Arboviral diseases and malaria in Australia, 2008–09: Annual report of the National Arbovirus and Malaria Advisory Committee

Gerard J Fitzsimmons, Phil Wright, Cheryl A Johansen, Peter I Whelan and the National Arbovirus and Malaria Advisory Committee

Abstract

The National Notifiable Diseases Surveillance System received 8,677 notifications of diseases transmitted by mosquitoes in Australia from 1 July 2008 to 30 June 2009. The alphaviruses, Barmah Forest and Ross River, accounted for 6,574 (78%) of these notifications during 2008–09. There were 1,009 notifications of dengue virus infection locally-acquired in North Queensland and 484 notified cases resulted from overseas travel. Notification rates of dengue virus infection for 2008–09, regardless of where infection was acquired, exceeded the five-year mean rate and may be attributed to increased disease activity in the Asia–Pacific region. North Queensland was the site of several outbreaks of locally-acquired dengue virus infection involving all 4 serotypes. These dengue outbreaks affected several locations with over 1,000 notifications. Detection of flavivirus seroconversions in sentinel chicken flocks across Australia provides an early warning of increased levels of Murray Valley encephalitis virus and Kunjin virus activity. Increased levels of flavivirus activity were detected in western and northern Australia, which prompted public health action. This action preceded 4 notifications of Murray Valley encephalitis infections, 2 (fatal) cases acquired in the Northern Territory and two in Western Australia. There were no notifications of locally-acquired malaria in Australia and 567 notifications of overseas-acquired malaria during 2008–09. This annual report presents information of diseases transmitted by mosquitoes in Australia and notified to the National Notifiable Diseases Surveillance System. *Commun Dis Intell* 2010;34(3):225–240.

Keywords: arbovirus; Barmah Forest virus, chikungunya, dengue, disease surveillance; epidemiology, flavivirus, Japanese encephalitis, Kunjin, malaria, mosquito-borne disease, mosquitoes, Murray Valley encephalitis virus, Ross River virus, yellow fever

Introduction

This report describes the surveillance of mosquito-borne diseases of public health importance in Australia from 1 July 2008 to 30 June 2009. It includes those diseases caused by the alphaviruses (Barmah Forest, chikungunya and Ross River), flaviviruses (dengue, Murray Valley encephalitis, Kunjin, Japanese encephalitis and yellow fever) and malaria.

The Australian Government Department of Health and Ageing established the National Arbovirus Advisory Committee (NAAC) in 2001 as a technical advisory group. In March 2003, the NAAC became the National Arbovirus and Malaria Advisory Committee (NAMAC) when malaria was included in its terms of reference. NAMAC monitors arbovirus and malaria surveillance, strategic arbovirus and malaria disease management, and vector control, and has a key role in making recommendations on the management of mosquito-borne diseases. NAMAC provides expert technical advice on arboviruses and malaria to the Australian Health Protection Committee through the Communicable Diseases Network Australia. It also assists in the detection, management and control of actual or potential outbreaks of arboviral and malarial disease. Members of the Committee have expertise in disease surveillance, virology, vector surveillance, vector control and quarantine, and represent agencies with a substantial interest in this area.

Methods

Human cases of arbovirus infection and malaria are monitored using the National Notifiable Diseases Surveillance System (NNDSS). All Australian states and territories require doctors and/or pathology laboratories to notify cases of infectious diseases that are important to public health including several arboviruses and malaria. The *National Health Security Act 2007* provides the legislative basis for communicable disease notifications in Australia and authorises the exchange

of health information between jurisdictions and the Commonwealth. The Act provides for the establishment of the National Notifiable Diseases List, which specifies the diseases about which personal information can be provided. State and territory health departments transfer these notifications regularly to the NNDSS, as described in the *National Health Security Agreement 2008*. The primary responsibility for public health action resulting from a notification resides with state and territory health departments. This report presents data extracted from NNDSS during February 2010 and analysed by date of diagnosis. This is a derived field and represents the earliest of the reported fields of notification date and notification received date. The dataset represents a 'snap shot', and numbers in this report may vary slightly from those reported from other NNDSS sources. Detailed notes on the interpretation of NNDSS are available in the 2008 NNDSS annual report.[1] Case definitions for the diseases included in this report are available from: http://www.health.gov.au/casedefinitions The report includes information on the following pathogens transmitted by mosquitoes:

- alphaviruses (Barmah Forest, Ross River, and chikungunya);
- flaviviruses (dengue, Japanese encephalitis, Kunjin, Murray Valley encephalitis, yellow fever and arbovirus not elsewhere classified); and
- malaria.

To compare notifications in 2008–09 to historical totals, crude numbers and rates of notification were compared either with the mean of the previous 5 years or with data from the previous year. The Australian Bureau of Statistics estimated resident populations for Australia and each state or territory at June 2008, was used to calculate rates of notification.

Additional information was available from a survey conducted with state and territory public health surveillance managers. The survey sought to confirm cases reported to NNDSS and determine the place of acquisition for locally-acquired cases of dengue virus infections. States and territories may conduct follow-up of arbovirus and malaria cases to determine the likely place of acquisition of infection. To date, the Northern Territory, Queensland, Victoria, and Tasmania are able to transfer place of acquisition details to NNDSS.

Overseas and locally-acquired dengue notifications from the Cairns and Townsville areas were mapped, based on the residential postcode of each case, to illustrate the spatial distribution of reported cases during the 2008–09 season. Each dot on the map is randomly assigned to an urban area within the postcode boundary (Map 1).

Results

During the 2008–09 season, there were 8,677 notifications of diseases transmitted by mosquitoes. This represented a 27% increase from the mean of 6,848 notifications for the previous 5 years and can be largely attributed to increased numbers of dengue notifications from the outbreak in Queensland. A summary of the number and rates of these mosquito-borne diseases is shown in Table 1. There were no reported cases of yellow fever during 2008–09.

Alphavirus

The main alphaviruses occurring in Australia, Ross River virus (RRV) and Barmah Forest virus (BFV), can cause illnesses characterised by fever, rash and polyarthritis. These viruses are transmitted by numerous species of mosquitoes that breed in diverse environments (freshwater habitats, coastal regions, salt marshes, floodwaters, established wetlands and urban areas).[2] No specific treatment or vaccine is available for these diseases. During 2008–09, there were 6,574 notifications of alphaviruses (BFV and RRV) of which RRV infections accounted for 74% (4,858).

Barmah Forest virus infections

There were 1,716 notifications of BFV infections during 2008–09, representing a rate of eight per 100,000 population. This was a 4% increase over the mean of the previous 5 years (Table 1). Queensland reported the largest number of notifications of BFV (940) while the highest rate was reported in the Northern Territory (56 per 100,000 population).

The highest age specific rate for males of 16 per 100,000 population was reported in the 50–54 year age group and for females 14 per 100,000 population in the 45–49 year age group. Approximately half of all notifications were male (53%). Cases were reported in all jurisdictions.

As in previous years, there was a marked seasonal trend with the highest number of notifications being diagnosed in the months of January (162) and February (214). The number of BFV notifications per month did not exceed the 5-year rolling mean during the 2008–09 season.

Table 1: Number of notified cases, rate and 5-year mean rate per 100,000 population of mosquito-borne diseases, Australia, 2003–04 to 2008–09, by disease and state or territory

Disease		State or territory								
		ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Aust
Arbovirus infection (NEC*)	Notified cases 2008–09	0	0	0	29	0	0	6	0	35
	Rate, 08–09	0.0	0.0	0.0	0.7	0.0	0.0	0.1	0.0	0.2
	Mean rate, 2003–04 to 07–08	0.0	0.0	0.0	0.7	0.0	0.0	0.1	0.0	0.2
Barmah Forest virus infection	Notified cases 2008–09	2	393	123	940	39	2	15	202	1,716
	Rate, 08–09	0.6	5.6	56.0	21.9	2.4	0.4	0.3	9.3	8.0
	Mean rate, 2003–04 to 07–08	1.3	7.5	32.3	20.1	4.0	0.0	0.5	5.7	7.7
Dengue virus infection– infection acquired from north Queensland	Notified cases 2008–09	0	5	0	1,001	0	0	2	1	1,009
	Rate, 08–09	0.0	0.1	0.0	23.3	0.0	0.0	0.0	0.0	4.7
	Mean rate, 2003–04 to 07–08	0.0	0.0	0.1	3.0	0.0	0.0	0.0	0.0	0.6
Dengue virus infection – infection acquired from overseas	Notified cases 2008–09	13	147	24	131	25	6	18	120	484
	Rate, 08–09	3.8	2.1	10.9	3.1	1.6	1.2	0.3	5.5	2.3
	Mean rate, 2003–04 to 07–08	1.3	0.9	9.2	1.3	0.8	0.2	0.2	1.6	0.9
Japanese encephalitis virus infection – infection acquired from overseas	Notified cases 2008–09	0	1†	0	0	0	0	0	0	1
	Rate, 08–09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean rate, 2003–04 to 07–08	0.0	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0
Kunjin virus Infection	Notified cases 2008–09	0	0	1	2	0	0	0	0	3
	Rate, 08–09	0.0	0.0	0.5	0.0	0.0	0.0	0.00	0.0	0.01
	Mean rate, 2003–04 to 07–08	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Malaria	Notified cases 2008–09	9	111	20	200	24	9	113	81	567
	Rate, 08–09	2.6	1.6	9.1	4.7	1.5	1.8	2.1	3.7	2.6
	Mean rate, 2003–04 to 07–08	3.9	1.9	19.5	5.9	1.9	4.1	1.9	3.9	3.1
Murray Valley encephalitis virus infection	Notified cases 2008–09	0	0	1	1‡	0	0	0	2	4
	Rate, 08–09	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.1	0.0
	Mean rate, 2003–04 to 07–08	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Ross River virus infection	Notified cases 2008–09	8	937	413	2,116	234	25	104	1,021	4,858
	Rate, 08–09	2.3	13.4	187.9	49.3	14.6	5.0	2.0	47.0	22.7
	Mean rate, 2003–04 to 07–08	2.9	12.5	113.7	51.4	10.9	5.1	2.7	39.0	20.9

Does not include 21 chikungunya virus infections reported to the National Notifiable Diseases Surveillance System during the 2008–09 season.

NEC Not elsewhere classified

* Flavivirus (NEC) replaced Arbovirus (NEC) from 1 January 2004. Arbovirus (NEC) replaced Flavivirus (NEC) from 2008.

† New South Wales resident acquired Japanese encephalitis virus infection while visiting Japan.

‡ Queensland resident acquired Murray Valley encephalitis infection while visiting the Northern Territory.

Authorities are considering the possibility of the first evidence of local transmission of BFV in Tasmania based on the travel histories of 2 cases reported during early 2009. All previous notified cases of BFV in Tasmania have reported a travel history to other parts of Australia affected by BFV. These cases justify the provision of advice to general practitioners in Tasmania to assist with the diagnosis of future cases. Further investigation will also be undertaken in an attempt to isolate the virus from known vector mosquito species and local wildlife in Tasmania (personal communication: Department of Health and Human Services, Tasmania).

Ross River virus infections

There were 4,858 notifications of RRV infection during 2008–09 representing a rate of 23 per 100,000 population (Table 1). This was a 9% increase over the mean of the previous five years. Queensland reported the largest number of notifications of RRV (2,116) while the highest rate was reported in the Northern Territory (188 per 100,000 population).

The highest age specific rate for males of 33 per 100,000 population was reported in the 45–64 year age groups and for females 40 per 100,000 population in the 40–45 year age group. Nearly half of all notifications were male (48%).

As in previous years, there was a marked seasonal trend with the highest number of notifications being diagnosed in March (680) and April (597). The number of notifications per month was either similar or less than the 5-year rolling mean during the 2008–09 season.

Both Western Australia and the Northern Territory reported a large increase in RRV notifications when compared with the mean of the previous 5-year period. In 2008–09, the number of notifications reported was the largest for a season since NNDSS began in 1991. This increase was probably due to variations in the amount and timing of rainfall in the various regions compared with previous years, but was possibly complicated to some extent by movement of people between the regions, and differences in pathology test requests or methods.[3]

Chikungunya virus infection

Chikungunya virus (CHIKV) is a member of the Alphavirus genus in the family Togaviridae and is closely related to RRV and BFV. Illness is characterised by an abrupt onset of fever, rash and severe joint pain. The acute disease lasts one to 10 days, but convalescence may include prolonged joint swelling and pain lasting months. It has clinical similarities to dengue, including occasional cases with haemorrhagic manifestations.[4] CHIKV is of concern given that humans are amplification hosts rather than incidental hosts, and other vertebrates are not required for high levels of transmission to occur. In Australia, the known competent mosquito vectors for CHIKV include *Aedes aegypti*, which occurs in northern Queensland and *Aedes albopictus* (Asian Tiger mosquito), which is found on the Cocos, Christmas and the Torres Strait islands.[5] Other Australian mosquitoes have been shown to be competent laboratory vectors of CHIKV and in particular *Aedes* spp., which have been implicated previously as endemic RRV and BFV vectors.[6]

CHIKV infection is a notifiable disease in all jurisdictions other than the Australian Capital Territory. There were 21 notifications of overseas-acquired CHIKV infection reported to NNDSS during 2008–09 compared with 3 cases notified during 2007–08. Ten of the cases were reported to have acquired their infection during travel to Malaysia.

Flaviviruses

This section provides information on several flaviviruses notified to NNDSS including dengue virus, Murray Valley encephalitis virus (MVEV) infection, Kunjin virus (KUNV) infection and Japanese encephalitis virus (JEV) infection. Other flaviviruses may be notified under the Arbovirus (NEC) category. Dengue is characterised by flu like symptoms (fever, headache, muscle or joint pain) and has 4 distinct serotypes. MVEV, KUNV and JEV can, in a small percentage of cases, result in illness involving the central nervous system including encephalitis of variable severity. *Ae. aegypti* is the major vector of dengue in Australia and *Culex annulirostris* is the major vector of MVEV, JEV and KUNV. No specific treatment is available for these diseases and care is largely supportive. A vaccine is not available for dengue, MVEV or KUNV infection but a vaccination to prevent JEV infection is available.[7] Dengue is the most commonly notified flavivirus infection in Australia and accounted for 99% (1,493) of the 1,501 flavivirus notifications reported during 2008–09 (Table 1). The remaining flavivirus notifications included 4 notifications of MVEV infection, 3 notifications of KUNV infection and a single notification of overseas-acquired JEV infection.

Dengue virus infection

There were 1,493 notifications of dengue infection notified during the season of 2008–09. Of

these, 1,009 notified cases were locally-acquired from north Queensland and 484 notified cases acquired their dengue infection while overseas (Table 2). The highest age specific rate for males of 12 cases per 100,000 population was reported in the 40–44 year age group and for females 11 cases per 100,000 population in the 25–29 year age group. Approximately half of all notifications were male (54%). A case of dengue notified from jurisdictions other than Queensland and who did not acquire their infection in Queensland were reported as overseas-acquired cases of infection.

Locally-acquired dengue virus infection

Local transmission of dengue is restricted to areas of northern Queensland where the key mosquito vector, *Ae. aegypti* is present.[8] Dengue is not endemic in North Queensland, however local transmission can occur upon introduction of the virus to the key mosquito vector by a viraemic tourist or a resident returning from a dengue-affected area overseas.[9] These cases of dengue acquired from overseas are of particular public health importance as they resulted in outbreaks in Cairns and Innisfail, Townsville, Yarrabah, Injinoo, Mareeba and Port Douglas. (Table 3). There were 1,009 notifications of locally-acquired dengue infection during 2008–09 representing a rate of 4.7 per 100,000 population (Table 1). The number of notifications reported was the largest for a season since NNDSS began in 1991. All cases of infection were acquired in North Queensland, including a single dengue associated death in March 2009.

Table 2: Place of acquisition of notified cases of dengue virus infection, Australia, 1 July 2004 to 30 June 2009, by state or territory

Place of acquisition	Season	State or territory								
		ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Locally-acquired	2004–05	0	0	0	72	0	0	0	2*	74
(North Queensland)	2005–06	0	0	0	42	0	0	1*	0	43
	2006–07	0	0	1*	46	0	0	0	0	47
	2007–08	0	2*	0	26	2*	0	0	0	30
	2008–09	0	5*	0	1,001	0	0	2*	1*	1,009
Sub-total		0	7	1	1,187	2	0	3	3	1,203
Overseas-acquired	2004–05	1	33	16	41	3	0	8	11	113
	2005–06	7	54	16	33	10	0	12	21	153
	2006–07	2	71	14	67	12	0	9	27	202
	2007–08	4	102	26	84	33	4	15	94	362
	2008–09	13	147	24	131	25	6	18	120	484
Sub-total		27	407	96	356	83	10	62	273	1,314
Total		27	414	97	1,543	85	10	65	276	2,517

* Cases acquired their infection while visiting North Queensland.

Table 3: Number of notified cases of dengue virus infection, Australia, 1 July 2008 to 30 June 2009, by location of outbreak

Outbreak location	Reported cases	Type/s	Past outbreak		Comments
			Year	Serotype[10]	
Cairns (Port Douglas, Yarrabah Injinoo, Mareeba)	915	3	2006	2	Index case imported from Indonesia
Townsville	16	3	2007	3	Linked to Cairns
Cairns	2	2	2006	2	Index case likely imported from Papua New Guinea
Townsville	57	1	2007	3	Index case not identified
Innisfail	35	4	Not reported		Index case imported from Vanuatu

Source: Queensland Health

Published case numbers differ from the National Notifiable Diseases Surveillance System data due to different notification criteria.

The first and largest of these outbreaks started in Cairns with subsequent spread to Townsville and other towns. The initial outbreak in Cairns was declared on 1 December 2008. An investigation identified the earliest case as a Queensland resident who had become unwell after returning from a trip to Kalimantan in Indonesia. Recognition of this outbreak was delayed as the case did not seek prompt medical attention despite being unwell for four to 5 days early in November. Local weather conditions were ideal for mosquito breeding and a relatively short virus incubation period led to a rapid expansion of cases.[10]

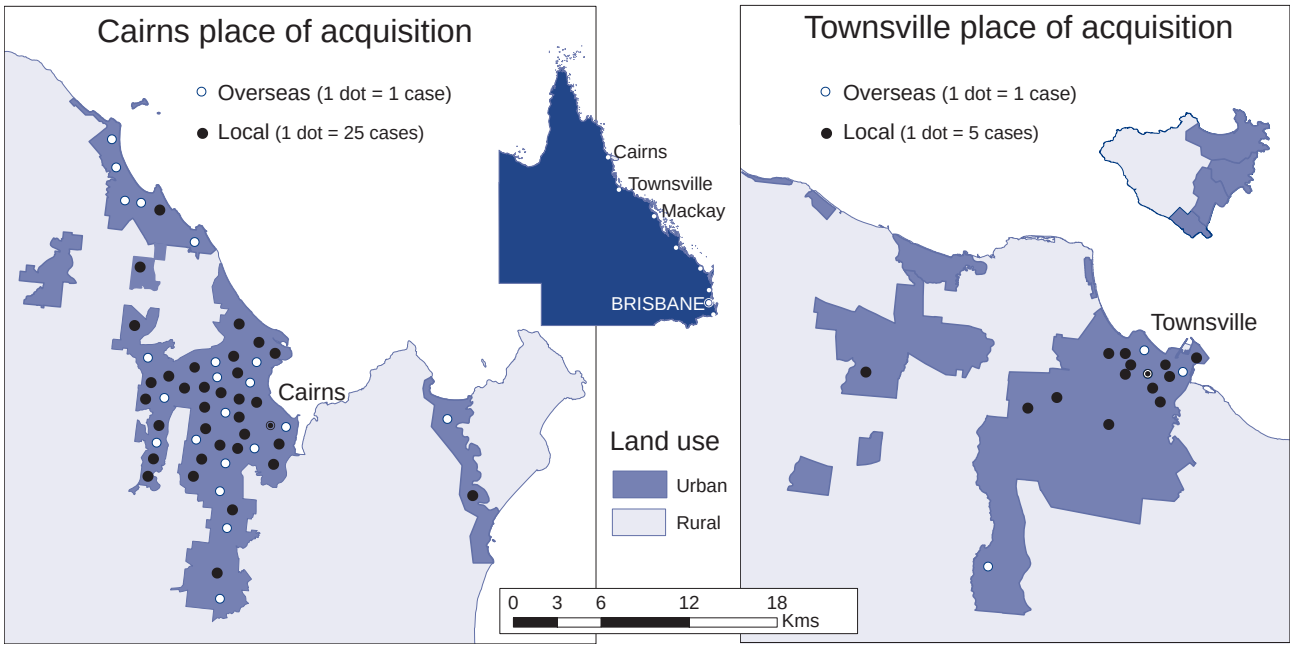
Map 1 shows the extent and general location of cases in the 2008–09 outbreaks in North Queensland, including the notification of 21 overseas-acquired cases of dengue returning to Cairns and 3 cases in Townsville during the season. Of these, just a few of the overseas-acquired cases were responsible for the outbreaks of locally-acquired dengue infection in North Queensland during the 2008–09 season. While authorities attempt to identify the index case (imported case that leads to a local outbreak), it is not always possible, particularly if the index case does not seek or delays seeking medical attention. These overseas-acquired cases present a challenge for local authorities, as any impediment in the identification of a case will delay other public health actions, including mosquito control activities.

As in previous years, there was a marked seasonal trend with locally-acquired cases predominantly being diagnosed between October and May (Figure 1). All 4 serotypes of dengue have circulated in North Queensland at some time in the last 7 years. However, this is the first time that all 4 serotypes had been in circulation at the same time.[10] Having more than 1 strain of the virus circulating in an area may increase the risk of a case of dengue haemorrhagic fever (DHF) or dengue shock syndrome (DSS). DHF/DSS may occur when a person, infected at some time in the past, becomes infected with a different dengue serotype. DHF/DSS occurs most frequently in infants and young children.

Overseas-acquired dengue virus infection

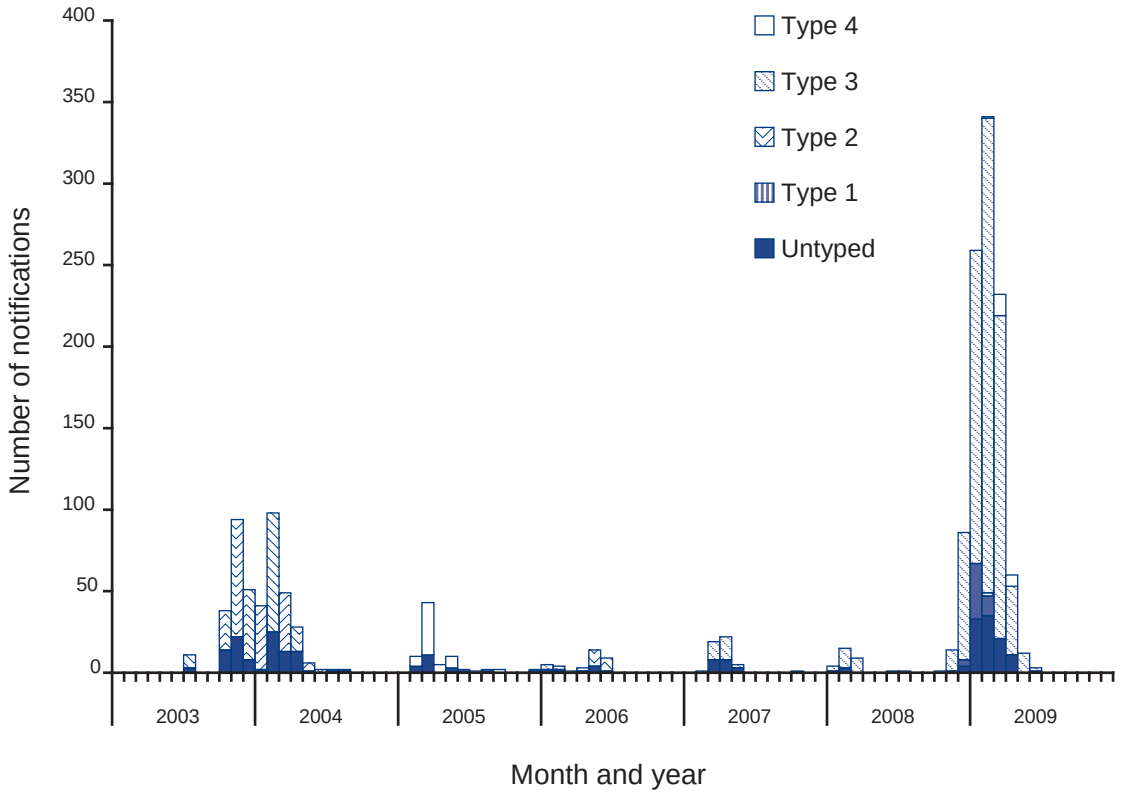
There were 484 notifications of dengue virus infection acquired overseas during the 2008–09 season (Table 1). This was an increase when compared with the mean rate of the previous 5 years of 193 overseas-acquired dengue cases and began at the beginning of 2007 (Figure 2). Case numbers per month were similar throughout the season other than for a peak in January (81). All jurisdictions reported increased numbers of notifications of overseas-acquired dengue virus infection.

Map 1: Geographic distribution of notified cases of overseas and locally-acquired dengue virus infection, Cairns and Townsville, Queensland, Australia, 2008–09



Each dot is randomly assigned within the urban area of the postcode boundary.

Figure 1: Number of notified locally-acquired cases of dengue virus infection, Australia, 1 July 2003 to 30 June 2009, by serotype



Country of acquisition was available for 132 (27%) cases of overseas-acquired dengue reported to NNDSS (Table 4). Indonesia (including Bali) was reported for 32 (7%) cases and involved 3 dengue serotypes. Twenty-four other destinations were identified by cases, which reflect the worldwide distribution of dengue virus infection. The infecting DENV serotype was determined for 105 (22%) of the 484 overseas-acquired dengue cases of which DENV serotype 4 (35) was the most frequently reported.

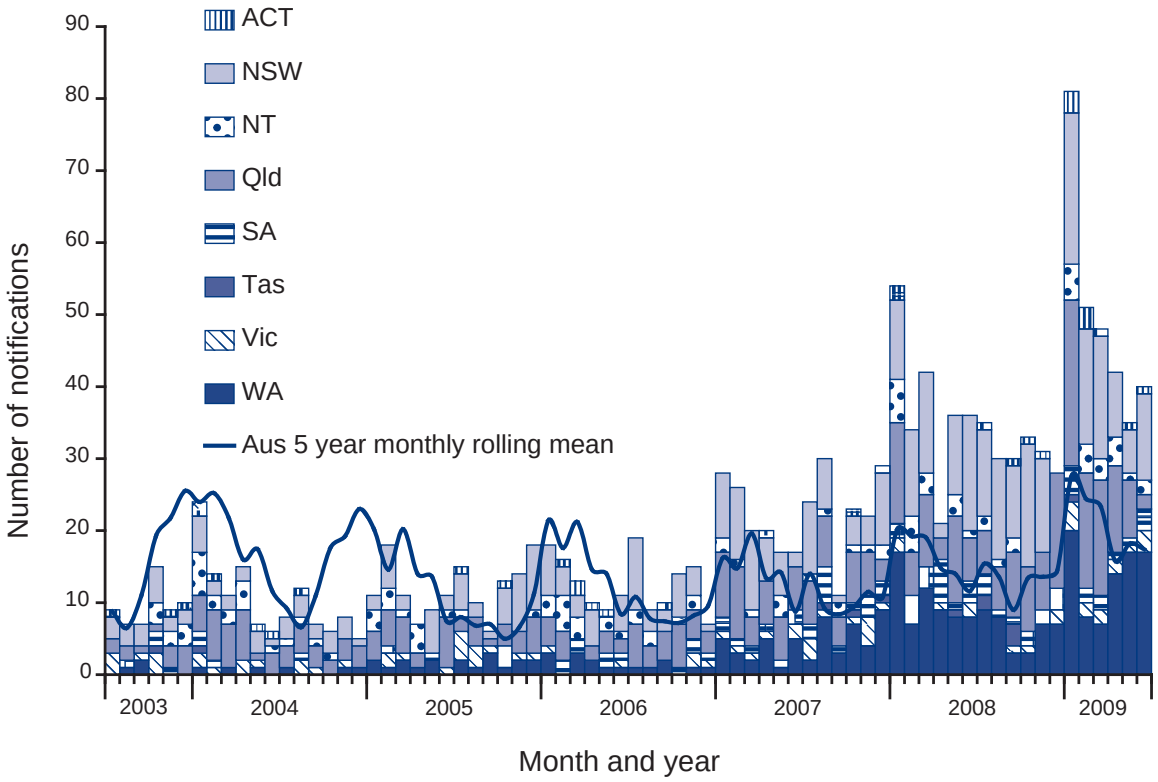
Japanese encephalitis virus infections

There was 1 case of JEV infection notified by New South Wales in Australia in 2008–09. The case was a male in his 20s who reported recent travel to Japan (personal communication: NSW Health). Prior to this notification, the last JEV infection notification was reported by Queensland in February 2004 when a 66-year-old male acquired JEV in Papua New Guinea.[11] There were no cases of locally-acquired JEV infection notified

Table 4: Serotype and country of acquisition of overseas-acquired dengue notifications, Australia, 1 July 2008 to 30 July 2009

Country of acquisition	Total	Dengue serotype				
		Untyped	Virus 1	Virus 2	Virus 3	Virus 4
Indonesia	32	20	0	5	5	2
Thailand	19	12	1	0	6	0
East Timor	12	8	2	0	2	0
Fiji	11	3	0	1	0	7
Tonga	11	7	0	0	1	3
Vanuatu	7	4	0	0	0	3
Samoa	7	1	1	0	0	5
Papua New Guinea	6	1	2	0	3	0
Other country	27	12	4	2	5	4
Country not listed	352	311	15	6	9	11
Total	484	379	25	14	31	35

Figure 2: Number of notified overseas-acquired cases of dengue virus infection, Australia, 1 July 2003 to 30 June 2009, by state or territory



to NNDSS in Australia during 2008–09. The last case of locally-acquired JEV infection was reported in 1998.[12]

Kunjin virus infection

There were 3 locally-acquired human cases of KUNV infection reported in Australia during 2008–09. Two cases were from Queensland and a single case was from the Northern Territory.

Murray Valley encephalitis virus infection

There were 4 notifications of locally-acquired MVEV in Australia resulting in 2 deaths during 2008–09. Two MVEV cases were notified from Western Australia, with 1 case in Broome in March 2009 and 1 case in Port Hedland in May 2009.

The 2 fatal cases of MVEV infection were reported from the Northern Territory. The first case was a long term resident from the Batchelor area in March 2009 and the other was a Queensland resident holidaying at Channel Point in May 2009. Health warnings were given both before and after the cases, with warnings based on vector numbers, rainfall, historical risk periods and/or detections of seroconversions in sentinel chicken flocks.

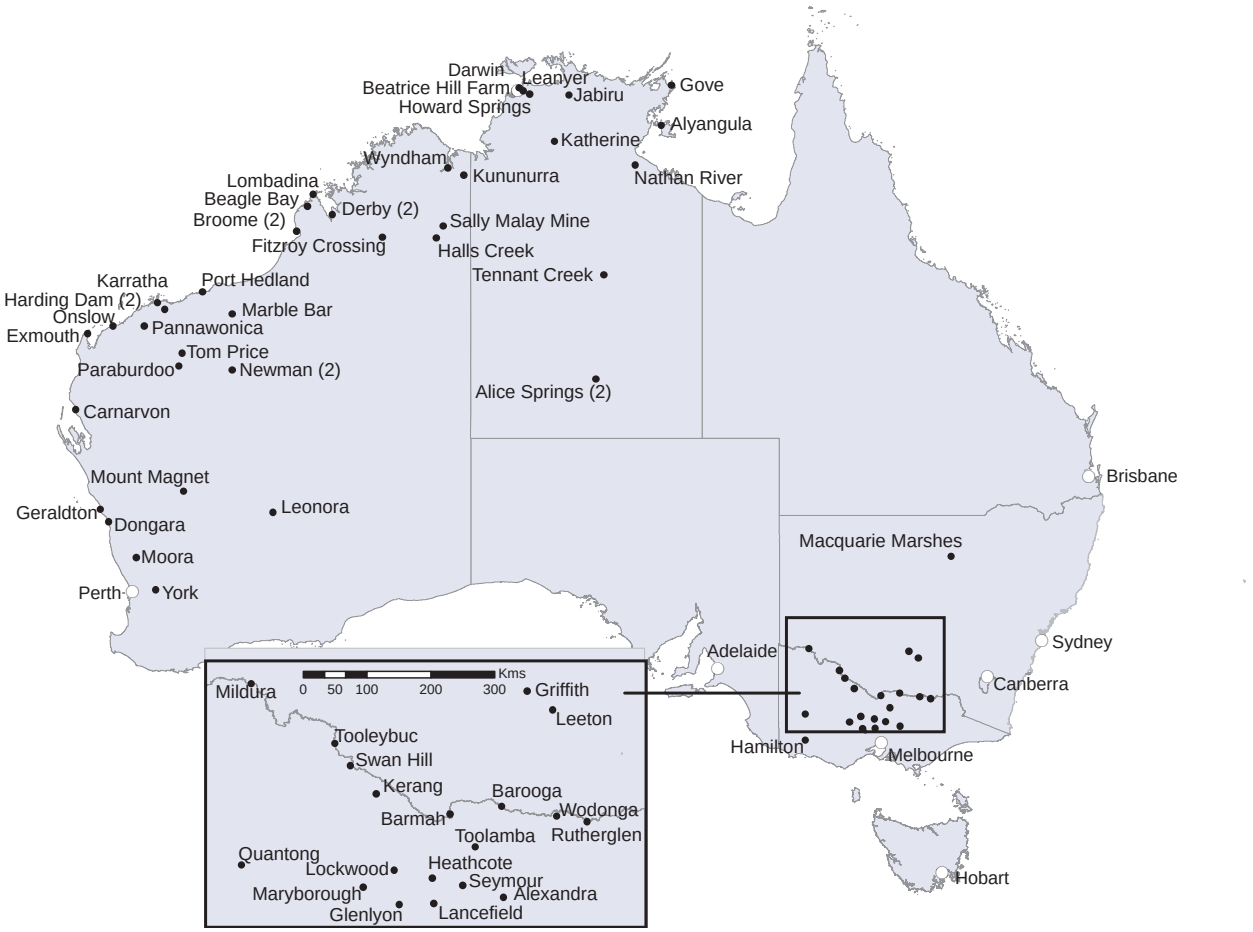
Sentinel chicken flavivirus surveillance programs

The sentinel chicken program is designed to detect flavivirus activity in Western Australia, New South Wales, Victoria and the Northern Territory. The program aims to provide early warning of the endemic arboviruses MVEV and KUNV, as well as exotic arboviruses such as JEV.[13] A public health response or warning can be implemented when chickens from a flock develop new antibodies to a flavivirus of interest. These warnings advise residents of the need to take added precautions to avoid mosquito bites and may be used to direct mosquito management programs. Chickens are replaced at least annually and more frequently if birds die or large proportions seroconvert. The flocks are well positioned to detect flavivirus activity and provide a timely and accurate indication of risk to people.[14] The location of sentinel chicken sites during 2008–09 is shown in Map 2.

Northern Territory

Sentinel chicken flocks in the Northern Territory are maintained, bled and analysed for flavivirus antibodies in a combined program between the Northern Territory Department of Health and Families, the Northern Territory Department of Primary Industry, Fisheries and Mines (DPIFM), and volunteers.

Map 2: Sentinel chicken testing sites, Australia, 2008–09



Sentinel chicken flocks are presently located at Leanyer, Howard Springs, Coastal Plains Research Station, Katherine, Nhulunbuy, Tennant Creek, Jabiru, Alice Springs (2), Nathan River, and Alyangula (Map 2). DPIFM officers or volunteers usually bleed flocks once a month and the samples are tested for antibodies to MVEV and KUNV.

In the 2008–09 season, MVEV activity was detected in the flocks at Howard Springs in May, Leanyer in May, Adelaide River in March and May, Nhulunbuy in January and June, Katherine in December, February, March and April, Tennant Creek in February and March, Jabiru in March and Nathan River in January, March and April. It was notable that during the 2008–09 MVEV season, unusually large numbers of chickens seroconverted to MVEV in a number of flocks including Coastal Plains, Katherine and Tennant Creek, indicating widespread and relatively high virus activity in the Top End and as far south as Tennant Creek. However, there was no seroconversion to either MVEV or KUNV in the Alice Springs flocks. This reflected relatively dry weather conditions and the present lack of the Ilparpa wetland during summer after drainage provisions were installed in 2001–02, whereby excess effluent is being pumped to a site for injection into an aquifer rather than routinely released into the wetland. The Jabiru, Nathan River and Katherine flock were not bled in May or June, and the Leanyer, Coastal Plains and Tennant Creek flocks were not bled in June, generally because appreciable numbers of chickens had already seroconverted. The Howard Springs chickens were not bled between August 2008 and March 2009 due to operational problems, and the Robinson River chickens were only bled once in July 2008. The Robinson River flock will no longer be part of the flavivirus surveillance program.

KUNV activity occurred in all Northern Territory regions except in the Alice Springs region, where chickens seroconverted to a flavivirus that could not be further identified. Seroconversions to KUNV occurred between January and May 2009. Seroconversions to both MVEV and KUNV were the highest this year since the current sentinel chicken program started in 1992–93. Most of the MVEV and KUNV seroconversions occurred in March, notably around the same time as the first human case of MVEV in the Northern Territory.

Northern Territory sentinel chicken surveillance indicated that during the 2008–09 season, MVEV was wide-spread in the Northern Territory as far south as Tennant Creek, with large numbers of chickens seroconverting to MVEV, and all flocks except Alyangula and the Alice Springs flocks showing seroconversions. The absence of MVEV seroconversions around Alyangula over the last 3 years indicate that the Alyangula locality is not conducive to MVEV transmission, probably as a result of relatively low numbers of the principle vector and the lack of a nearby wetland and associated birds. There have been no seroconversions to MVEV in the Alice Springs flocks since 2001–02, when the Ilparpa swamp was drained. Health warnings were issued throughout the main MVEV risk period between January and June 2009.

Western Australia

The Arbovirus Surveillance and Research Laboratory (ASRL) at The University of Western Australia, on behalf of the Western Australian Department of Health, undertakes the flavivirus sentinel chicken program in Western Australia. Many state and local government authorities and community volunteers also take part in the program. Thirty sentinel chicken flocks (of up to 12 chickens) are located at major towns and communities in the Kimberley, Pilbara, Gascoyne, Goldfields, Midwest and Central Coastal regions of Western Australia (Map 2). Blood samples are collected from the chickens by environmental health officers or trained volunteers at fortnightly intervals during the peak MVEV risk season (December to June). At other times of the year, monthly blood samples are collected, unless prolonged flavivirus activity warrants continued fortnightly sampling. Samples are transported to the ASRL where they are tested for antibodies to flaviviruses using an epitope blocking ELISA.[15]

The passage of Tropical Cyclone Billy in the northern Kimberley region in December caused heavy rain and flooding. Above average rainfall was recorded across most of the Kimberley, Pilbara, Interior and southern Goldfields. Successive tropical cyclones and low pressure systems caused further rainfall and flooding in northern Western Australia in January, February and March. The west Pilbara was particularly affected in February, and the eastern Pilbara received heavy rainfall in March. Conditions were generally dry in northern Western Australia between April and June 2009.

A total of 4,067 serum samples from the 30 sentinel chicken flocks were tested for antibodies to flaviviruses during 2008–09.[16] Seroconversions were detected in 247 (6.1%) of the samples. Two MVEV seroconversions detected at Onslow in the Pilbara region in July and August 2008 were associated with activity extending from the 2007–08 wet season. The first activity associated with the 2008–09 wet season occurred in February 2009, when MVEV was detected at Kununurra in the north-east Kimberley region, Halls Creek and Sally Malay mine in the south-east Kimberley region, Fitzroy Crossing in the West Kimberley region, and a couple of weeks later at Harding Dam in the Pilbara region. KUNV activity was also detected in February, when 2 seroconversions to KUNV were detected at Marble Bar, in the Pilbara region. Widespread MVEV activity continued, and was ultimately detected at all locations where sentinel chickens were in place in the Kimberley, Pilbara and Gascoyne regions. The level of MVEV activity was very high in 2008–09, with 108 MVEV seroconversions in the Kimberley, 99 in the Pilbara and four in the Gascoyne region. Overall, the level of MVEV activity was substantially higher than the previous season, and was almost as high as 2000, when there was widespread activity of MVEV and 11 clinical cases, including 9 cases of encephalitis.[17] Despite the high level of MVEV activity, no seroconversions to MVEV were detected south of the Gascoyne region. In contrast, the level of activity of KUNV was relatively low, and activity of KUNV was not detected south of Newman. A small proportion of unidentified flavivirus infections were detected at several locations in the Kimberley and Pilbara regions, possibly due to activity of other flaviviruses that have previously been isolated from mosquitoes collected in northern Western Australia.

New South Wales

The NSW Arbovirus Surveillance and Mosquito Monitoring program at the Institute of Clinical Pathology and Medical Research undertakes the New South Wales sentinel chicken program. The 2008–09 season began on 2 October 2008 and ended on 12 April 2009. A total of 1,509 samples were received from 6 sentinel chicken flocks in New South Wales over a 7-month period in 2008–09. The sentinel chicken flocks were located at Bourke, Deniliquin, Griffith, Leeton, Macquarie Marshes and Menindee (Map 2). There were no seroconversions to MVEV or KUNV.[18] A description of the bleeding method of the chickens and the testing regime is outlined in the 2003–2004 New South Wales Arbovirus Surveillance Program annual report.[19]

Victoria

The Victorian Department of Primary Industry on behalf of the Victorian Department of Health undertakes the Victorian sentinel chicken program.

The program received 6,160 samples from the 10 sentinel chicken flocks in Victoria during the season (Map 2). There were no seroconversions to MVEV or KUNV. Detection of MVEV activity in Victoria during March and April 2008 prompted the addition of 9 sites to test weekly from 1 January 2009 to 30 March 2009 (total tests 1,620). These sites were across an east/west direction and further south than the established 10 sites in the Murray Valley region. Similarly, no seroconversions were detected (personal communication: Victorian Government Department of Health).

Malaria

Malaria is a serious acute febrile illness that is normally transmitted from person to person through the bite of an infected mosquito. It is caused by a protozoan parasite called *Plasmodium* that includes 4 species – *vivax*, *falciparum*, *malariae* and *ovale*.[20] A 5th species, *Plasmodium knowlesi* has been recently identified as a cause of human malaria occurring predominantly throughout South East Asia. Infection with this primate malaria has the potential of being fatal if treatment is not given early in the course of an infection.[21]

There were 567 notifications of overseas-acquired malaria during the season 2008–09, representing a rate of 2.6 per 100,000 population (Table 1). This was a decrease when compared with the mean rate of the previous 5 years of 3.1 per 100,000 population. There were no reports of locally-acquired malaria. The last outbreak of locally-acquired malaria occurred in North Queensland during 2002.[22] Notification rates ranged from 1.5 per 100,000 population in South Australia to 9.1 per 100,000 population in the Northern Territory. All jurisdictions reported a decrease in notifications when compared with the previous 5 years, other than in Victoria (1.9 to 2.1 per 100,000 population). Seventy-one per cent of notifications were male, which was consistent with the past 5 years. The highest age specific rate for males of 8.2 per 100,000 and 4.1 per 100,000 population for females was reported in the 20–24 year age group. No deaths from malaria were reported during the 2008–09 season.

The infecting *Plasmodium* species was reported for 96% of malaria notifications during 2008–09 (Table 5). Of these 567 notifications, *P. falciparum* and *P. vivax* were the predominant species. There were no cases of *P. knowlesi* notified to NNDSS during 2008–09.

The country of acquisition of infection was available for 227 (40%) cases of malaria reported to NNDSS (Table 6). Papua New Guinea was reported as the country of acquisition by 113 (20%) cases and included both *P. falciparum* and *P. vivax* species. Twenty-four other destinations were identified by cases. They included India (34), Indonesia (9) and Mozambique (7).

Arbovirus infection (NEC)

The category Arbovirus infection (NEC) includes notifications of vectorborne infections not elsewhere classified. There were 35 notifications in this category during 2008–09, which was similar when compared with the previous 5 years. Queensland (29) and Victoria (6) accounted for all notified cases. Single notifications were identified as Kokobera and Stratford virus infection.

Other surveillance and research activities

National Arbovirus Monitoring Program

The National Arbovirus Monitoring Program (NAMP) monitors the distribution of economically important arboviruses of livestock and their vectors

Table 5: Overseas-acquired malaria cases, Australia 1 July 2008 to 30 June 2009, by species and state or territory

Plasmodium species	State or territory									Type (%)
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Aust	
Plasmodium falciparum	2	41	10	80	11	6	32	49	231	41
Plasmodium vivax	6	63	8	94	11	2	73	21	278	49
Other *Plasmodium* species	1	7	1	6	0	1	2	4	22	4
Mixed *Plasmodium* species	0	0	1	0	2	0	5	5	13	2
Plasmodium species	0	0	0	20	0	0	1	2	23	4
Total	9	111	20	200	24	9	113	81	567	

New South Wales, Victoria, South Australia, Western Australia, Tasmania and the Northern Territory report mixed species infections per notified case. Queensland and the Australian Capital Territory report 1 notification for each species in a mixed infection.

Table 6: Overseas-acquired malaria cases, Australia, 1 July 2008 to 30 June 2009, by country of acquisition and species

Country of acquisition	Total	*Plasmodium* species				
		Not specified	*Falciparum*	*Vivax*	Other *Plasmodium* species	Mixed *Plasmodium* species
Papua New Guinea	113	6	31	73	2	1
India	34	1	0	33	0	0
Indonesia	9	0	3	4	0	2
Mozambique	7	0	7	0	0	0
Other country	64	0	46	15	1	2
Country not listed	340	16	144	153	19	8
Total	567	23	231	278	22	13

in Australia. Important arboviruses include bluetongue, Akabane and bovine ephemeral fever and are further described in the NAMP 2008–2009 annual report. NAMP is jointly funded by its primary beneficiaries, including the cattle, sheep and goat industries and the state, territory and Australian governments.[23]

Northern Australia Quarantine Strategy

The Australian Quarantine and Inspection Service Northern Australia Quarantine Strategy continues to undertake limited surveillance for transmission of JEV in the Torres Strait and mainland Australia. A sentinel pig herd at Injinoo airport near Bamaga in Cape York, Queensland has not shown any serological evidence of mainland transmission since early 2004.[24]

Torres Strait Mosquito Elimination Program

The mosquito *Ae. albopictus*, which is exotic to Australia, was found on the outer islands of Torres Strait in April 2005.[25] If this mosquito establishes in Australia it will increase the number and spread of mosquitoes capable of transmitting dengue and chikungunya as well as becoming a new serious pest mosquito. Since 2005, the Australian Government has provided funding to Queensland Health towards a mosquito elimination program in the Torres Strait. The initial aim of the program was to eliminate *Ae. albopictus* from the Torres Strait islands. The development and implementation of a program based on the 'cordon sanitaire' approach (a barrier designed to prevent a disease or other undesirable condition from spreading) around Thursday and Horn islands was initiated in May 2008 in an attempt to prevent the spread of *Ae. albopictus* further south, following unsuccessful attempts to eliminate *Ae. albopictus* from the outer islands of the Torres Strait.[26] Multiple incursions of *Ae. albopictus* into the Torres Strait had likely occurred and resulted from human activity or traffic moving these mosquitoes around the Torres Strait. In May 2009, the Australian Government agreed to provide further funding to Queensland Health over 4 years, to continue support towards the Torres Strait Health Protection Strategy mosquito program.[27] The focus of the program is surveillance and control of *Ae. albopictus* in the Torres Strait and prevention of the spread of *Ae. albopictus* from the Torres Strait to mainland Australia.

Enhancing emerging zoonotic disease surveillance data from animals

In light of worldwide animal and human health crises such as severe acute respiratory syndrome, the pandemic influenza (H1N1) 2009 and Nipah virus, the need for an interdisciplinary approach to emerging and re-emerging zoonoses is gaining significant international recognition. Samples currently collected in Australia from wildlife are only analysed for a limited number of diseases such as avian influenza or Newcastle disease.

The Australian Government Department of Agriculture, Fisheries and Forestry funded a pilot project in the 2008–2009 financial year to determine how surveillance of zoonotic infections in animals can add to the understanding of the epidemiology of emerging zoonoses in humans, using MVEV as a model. Project partners, which reflect the 'One Health' philosophy, include the Australian Government Department of Health and Ageing, the Australian Wildlife Health Network and Animal Health Australia.

Initial findings of this report (which is to be published in *Vector-Borne and Zoonotic Diseases*) support the use of chickens for surveillance, and also recommend the use of young cattle and horses for general MVEV surveillance. Eastern grey kangaroos also showed a high prevalence of antibody to MVEV, making them a potential source for

monitoring outbreaks and retrospectively determining the extent of an outbreak (personal communication: Australian Government Department of Agriculture, Fisheries and Forestry).

Discussion

This report summarises the surveillance of nationally notifiable mosquito-borne disease in Australia for 1 July 2008 to 30 June 2009. Of particular concern were the outbreaks of locally-acquired dengue infection in North Queensland and the occurrence of fatal human cases of MVEV infection in the Northern Territory.

Australia experienced several outbreaks of locally-acquired dengue virus infections involving all 4 serotypes in Queensland from 1 July 2008 to 30 June 2009. It is important to rapidly diagnose the disease in returning residents and tourists to prevent local spread in North Queensland. Queensland health authorities are experienced in responding to outbreaks of the disease and implemented the Dengue Fever Management Plan. A major focus of the response was raising public awareness of the need to take responsibility for reducing mosquito breeding opportunities around homes, and for those people living in areas where dengue fever was known to occur to seek medical advice if feeling unwell. Control measures also included spraying known mosquito breeding sites with insecticide. People were encouraged to avoid dengue infection by taking measures to prevent mosquito bites. This included using insect repellent, wearing long sleeve clothing and reducing mosquito breeding sites by ensuring that pools and other receptacles of water are not available in and around the home.

Outbreaks of dengue in North Queensland are not unprecedented; in 2003–04 there were over 800 cases of locally-acquired dengue reported in Queensland and in 1998 nearly 500 cases of dengue serotype 2 were recorded.[10] By comparison, the 2008–09 outbreaks of all 4 serotypes affected several locations with over 1,000 dengue cases in a short period and represented the largest reported annual number of cases in recent times.[10,28] Much of the increase in overseas-acquired dengue virus infections over the past few years can be attributed to an increase in disease activity in the Asia–Pacific region. The World Health Organization has warned of a spreading threat of dengue outbreaks in the Asia–Pacific region. This threat has been recognised in the publication of a regional strategic plan.[29]

Authorities are concerned that the more severe forms of the disease, DHF/DSS may eventuate as outbreaks of multiple serotypes of dengue continue to occur in North Queensland. DHF/DSS may occur when a person, infected at some time in the past, becomes infected with a different dengue serotype. As a result, NAMAC is considering the feasibility of the eradication of the *Ae. aegypti* mosquito from North Queensland.

The main way of preventing and controlling the further spread of dengue fever is to control the vector *Ae. aegypti* through environmental management (e.g. eliminating larval habitats) and/or insecticide application. Mosquito control strategies will continue to evolve but must now take account of the recent drought conditions that has led to water storage vessels increasingly being used across Australia. If vessels such as water tanks are not mosquito 'proof' then there is the potential for increased mosquito breeding and mosquito-borne diseases such as dengue.[30] Water tanks in Australia built to Australian standards and maintained to that standard will not allow mosquito breeding because of the mosquito proofing at access points. However, poorly maintained water tanks may quickly become a suitable site for mosquito breeding.

Malaria and dengue, although almost completely preventable, remain a significant risk to travellers overseas despite warnings and other travel advice. Travellers continue to acquire malaria and dengue infections. The main way to minimise the risk of infection is to avoid being bitten by mosquitoes through the application of personal prevention measures. Travellers are encouraged to consider the information available on the Smartraveller travel health web site and to seek a doctor's advice prior to travel.

MVEV activity in the sentinel chicken flocks in northern Western Australia and the Northern Territory both led to public health actions in the form of media releases to warn the public of potential infection and other prevention strategies. These warnings started prior to the human cases of MVEV infection during the season and demonstrate that sentinel chicken surveillance provided public health authorities forewarning of virus activity.

The limitations of surveillance data used in this report are referred to in detailed notes on the interpretation of NNDSS, which are available in the 2008 NNDSS annual report.[1] A specific limitation of the data used in this report relates to the virological testing, which is required to distinguish alphavirus disease from other causes of arthritis. The alphavirus infections notified to NNDSS each season are based on laboratory definitive evidence only and assumes a clinically compatible arthritic infection. A case can still be

notified when clinical illness may not be consistent with the diagnosis of alphavirus infection. Furthermore, false positive reactions are an issue in the serological diagnosis of some arboviral infections and cross-reacting IgM can occur, particularly with flavivirus infections. Following some infections, particularly alphaviruses and flaviviruses, IgM antibodies can persist for long periods and should be interpreted as presumptive evidence of recent infection.[31] The Case Definitions Working Group of the Communicable Diseases Network Australia is reviewing this issue. Human surveillance for alphavirus infection enables local authorities to implement public health action and manage local disease outbreaks, but does not necessarily provide a reliable indication of the true incidence of a disease.

Another limitation on the findings of this report relates to place or country of acquisition of infection. This information is currently not available for all notifications due to system limitations. The Northern Territory, Queensland, Victoria, and Tasmania are the jurisdictions able to provide place of acquisition details to NNDSS.

Surveillance and reporting systems for arbovirus disease and malaria encompassing humans and animals provides information to assist in the detection, management and control of real or potential outbreaks in Australia. The surveillance of these diseases contributes to the preparation for and prevention of outbreaks, implementation of response measures to control outbreaks, and enables NAMAC to provide advice on the strategic approaches for the management of arbovirus disease and malaria.

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Author details

Gerard J Fitzsimmons[1]
Phil Wright[1]
Cheryl A Johansen[2]
Peter I Whelan[3]

1. Zoonoses, Foodborne and Emerging Infectious Diseases, Office of Health Protection, Australian Government Department of Health and Ageing, CANBERRA, Australian Capital Territory
2. Arbovirus Surveillance and Research Laboratory, Discipline of Microbiology and Immunology, The University of Western Australia, Western Australia
3. Medical Entomology, Communicable Disease Control, Department of Health and Families, Northern Territory

Corresponding author: Mr Gerard Fitzsimmons, Zoonoses, Foodborne and Emerging Infectious Diseases, Office of Health Protection, Australian Government Department of Health and Ageing, GPO Box 9848, MDP 14, CANBERRA, ACT 2601. Telephone: +61 2 6289 2748. Facsimile: +61 2 6289 2500. Email: Gerard.Fitzsimmons@health.gov.au

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