is that malaria vectors will be introduced and become established in islands of the non-malarious Pacific, but the potential for viraemic humans to introduce dengue and other viruses into countries of the Pacific where efficient vectors exist is also important. The potential for such introductions and the implications should be reinforced to health authorities, the medical profession and the general public.

Malaria infections acquired during flight and on the ground at European airports (Curtis & White 1984, Isaacson 1989) attest to the potential for movement of pathogens with vectors in international air traffic. Considerable malaria activity continues in Melanesia (PNG, Solomons, Vanuatu) and eastern Asia from whence parasite importations to Pacific area could (and perhaps do) occur–but currently there are no vectors east of Vanuatu in the south Pacific and none in Micronesia except for Guam where all local potential vectors have been introduced. Malaria infections recorded in Guam have been attributed to these introduced *Anopheles* vectors (Smith & Carter 1984).

Dengue virus activity has been widespread in recent decades and almost continuous in the Pacific region through 1988–90, with various serotypes reported, and haemorrhagic manifestations and deaths in some countries; dissemination of the viruses can be presumed to be via inter-island travellers, although dispersal of infected vectors cannot be excluded for those countries not insisting on disinsection of arriving aircraft.

A signal example of the potential for disease caused by the introduction of an exotic disease agent able to be transmitted by local vectors is that related to the introduction of Ross River (RR) virus to the region in 1979. In April 1979, cases resulting from RR virus infection appeared in Nadi, Fiji and were subsequently reported elsewhere in the country to eventually total an estimated 50,000 clinical cases (possibly more than 300,000 infections among the 630,000 population); by August 1979 the outbreak spread to American Samoa (with an estimate of half the population affected), by November 1979 to Wallis and Futuna Islands and thence to New Caledonia; by February 1980 cases were appearing in the Cook Islands. The likelihood is that the virus was introduced to Fiji from Australia in 1979 in a human incubating the disease or in a mosquito that escaped aircraft disinsection, probably the former who infected local mosquitoes at a time when the introduced species, and known vector in Australia, *Ae. vigilax* was very abundant in the area of the Nadi airport. Human transportation of the virus to the other island groups of the region, initiating local outbreaks, can explain the rest of the story. As far as local vectors are concerned, introduced species such as *Ae. vigilax* and *Ae. aegypti*, and the local *Culex annulirostris*, could have been involved as vectors in Fiji but, in all the island groups involved other than New Caledonia, a local species, *Ae. polynesiensis*, appeared to have been most commonly involved as the vector for the exotic virus (Miles 1984).

Although RR virus may cause considerable morbidity within communities, that it does not cause human mortality is something for which the region can be thankful considering the extent and intensity of the 1979–80 outbreak. The implications of a similar introduction and epidemic of Yellow Fever virus in the region should be considered by health authorities.

Minimizing the Risks of Introduction and Establishment of Vectors and Vector-Borne Disease

There is a requirement for an improvement in collection and dissemination of technical information relating to potential risk of introductions and actual introductions, and to national measures designed to prevent or inhibit introduction and establishment of exotic pests.

Education of the travelling public, travel agents, and companies involved in international transport, trade and tourism, as well as health authorities should be improved to complement 'official' quarantine measures.

Aircraft introductions probably present the major problem for the region, and air routes presenting the greatest risks for importing vectors or human carriers should be identified by each national authority and local quarantine measures instituted where required. For instance, flights from malarious to non-malarious regions, particularly where nighttime departures that may attract *Anopheles* vectors are involved, should command quarantine attention. And humans recently visiting yellow fever endemic regions of Africa or South America, and wishing to enter islands of the region with competent vectors, should command quarantine attention.

Aircraft disinsection is often employed as a first line of defence in many countries of the region to prevent introduction of exotic insect vectors, and whether done 'blocks-away', 'in-flight' or 'on-arrival', it can be an effective quarantine procedure (Russell et al. 1984, Russell 1989, Russell & Paton 1989). However, airport sanitation is an important complementary measure and assists in preventing the establishment of introduced species.

Regular and frequent surveys should be undertaken in the vicinity of all major air- and sea-ports in the region to monitor abundance of indigenous insect species and detect the presence of exotic species. International vessels and aircraft should be examined periodically, and insects collected and identified to assess relative risks associated with particular routes. Seaport inspections and consideration of shipping routes should not be ignored, and routine ship inspections should include examination of water containers for mosquito larvae and eggs.

Sanitation of the port vicinity should be maintained and improved where necessary to prevent establishment of introduced species and minimize breeding of local vectors that may contact passengers and infiltrate departing vessels or aircraft. Measures should include appropriate engineering and chemical treatment, as well as collection and disposal of non-essential containers that serve as larval habitats. Airport lounges need to be screened and air-conditioned if possible to protect transit passengers from passing on or picking up mosquito-borne infections.

In an international health context, vector surveillance and control is as relevant for points of departure as for points of entry, and international cooperation will go a long way to reducing the risk faced by many countries in the region.

There are many considerations within the overall context of this issue. However, the establishment of malaria vectors in the malaria-free zone of the Pacific would greatly threaten the public health, the introduction of supplementary efficient domestic dengue vectors into the eastern Pacific and/or the continuing introduction of various dengue virus serotypes to the Pacific would seriously increase the incidence and severity of the disease, and the introduction of potentially calamitous exotic virus diseases such as yellow fever is something that cannot be excluded with modern travel.

With the current situation of decreasing quarantine barriers world-wide, health authorities of the Pacific basin and its rim should carefully consider the implications for the introduction of vectors and vector-borne diseases, and institute guidelines and provisions to reduce the risk of such introductions, in cooperation with fellow nations of the region.

References

Basio, R. G. 1973. The mosquito control program at the Manila International Airport and vicinity (Philippines) with comments on problems encountered on the aerial transportation of mosquitoes. *In* Y. C. Chan, K. L. Chan & B. C. Ho (eds.), Vector Control in Southeast Asia, pp. 78–84. Proc. First SEAMEO workshop.

Basio, R. G., M. J. Prudencio & I. E. Chanco. 1970. Notes on the aerial transportation of mosquitoes and other insects at the Manila International Airport. Philipp. Entomol. 1: 407–408.

Curtis, C. F. & G. B. White. 1984. *Plasmodium falciparum* transmission in England: entomological and epidemiological data relative to cases in 1983. J. Trop. Med. & Hyg. 87: 101–114.

Francy, D. B., C. G. Moore & D. A. Eliason. 1990. Past, present and future of *Aedes albopictus* in the United States. J. Am. Mosq. Cont. Assoc. 6: 127–132.

Goh, K. T., S. K. Ng & S. Kumarapathy. 1985. Disease-bearing insects brought in by international aircraft into Singapore. Southeast Asian J. Trop. Pub. Hlth. 16: 49–53.

Isaacson, M. 1989. Airport malaria: a review, Bull. Wld. Hlth. Org. 67: 737–743.

Miles, J. A. R. 1984. On the spread of Ross River virus in the islands of the south Pacific, *In* M. Laird (ed.), Commerce and the spread of pests and diseases, pp., 209–224. Praeger, New York.

Pillai, J. S. & S. Ramalingam. 1984. Recent introductions of some medically important Diptera in the northwest, central and south Pacific (including New Zealand), *In* M. Laird (ed.), Commerce and the Spread of Pests and Diseases, pp. 81–101. Praeger, New York.

Russell, R. C. 1987. Survival of insects in the wheel bays of a Boeing 747B aircraft on flights between tropical and temperate airports. Bull. Wld. Hlth. Org. 65: 659–662.

Russell, R. C. 1989. Transport of insects of public health importance on international aircraft. Travel Medicine Int. 7: 26–31.

Russell, R. C. & R. Paton. 1989. In-flight disinsection as an efficacious procedure for preventing international transport of insects of public health importance. Bull. Wld. Hlth. Org. 67: 543–547.

Russell, R. C., N. Rajapaksa, P. I. Whelan & W. A. Langsford. 1984. Mosquito and other insect introductions to Australia aboard international aircraft, and the monitoring of disinsection procedures, *In* M. Laird (ed.), Commerce and the Spread of Pests and Diseases, pp. 109–41. Praeger, New York.

Self, L. S. & A. Smith. 1984. Preventive measures against importing malaria vectors into Pacific islands, *In* M. Laird (ed.), Commerce and the Spread of Pests and Diseases, pp. 163–175. Praeger, New York.

Smith, A. & I. D. Carter. 1984. International transportation of mosquitoes of public health importance. *In* M. Laird (ed.), Commerce and the Spread of Pests and Diseases, pp. 1–21. Praeger, New York.

Takahashi, S. 1984. Survey on accidental introductions of insects entering Japan via aircraft, *In* M. Laird (ed.), Commerce and the Spread of Pests and Diseases, pp. 65–79. Praeger, New York.

Ward, R. A. 1984. Mosquito fauna of Guam: case history of an introduced fauna, *In* M. Laird (ed.), Commerce and the Spread of Pests and Diseases, pp. 143–162. Praeger, New York.