Annual report

Arboviral diseases and malaria in Australia, 2012–13: Annual report of the National Arbovirus and Malaria Advisory Committee

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Abstract

This report describes the epidemiology of mosquito-borne diseases of public health importance in Australia during the 2012–13 season (1 July 2012 to 30 June 2013) and includes data from human notifications, sentinel chicken, vector and virus surveillance programs. The National Notifiable Diseases Surveillance System received notifications for 9,726 cases of disease transmitted by mosquitoes during the 2012–13 season. The Australasian alphaviruses Barmah Forest virus and Ross River virus accounted for 7,776 (80%) of total notifications. However, over-diagnosis and possible false positive diagnostic test results for these 2 infections mean that the true burden of infection is likely overestimated, and as a consequence, the case definitions were revised, effective from 1 January 2016. There were 96 notifications of imported chikungunya virus infection. There were 212 notifications of dengue virus infection acquired in Australia and 1,202 cases acquired overseas, with an additional 16 cases for which the place of acquisition was unknown. Imported cases of dengue were most frequently acquired in Indonesia. No locally-acquired malaria was notified during the 2012–13 season, though there were 415 notifications of overseas-acquired malaria. There were no cases of Murray Valley encephalitis virus infection in 2012–13. In 2012–13, arbovirus and mosquito surveillance programs were conducted in most jurisdictions with a risk of vectorborne disease transmission. Surveillance for exotic mosquitoes at the border continues to be a vital part of preventing the spread of mosquito-borne diseases such as dengue to new areas of Australia, and in 2012–13, there were 7 detections of exotic mosquitoes at the border. *Commun Dis Intell* 2016;40(1):E17–E47.

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

Introduction

This report describes the epidemiology of mosquito-borne diseases of public health importance in Australia during the period 1 July 2012 to 30 June 2013. It includes a summary of notified cases of disease caused by the alphaviruses Barmah Forest virus (BFV), chikungunya virus (CHIKV) and Ross River virus (RRV); the flaviviruses dengue virus (DENV), Murray Valley encephalitis virus (MVEV), West Nile virus (WNV) and the Kunjin lineage of West Nile virus (KUNV), Japanese encephalitis virus (JEV) and yellow fever virus (YFV); and malaria. Both locally acquired and overseas acquired cases are described. Vector, climate and sentinel chicken surveillance measures for arboviruses conducted by states and territories, and also at the international first ports of entry are described.

The National Arbovirus and Malaria Advisory Committee (NAMAC) provides expert technical advice on arboviruses and malaria to the Australian Health Protection Principal Committee (AHPPC) through the Communicable Diseases Network Australia (CDNA). Members of NAMAC have expertise in virus and disease surveillance, epidemiology, virology, vector ecology, vector control and quarantine, and represent agencies with a substantial interest in this area. NAMAC makes recommendations about surveillance and reporting systems, strategic approaches for disease and vector management and control, and laboratory support outlines research priorities. NAMAC develops and provides input to national guidelines and response plans. NAMAC assists in the detection, management and control of real or potential outbreaks of arboviruses or malaria and provides advice on the risk of these diseases or exotic vectors being imported from overseas and the potential impacts on Australia. NAMAC members participate in outbreak management teams as required.

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. The *National Health Security Act 2007* (NHS Act 2007) provides the legislative basis for the national notification of communicable diseases and authorises the exchange of health information between the Commonwealth and the states and territories. The NHS Act 2007 provides for the establishment of the National Notifiable Diseases List, which specifies the diseases about which personal information can be exchanged between the states and territories and the Commonwealth. State and territory health departments transfer these notifications regularly to the NNDSS. The primary responsibility for public health action resulting from a notification resides with state and territory health departments.

This report presents data from a snap-shot of NNDSS taken during July 2015 and analysed by date of diagnosis. This derived field is the onset date, or where the date of onset was not known, for vectorborne diseases, it is the earliest of the specimen collection date, the notification date, or the notification received date. Since the data are from a snap-shot, numbers in this report may vary slightly from those reported elsewhere due to changes in diagnostic validation or classification. Data were verified with state and territory public health surveillance managers. Detailed notes on the interpretation of NNDSS are available in the 2013 NNDSS annual report.[1] Case definitions for the diseases included in this report are available on the Australian Government Department of Health web site (http://www.health.gov.au/casedefinitions).

CHIKV infection became nationally notifiable in 2015, though a national case definition was implemented from 2010. Prior to this, CHIKV infections were notified under the disease category flavivirus (unspecified), and all notifications have now been included under CHIKV.

Data were analysed by financial year to reflect the seasonal cycle of arboviral activity in most areas of Australia. Crude notification rates or counts for the 2012–13 season were compared with those recorded over the previous 5 years. Notification rates were not calculated for diseases that are primarily acquired overseas because resident populations are not an appropriate denominator. Rates are not provided for rare diseases ($n < 20$) because these rates typically have large standard errors and therefore cannot be meaningfully compared across time or geographical location.

Notification rates were calculated using the Australian Bureau of Statistics estimated resident populations for Australia and each state or territory at June 2013.[2] Population data are supplied as an estimate for calendar years; for this report, the population for the second half of the financial year was applied (2013 population applied to the 2012–13 financial year). Analyses were conducted using Microsoft Excel® and Stata SE version 13.

Due to a limitation of surveillance systems, Queensland notifies mixed infections of malaria as a separate notification for each infecting organism. For the 2012–13 season, additional information was collected to enable these mixed infections to be reported as 1 case for the purpose of this report, resulting in 3 fewer notifications than if the adjustment was not made.

Additional information on the details of some notifications was obtained from state and territory public health surveillance managers. Data on sentinel chicken surveillance and vector (including detection of exotic mosquitoes at the border) and virus surveillance are also reported here.

Vertebrate, vector and climate surveillance in states and territories

Sentinel chicken flavivirus surveillance programs aim to provide early warning of the endemic arboviruses MVEV and KUNV and where relevant, exotic flaviviruses such as JEV.[3] Public health messaging or other response measures can be implemented in response to surveillance signals. Public health messaging may advise at-risk residents or target groups such as campers or fishermen of the need to take added precautions to avoid mosquito bites. Sentinel chicken flocks are an important component of the early warning system in several jurisdictions, and these are located geographically to detect flavivirus activity and provide a timely and accurate indication of the risk of transmission to people (Map).[4] Detailed descriptions of the sentinel chicken, vector and virus surveillance programs, as well as contact details for jurisdictional arbovirus reference/research laboratories are included in the Appendix.

Results

During the 2012–13 season, there were 9,726 notifications of mosquito-borne diseases in humans (Table 1). This represented a 16% increase from the mean of 8,404.2 notifications for the previous 5 years.

Table 1: Number of notified human cases, notification rate* and 5 year mean for mosquito-borne disease, Australia, 2012–13, by disease and state or territory

		ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Aust. total
Barmah Forest virus infection	Cases 2012–13	5	456	353	2,025	84	2	70	926	3,921
	5 year mean cases	3.8	398.6	78.6	926.2	61.2	1.6	69.2	135.4	16,74.6
	Rate 2012–13	1.3	6.2	146.4	43.5	5.0	0.4	1.2	36.7	16.9
	5 year mean rate	1.1	5.6	34.6	20.8	3.7	0.3	1.2	5.9	7.6
Chikungunya virus infection	Cases 2012–13	0	12	1	11	7	1	26	38	96
	5 year mean cases	0.0	7.6	2.8	2.8	1.4	0.4	9.4	5.4	29.8
	Rate 2012–13	–	–	–	–	–	–	–	–	–
	5 year mean rate	–	–	–	–	–	–	–	–	–
Dengue virus infection	Cases 2012–13	16	263	38	425	49	8	305	326	1,430
	5 year mean cases	13.2	174.8	37.6	384.8	29.0	5.6	101.6	305.8	1,052.4
	Rate 2012–13	–	–	–	–	–	–	–	–	–
	5 year mean rate	–	–	–	–	–	–	–	–	–
Flavivirus (unspecified)†	Cases 2012–13	0	0	1	6	0	0	0	0	7
	5 year mean cases	0.0	0.2	0.0	4.0	0.2	0.0	6.4	0.0	10.8
	Rate 2012–13	–	–	–	–	–	–	–	–	–
	5 year mean rate	–	–	–	–	–	–	–	–	–
Japanese encephalitis virus infection	Cases 2012–13	0	0	0	0	1	0	0	1	2
	5 year mean cases	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.4
	Rate 2012–13	–	–	–	–	–	–	–	–	–
	5 year mean rate	–	–	–	–	–	–	–	–	–
West Nile virus/Kunjin virus infection	Cases 2012–13	0	0	0	0	0	0	0	0	0
	5 year mean cases	0.0	0.2	0.6	0.6	0.0	0.0	0.2	0.0	1.6
	Rate 2012–13	–	–	–	–	–	–	–	–	–
	5 year mean rate	–	–	–	–	–	–	–	–	–
Malaria	Cases 2012–13	16	81	23	105	10	9	89	82	415
	5 year mean cases	11.8	98.0	17.2	144.6	14.8	7.6	90.6	66.2	450.8
	Rate 2012–13	–	–	–	–	–	–	–	–	–
	5 year mean rate	–	–	–	–	–	–	–	–	–
Murray Valley encephalitis virus infection	Cases 2012–13	0	0	0	0	0	0	0	0	0
	5 year mean cases	0.0	0.8	0.6	0.4	0.4	0.0	0.0	2.4	4.6
	Rate 2012–13	–	–	–	–	–	–	–	–	–
	5 year mean rate	–	–	–	–	–	–	–	–	–
Ross River virus infection	Cases 2012–13	5	502	211	1,683	177	6	190	1,081	3,855
	5 year mean cases	13.6	909.6	295.4	2,149.4	440.4	34.0	458.6	877.8	5,178.8
	Rate 2012–13	1.3	6.8	87.5	36.2	10.6	1.2	3.3	42.9	16.7
	5 year mean rate	3.8	12.7	129.9	48.3	26.8	6.8	8.2	37.9	23.4
Yellow fever	Cases 2012–13	0	0	0	0	0	0	0	0	0
	5 year mean cases	0	0	0	0.3	0	0	0	0	0
	Rate 2012–13	–	–	–	–	–	–	–	–	–
	5 year mean rate	–	–	–	–	–	–	–	–	–
Total cases 2012–13		42	1,314	627	4,255	328	26	680	2,454	9,726

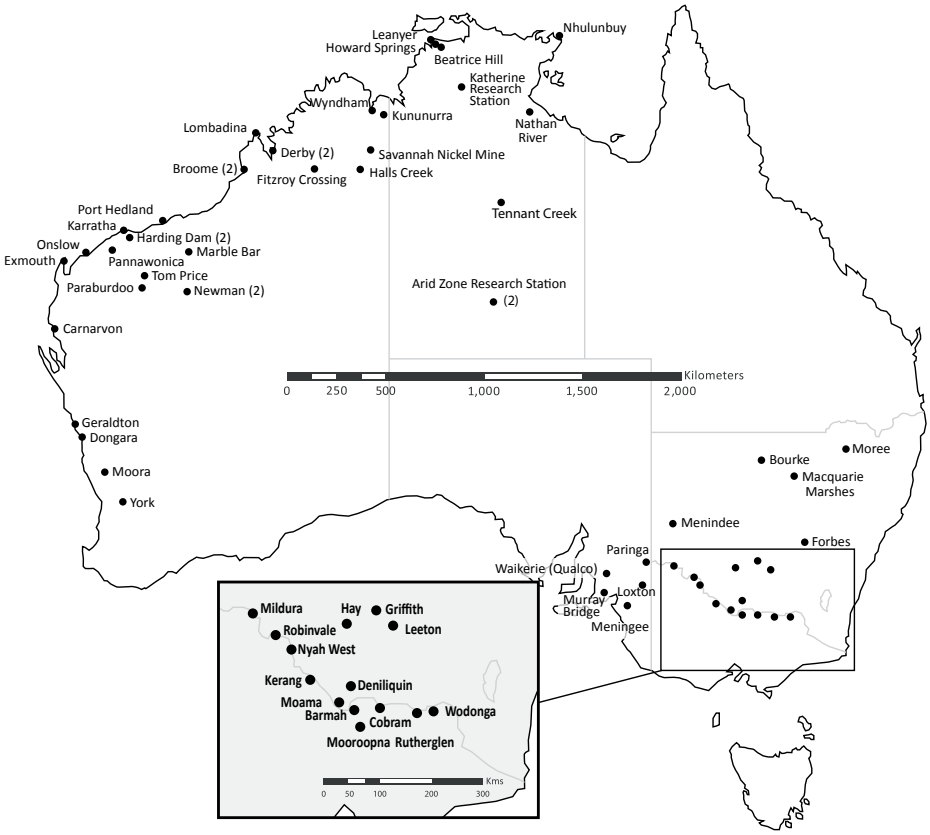
* Rates are not provided for diseases with less than 20 cases, or for diseases predominantly acquired overseas.

† Flavivirus (NEC) replaced Arbovirus (NEC) from 1 January 2004. Arbovirus (NEC) replaced Flavivirus (NEC) from 2008. Flavivirus (unspecified) replaced arbovirus (NEC) from 1 July 2015.

NEC Not elsewhere classified.

NN Not notifiable.

Map: Location of sentinel chicken sites, Australia, 2012–13



Alphaviruses

In Australia, the most frequently notified viruses in the genus alphavirus are RRV and BFV. RRV and BFV occur exclusively in the Australasian region.[5] Infection with RRV or BFV can cause illness 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).[6] However, there are known problems with the unreliability of serological tests that diagnose infection on the basis of IgM only and with the case definitions which allow for confirmation based on these tests, leading to over diagnosis particularly during the off-season.[7,8] Importantly, the case definitions have been reviewed by the case definitions working group (CDWG) and endorsed by CDNA. The revised case definitions were implemented on 1 January 2016.

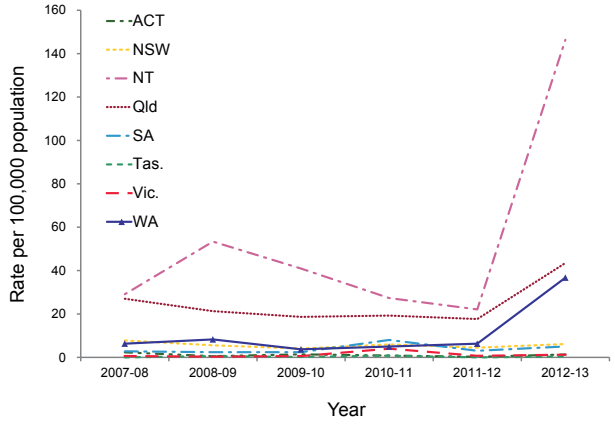
Local transmission of the alphavirus CHIKV has not occurred in Australia, but the infection is regularly reported in travellers returning from overseas. Illness is characterised by an abrupt onset of fever, rash and severe joint pain. The acute disease lasts 1 to 10 days, but convalescence may include prolonged joint swelling and pain lasting months. Haemorrhagic manifestations may occur occasionally.[9] Humans are amplification hosts for CHIKV, and other vertebrates are not required for transmission to occur. Internationally, CHIKV is most commonly transmitted by *Aedes aegypti*, which occurs in northern Queensland and *Aedes albopictus,* which is found on Cocos Island, Christmas Island and in some areas of the Torres Strait Islands.[10] Other Australian mosquito species have been shown to be competent vectors of CHIKV in the laboratory,[11] but any role in field transmission is likely to be minor compared with either *Ae. aegypti* or *Ae. albopictus*.[12]

Barmah Forest virus infections

There were 3,921 notifications of BFV infections during the 2012–13 season, representing a rate of 16.9 per 100,000 population, an increase from the mean of 7.6 per 100,000 for the previous 5 years (Table 1). Queensland reported the largest number of notifications of BFV infection (n=2,025) while the highest rate was reported in the Northern Territory (146.4 per 100,000 population). Rates in 2012–13 increased sharply for most state and territories compared to the past 5 years (Figure 1), and were greater than 2.0 times the 5 year mean for the Northern Territory, Queensland and Western Australia. Comparisons between regions are likely to be influenced by accuracy of case-ascertainment, which may vary between jurisdic-

tions due to differences in reporting criteria and diagnostic tests used (in particular, with IgM test kits).[13] It is important to note that seasonal trends vary between and within states and territories according to differences in mosquito vectors, hosts and climate. In addition, comparisons between regions are likely to be influenced by accuracy of case-ascertainment, which may vary between jurisdictions because of some differences in reporting criteria and the quality of diagnostic tests used, with false positive IgMs a long term issue.[8,14]

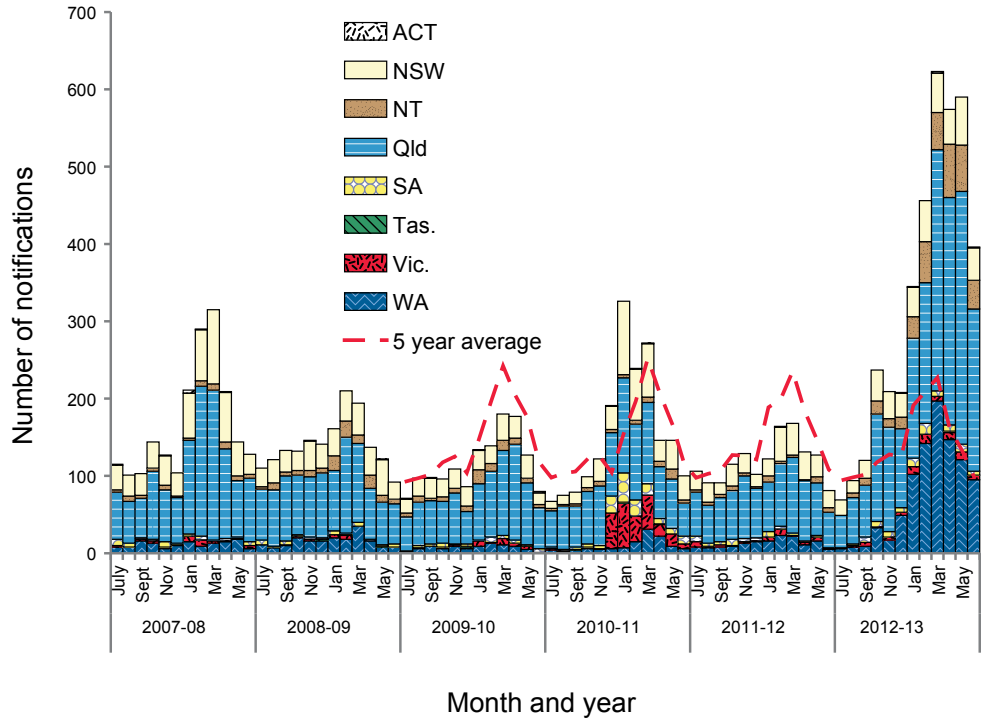
Figure 1: Notification rate for Barmah Forest virus infection, Australia, July 2007 to June 2013, by year and state or territory



In 2012–13, infections were most frequently notified between February and May (Figure 2). BFV infections are more common during the warmer months when suitable mosquito vectors are abundant, and are unexpected outside of these warmer months. The higher than expected numbers of BFV notifications in the cooler months is likely to be an artefact, reflecting the likelihood of false positive IgM diagnoses. In October 2012, the number of BFV notifications began to increase dramatically, and marked the start of an 'epidemic' of notifications due to false positive IgM diagnoses, which continued to the end of 2012–13 and into 2013–14 (data not shown).

In 2012–13, BFV notifications were most commonly reported among middle aged adults, with notification rates peaking in the 40–64 year age range for females, and with a secondary peak of notifications among females in the 15–39 years age group females (Figure 3). Rates among younger and middle aged females were increased compared with the previous year, with rates of 12.2 and 13.0 per 100,000 among females aged 15–19 and 20–24 years respectively in 2012–13, compared with 5.6 and 6.7 per 100,000 in 2011–12. In 2012–13, 41% of cases were male, which was lower than in previous years (48% of cases during the previous 5 years were male).

Figure 2: Notifications of Barmah Forest virus infection, Australia, July 2007 to June 2013, by month and year



Ross River virus infections

There were 3,855 notifications of RRV infection during the 2012–13 season, representing a rate of 16.7 per 100,000 population, compared with a 5-year mean of 5,178.8 notifications and a rate of 23.4 per 100,000 (Table 1, Figure 4). Queensland reported the largest number of cases (n=1,683), while the highest rate was in the Northern Territory (Figure 5).

Rates of RRV were similar to or below the 5-year mean in all jurisdictions (Table 1). RRV was most commonly reported among younger and middle-aged adults, with notification rates peaking in the 35–49 year age groups (Figure 6). In 2012–13, 47% of cases were male.

Figure 5: Notification rate for Ross River virus infection, Australia, 1 July 2007 to 30 June 2013, by year and state or territory

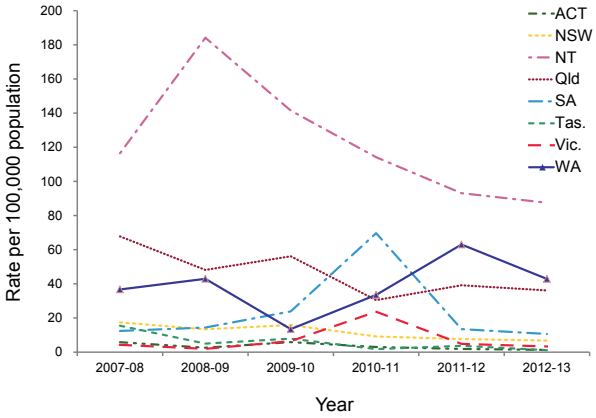


Figure 3: Notification rate for Barmah Forest virus infection, Australia, 2011–12 and 2012–13, by age group and sex (n=5,348)

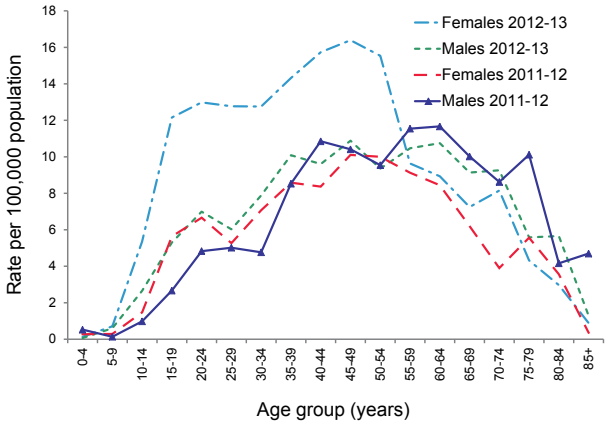


Figure 6: Notification rate for Ross River virus infection, Australia, 2012–13, by age group and sex (n=3,855)

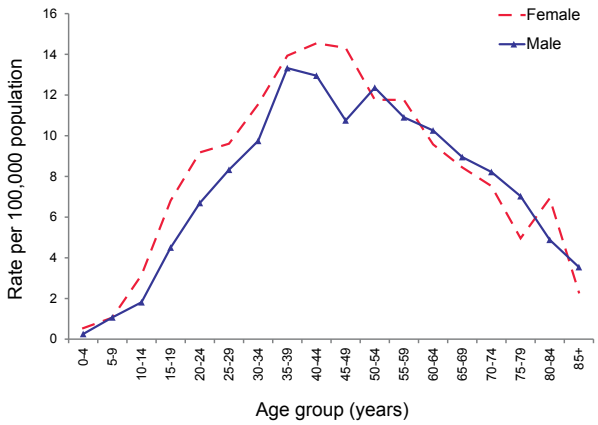
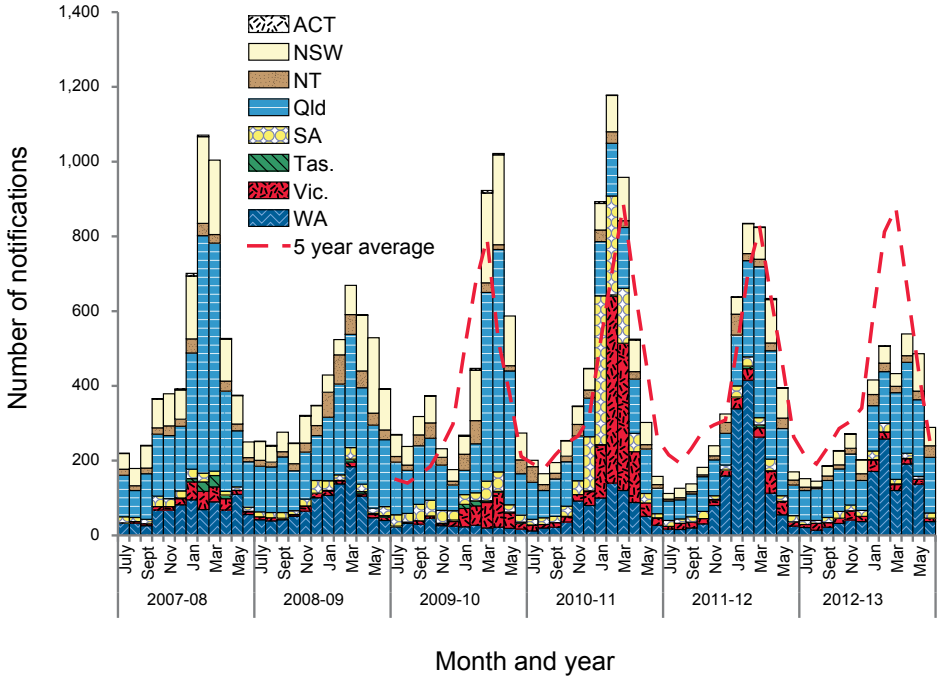


Figure 4: Notifications of Ross River virus infection, 1 July 2007 to 30 June 2013, by month



As in previous years, there was a marked seasonal trend in RRV notifications, with the largest number notified between January and April (Figure 4). It is important to note that as for BFV, seasonal trends vary between and within states and territories according to differences in mosquito vectors, hosts and climate. In addition, comparisons between regions are likely to be influenced by accuracy of case-ascertainment, which may vary between jurisdictions because of some differences in reporting criteria and the quality of diagnostic tests used, with false positive IgMs a long term issue.[8,14]

Chikungunya virus infection

There were 96 notifications of CHIKV infection during the 2012–13 season compared with a 5–year mean of 29.8 cases (Table 1, Figure 7). This was the largest number of cases ever reported in Australia. All cases were acquired overseas, with complete information supplied on the country of acquisition for 60% (58/96) of these (Table 2). The most frequently reported country of acquisition was Indonesia (34 cases). There were 13 importations from Papua New Guinea, where chikungunya was reported for the first time in June 2012 on PacNet,

Figure 7: Notifications of chikungunya virus infection, Australia, 2012–13, by month and year and state or territory

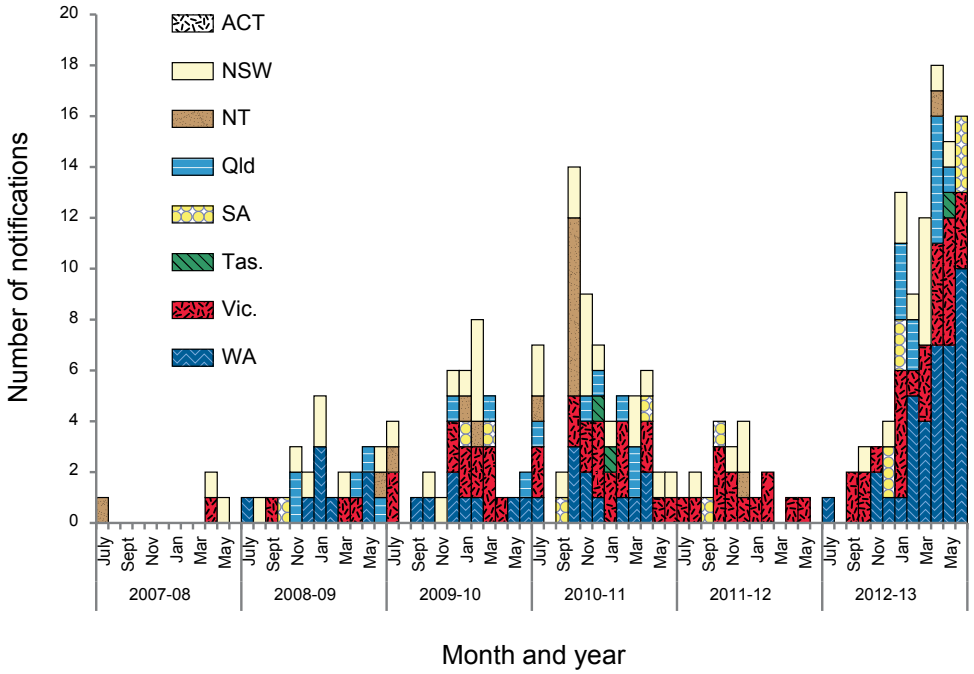


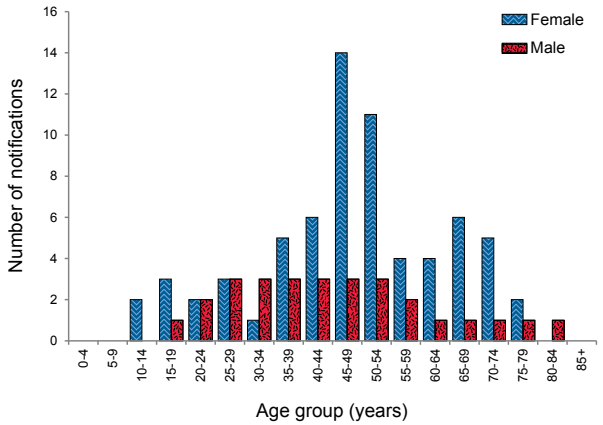
Table 2: Notifications of chikungunya virus infection, Australia, by year and country or region of acquisition

Country or region of acquisition	2008–09	2009–10	2010–11	2011–12	2012–13
Indonesia	2	7	32	2	34
Papua New Guinea	0	0	2	0	13
India	1	14	11	6	2
Philippines	0	1	0	2	2
Thailand	3	0	2	3	2
Malaysia	6	4	1	1	1
Cambodia	0	0	0	0	1
Vietnam	0	0	2	0	1
Kenya	0	0	0	0	1
Other countries or regions	2	10	11	4	0
Overseas – country unknown	11	1	2	2	39
Total	25	37	63	20	96

the Pacific Public Health Surveillance Network early warning system, with widespread outbreaks that continued into June 2013.[15,16]

CHIKV infection was most frequently notified among young and middle aged adults, particularly women aged between 45 and 54 years (Figure 8). The median age was 48 years and 71% of cases were female.

Figure 8: Notifications of chikungunya virus infection, Australia, 2012–13, by age and sex



Flaviviruses

This section provides information on several flaviviruses notified to NNDSS including DENV, MVEV, KUNV and JEV. Other flaviviruses may be notified under the flavivirus (unspecified) category.

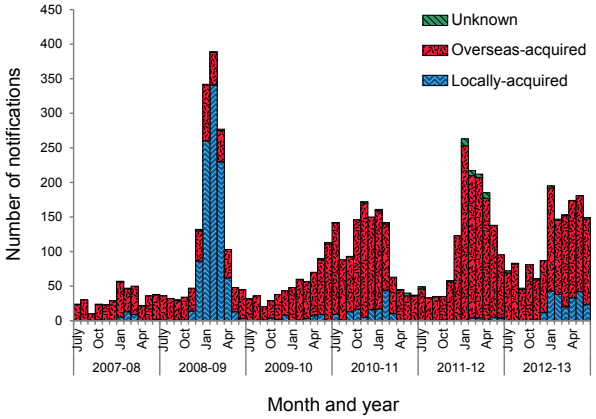
Four serotypes of dengue virus have been described and all 4 are reported in imported cases to varying degrees each year, some of which may result in local outbreaks. The clinical illness is characterised by mild to severe febrile illness with fever, headache, muscle/joint pain and sometimes a rash. A minority of cases progress to severe dengue with haemorrhage and shock, more commonly where, in a second or subsequent infection, a person is infected with a different DENV serotype to the first infection. Local transmission of dengue in Australia is normally restricted to areas of northern Queensland where the key mosquito vector, *Ae. aegypti,* is present in sufficient numbers and near human populations of sufficient size.[17] Dengue is not endemic in North Queensland, but local transmission can occur upon introduction of the virus to the mosquito vector by a viraemic tourist or a resident returning from a dengue-affected area overseas.[18]

Infection with MVEV, KUNV or JEV is usually asymptomatic or produces a non-specific illness, but a small percentage of cases progress to encephalomyelitis of variable severity. *Culex annulirostris* is the major vector of MVEV, KUNV and JEV. No specific treatment is available for these diseases and care is largely supportive. A vaccine is available to prevent JEV infection (available for residents in affected areas of Queensland and for long term travellers to endemic areas)[19] but there are no vaccines currently available for DENV, MVEV or KUNV. YFV does not occur in Australia, but travellers to affected areas overseas need to be aware of the risks and vaccination requirements, and there is a risk of transmission in the areas of North Queensland in which the vector *Ae. aegypti* is present.

Dengue virus infection

There were 1,430 notifications of DENV infection during the 2012–13 season. Of these, 212 cases were acquired in Australia, while the majority (1,202 cases) acquired the infection overseas (Table 3, Figure 9). For the remaining 16 cases, no information on place of acquisition was supplied. In 2012–13, the median age of cases was 39 years (range 0–86 years), and 51% (n=733) of cases were male.

Figure 9: Notifications of dengue virus infection, Australia, 1 July 2007 to 30 June 2013, by month, year and place of acquisition



Locally-acquired dengue virus infection

The 212 notified cases of DENV infection acquired in Australia during 2012–13 was a marked increase compared with the 18 locally-acquired cases in 2011–12, but was more consistent with previous years (Table 3). Of these, 206 were reported by Queensland, and 6 by other states.

In Queensland, a single case of locally-acquired dengue is considered an outbreak. Ten discrete dengue outbreaks were reported by Queensland Health in the 2012–2013 season, all located in the north of the state. A total of 203 notifications were

known to have been associated with these outbreaks, with the number of cases in each outbreak ranging from 1 to 138 (these numbers do not match exactly with the 189 reported from NNDSS due to differences in the dates used for data extraction). Seven of the 10 outbreaks, including the largest, were attributable to dengue serotype 1. One outbreak each was associated with dengue serotypes 2 and 3 and the serotype responsible for the remaining outbreak was unknown. The unknown outbreak consisted of only a single case where the serotyping could not be completed.

The 6 notifications of locally-acquired dengue from other states were listed in NNDSS as being acquired in Queensland.

Overseas-acquired dengue virus infection

There were 1,202 notifications of DENV infection acquired overseas during the 2012–13 season (Table 3), 1.5 times the 5-year mean of overseas-acquired infections (793.8). Almost all states and territories reported increased numbers of notified cases of overseas-acquired DENV infection compared with the long-term average. The ratio of notifications in 2012–13 compared with the 5-year mean ranged from 1.0 in the Northern Territory to 3.2 in Victoria.

A specific country or region of acquisition was supplied for 73% (879/1,202) of cases listed as overseas-acquired (Table 4). Indonesia was the country of acquisition for nearly a quarter of overseas acquired cases for which a specific country or region was available (24%, n=278), much lower than the 64% in 2011–12.[7] The infecting DENV serotype was determined for 42% (n=506) of overseas-acquired dengue cases (up from 23% in 2011–12 but similar to the 50% in 2010–11). DENV 1 (n=210) was the most frequently reported serotype in 2012–13 (Table 4).

Table 3: Notifications of dengue virus infection, Australia, 1 July 2007 to 30 June 2013, by year, state or territory and place of acquisition

Place of acquisition	Year	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Aust.
Locally-acquired*	2007–08	0	2	0	26	2	0	0	0	30
	2008–09	0	5	0	1,003	1	0	3	0	1,012
	2009–10	0	2	0	33	0	0	0	0	35
	2010–11	0	2	1	125	0	0	2	1	131
	2011–12	0	1	0	16	0	0	1	0	18
	2012–13	0	0	0	206	2	0	4	0	212
Overseas-acquired	2007–08	4	103	25	78	31	4	15	94	354
	2008–09	14	169	27	115	26	6	19	121	497
	2009–10	19	121	36	126	11	4	52	226	595
	2010–11	4	222	29	181	28	5	140	525	1,134
	2011–12	11	240	69	209	44	9	246	561	1,389
	2012–13	12	257	38	216	47	8	299	325	1,202
Unknown	2007–08	0	0	0	4	2	0	0	0	6
	2008–09	0	0	0	5	0	0	1	0	6
	2009–10	0	3	0	1	0	0	1	0	5
	2010–11	8	2	1	2	0	0	0	1	14
	2011–12	6	2	0	0	0	0	28	0	36
	2012–13	4	6	0	3	0	0	2	1	16
Total	2007–08	4	105	25	108	35	4	15	94	390
	2008–09	14	174	27	1,123	27	6	23	121	1,515
	2009–10	19	126	36	160	11	4	53	226	635
	2010–11	12	226	31	308	28	5	142	527	1,279
	2011–12	17	243	69	225	44	9	275	561	1,443
	2012–13	16	263	38	425	49	8	305	326	1,430

* Locally-acquired cases are acquired in Australia and not necessarily in the state or territory from which they are reported. Under the cross-border notification protocol, cases are notified by their state or territory of residence where this differs from the diagnosing state or territory.

Table 4: Overseas acquired cases of dengue virus infection, Australia, 2012–13, by serotype and country of acquisition

Country/ or region	Total number	Percentage of cases*	Serotype 1	Serotype 1 and 4	Serotype 2	Serotype 3	Serotype 4	Unknown/ untyped
Indonesia	278	24	43	0	20	22	2	191
Thailand	217	19	31	0	11	16	0	159
India	63	5	4	0	5	12	0	42
Philippines	46	4	9	1	3	0	2	31
Papua New Guinea	35	3	6	0	6	5	0	18
Cambodia	34	3	8	0	0	1	1	24
Sri Lanka	29	2	7	0	0	3	0	19
Malaysia	19	2	1	0	0	0	3	15
Timor-Leste	19	2	2	0	0	9	0	8
Vietnam	17	1	2	0	2	2	0	11
Fiji	17	1	5	0	3	0	0	9
Bangladesh	14	1	1	0	0	0	0	13
Solomon Islands	14	1	0	0	0	6	0	8
South-East Asia, nfd	9	1	0	0	0	1	0	8
Singapore	9	1	0	0	2	1	0	6
New Caledonia	7	1	3	0	0	0	0	4
Myanmar, The Republic of the Union of	4	0	2	0	0	0	0	2
Sudan	3	0	0	0	0	0	0	3
South America, nfd	3	0	1	0	0	0	0	2
China†	3	0	0	0	0	0	0	3
Maldives	3	0	1	0	0	0	0	2
Vanuatu	3	0	1	0	0	0	0	2
Other countries‡	33	3	6	0	2	2	2	21
Overseas – country unknown	323		77	0	96	44	11	95
Total	1,202		210	1	150	124	21	696

* The denominator excludes cases with place of acquisition "Overseas–country unknown". Percentages do not add up due to rounding.

† Excludes special administrative regions and Taiwan.

‡ Each country with less than 3 cases.

nfd Not further defined

Flavivirus infection (unspecified)

This disease category enables the capture and epidemiological analysis of emerging infections within this very broad disease group. Emerging diseases can be made nationally notifiable if required. An unspecified category is particularly important for the flaviviruses, because it is recognised that some infections cannot be attributed to a single flavivirus.

There were 7 notifications of flavivirus (unspecified) in 2012–13, similar to the 5-year average of 10.8 cases. All were confirmed infections as per the case definition. Five notifications relate to infections that were known to have been acquired overseas while for the remaining 2, the place of acquisition was unknown. In 2012–13, 2 notifications were for Kokobera, 1 was for Zika (acquired in Indonesia) and for the remainder, the infection could not be attributed to a specific flavivirus (Table 5).

The largest number of notifications were from Queensland (n=6). In Queensland, an extensive panel of flaviviruses is used for testing. Flaviviruses

Table 5: Notifications of flavivirus infection (unspecified), Australia, 2012–13

Virus species	Country of acquisition	State or territory	Month
Kokobera	Place of acquisition unknown	Qld	Jan
Kokobera	Place of acquisition unknown	Qld	Mar
Unspecified	Thailand	Qld	July
Unspecified	Philippines	Qld	Jan
Unspecified	Thailand	Qld	May
Unspecified	Indonesia	Qld	Jun
Zika	Indonesia	NT	Mar

may be more prevalent particularly in the north of the state, so patients may be more likely to be exposed to more than 1 flavivirus, and these factors could increase the probability of cross-reacting antibodies (Dr Sonya Bennett, Queensland Health, personal communication) resulting in more notifications of flavivirus (unspecified).

Japanese encephalitis virus infections

There were 2 notifications of JEV infection in Australia during 2012–13. The first was notified by Western Australia in a 41-year-old woman who acquired the infection in Indonesia, and the second was notified by South Australia in a 57-year-old man who had been resident in Thailand during the 3 years prior to onset and was transferred to Australia for treatment.

JEV infection is a rare disease in Australia, with an average of 0.4 cases per year during the past 5 years. The last locally-acquired case was in 1998.[20]

West Nile virus/Kunjin virus infection

This category includes all WNV infections, including KUNV, which is an Australian lineage and has not been isolated from anywhere except on the Australian mainland and Torres Strait, and other WNV infections that are acquired overseas. While infection with KUNV is probably not uncommon in northern Australia, clinical KUNV cases are rare in Australia.[21,22]

There were no notifications of WNV/KUNV infection in Australia in 2012–13. There was an average of 1.6 cases per year during the past 5 years.

Murray Valley encephalitis virus infection

There were no notifications of MVEV infection in Australia in 2012–13. MVEV infection is a rare disease in Australia, with an average of 4.6 cases per year during the past 5 years.

Yellow fever virus infection

There were no notifications of yellow fever virus infection in 2012–13. The only previous notifications of yellow fever were in 2011, and while the notifications met the surveillance case definition at the time, they were thought to be vaccine-associated. The surveillance case definition has since been revised to exclude vaccine associated cases.

Malaria

Malaria is a serious acute febrile illness that is transmitted from person to person through the bite of an infected mosquito of the genus *Anopheles*. It is caused by a protozoan parasite in the genus *Plasmodium* that includes 5 species that infect humans – *Plasmodium vivax*, *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium knowlesi*.[23,24]

Australia is free of endemic malaria, but suitable vectors are present in northern Australia, and the area remains malaria-receptive. Malaria in Australia is therefore a disease associated with residing or travelling overseas in areas with endemic transmission. A case series in the Northern Territory showed that malaria cases were reported in travellers returning from endemic areas, but also reflected current events such as military operations and increased refugee arrivals from malaria endemic areas.[25] The last cases acquired on mainland Australia were during an outbreak in North Queensland in 2002.[26] Limited transmission occurs occasionally in the Torres Strait following importation. The most recent locally-acquired cases of malaria in Australia were a single case in 2013 acquired on Saibai Island in the Torres Strait and 7 locally-acquired cases in the Torres Strait in 2011.

There were 415 notifications of malaria during 2012–13 (Table 1), an 8% decrease compared with the mean of 450.8 notifications during the past 5 years, which is consistent with the steady decline in the number of notifications since 2004–05 (Figure 10). There was 1 locally-acquired case of malaria in Australia in 2012–13 (acquired in the

Torres Strait). Complete information on the overseas country or region of acquisition was supplied for 76% of overseas-acquired cases (316/414).

Malaria was most frequently reported among people aged 25–29 years, with 59 notified cases in this age group (Figure 11). Similar to previous years, the majority of cases were male (71%, n=294), and males predominated in every age group except those aged 70–74 years.

The infecting species was reported for 99% of notifications during 2012–13. *P. falciparum* and *P. vivax* were the predominant species (Table 6). No cases were infected with *P. knowlesi*. *P. vivax* infections were commonly associated with travel to Asia or Pacific nations while. *P. falciparum* infections were frequently associated with travel to the Middle East, Africa and Papua New Guinea.

Complete information about the country of acquisition was available for 77% (n=315) of malaria cases. Papua New Guinea was the most frequently reported place of acquisition (13%, 53/415), followed by India (12%, 50/415) (Table 6, Figure 12).

Figure 10: Notifications of malaria, Australia, 1 July 1991 to 30 June 2013

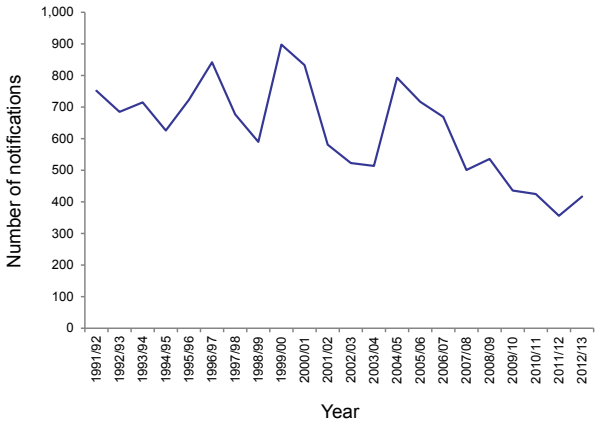
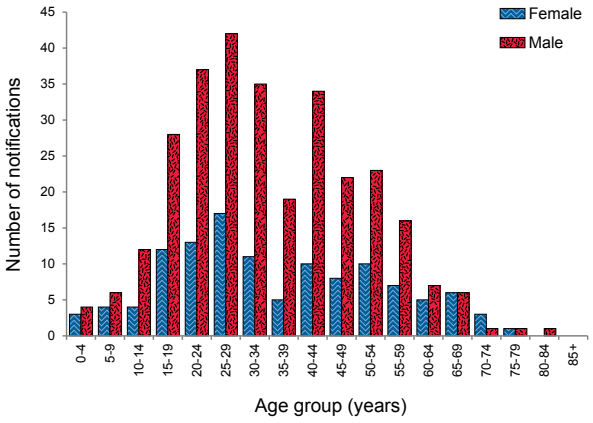
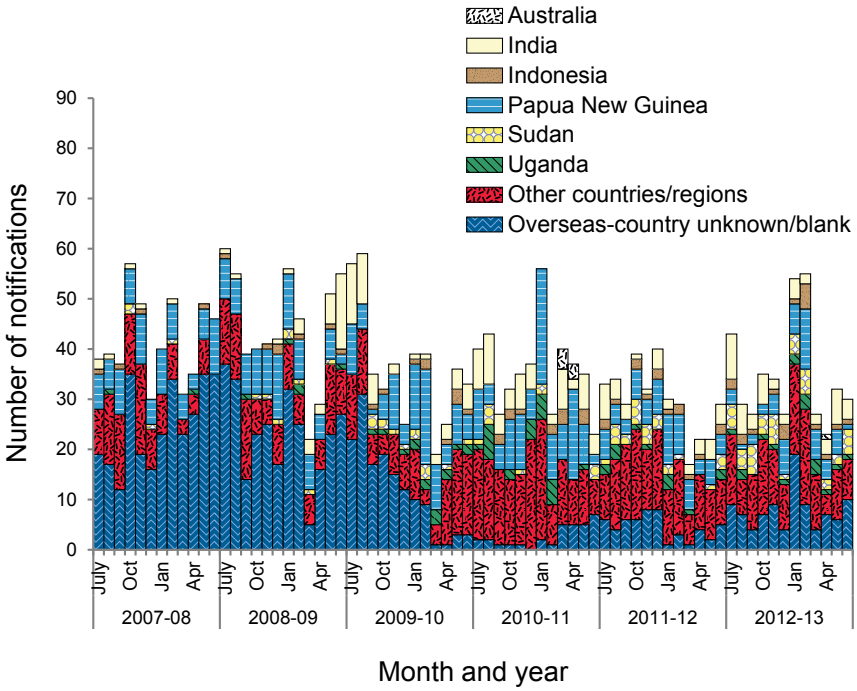


Figure 11: Notifications of malaria infection, Australia, 2012–13, by age group and sex*



* Cases were excluded where sex or age data were not available (n=2 cases).

Figure 12: Notifications of malaria, Australia, 1 July 2007 to 30 June 2013, by month, year and place of acquisition*



Note: Other countries/regions each had less than 17 cases in 2012–13.

Table 6: Cases of malaria, Australia, 2012–13, by *Plasmodium* species and country or region of acquisition

Country or region of acquisition	*Plasmodium falciparum*	*Plasmodium malariae*	*Plasmodium ovale*	*Plasmodium vivax*	Mixed species infections	*Plasmodium* spp	Total	% of all cases
Papua New Guinea	21	1	0	30	0	1	53	13
India	3	0	0	47	0	0	50	12
Sudan	40	0	3	1	0	0	44	11
Indonesia	6	0	1	12	0	0	19	5
Uganda	14	2	1	0	0	0	17	4
Pakistan	0	0	0	16	0	0	16	4
Tanzania	10	1	0	0	0	0	11	3
Kenya	7	0	1	0	1	0	9	2
Sub-Saharan Africa, nfd	8	1	0	0	0	0	9	2
Solomon Islands	0	0	0	8	0	0	8	2
Ghana	7	0	0	0	0	0	7	2
Nigeria	5	0	2	0	0	0	7	2
Sierra Leone	6	0	0	0	0	1	7	2
Guinea	6	0	0	0	0	0	6	1
Liberia	3	0	1	1	0	0	5	1
Southern and East Africa, nfd	3	0	1	0	0	0	4	1
Other countries or regions*	23	2	1	17	0	1	44	11
Australia	1	0	2	2	0	0	5	1
Overseas – country unknown	64	2	1	22	3	2	94	23
Total	227	9	14	156	4	5	415	100
% of cases	55	2	3	38	1	1	100	

* Each with less than 4 cases.

nfd Not further defined.

Sentinel chicken, arbovirus detections in mosquitoes and mosquito abundance monitoring

New South Wales

The season began with 150 pullets and a total of 2,929 samples were received from the 10 flocks in New South Wales over the 6-month period in 2012–2013. This represented 5,858 enzyme-linked immunosorbent assay (ELISA) tests (excluding controls and quality assurance samples), with each specimen being tested for MVEV and KUNV antibodies. There were no seroconversions to MVEV or KUNV recorded through the season.

For 2012–13 the climatic conditions leading up to the season for the inland were of well below average rainfall for the last quarter of 2012, whereas rainfall was average for the 1st quarter of 2013. Neither the Forbes nor the Nicholls hypotheses were suggestive of possible MVEV activity for the 2012–13 season. Despite the very dry spring months, moderate mosquito numbers were collected with close to 130,000 being trapped. However, arboviral activity was low; there were few isolates and no seroconversions in the sentinel chickens. Human notifications of arboviral infection were below normal; particularly from the inland where alphavirus notifications (RRV and BFV combined) were close to half the long term average.

For the coast, the climatic conditions were mostly similar to the inland (namely dry late 2012), however for the north coast, heavy precipitation fell during the first 3 months of 2013. With the ongoing wet conditions during the summer months, numbers of *Aedes vigilax* were quite low and only comprised around 10% of the overall mosquito collections. With reduced abundance of the major coastal vector, alphavirus activity was relatively minimal. Coastal disease notifications of RRV and BFV were 22% below the long-term average.

In a collaborative research project with colleagues in the United States of America, several new arboviruses were identified from New South Wales, including Liao Ning (previously only known from China), Beaumont, North Creek, Murrumbidgee, and Salt Ash viruses (all new). It is unknown if these have human health implications.

Further detail can be found in the New South Wales Arbovirus Surveillance Program annual reports (http://medent.usyd.edu.au/arbovirus/information/publications.htm).

Northern Territory

In 2012–13 there were 211 laboratory identified cases of RRV in the Northern Territory, which was similar to the 222 cases reported in 2011–12. Most cases were recorded in the Darwin region, and predominantly occurred in January and June, which coincided with a high number of *Ae. vigilax* in December and a high number of *Culex annulirostris* in June (Table 7).

A low number of RRV infections was recorded in the East Arnhem region, Katherine region and the Alice Springs region, with no cases recorded in the Barkly region in 2012–13.

As part of the investigation into the increased number of BFV disease cases (354) in the Northern Territory in 2012–13, mosquito trapping and virus isolations were carried out in liaison with the Department of Primary Industries and Fisheries (DPIF) in May 2013, to determine what levels of BFV were circulating in mosquito populations in the Darwin urban area. A total of 4,641 mosquitoes were tested for the presence of virus (Table 2). No BFV was isolated but 2 unidentified viruses were isolated from *Cx. annulirostris*. Most BFV cases in 2012–13 are believed to have been false positives.

In the 2012–13 season, no chickens seroconverted to MVEV or KUNV in the Northern Territory. One seroconversion to an unspecified flavivirus occurred at the Adelaide River Coastal Plains Research Station in May 2013 (Table 8).

However, between December 2012 and June 2013, honey bait traps were trialled at Leanyer (Darwin) and Beatrice Hill Research Farm near Fogg Dam to test the suitability of the new system for flavivirus surveillance. In April 2013, in a sugar-based surveillance system, the Flinders Technology Associates (FTA) cards from the trap set at Beatrice Hill Research Farm tested positive for MVEV (Table 8). This was the first detection of MVEV activity in Australia from FTA cards.[27]

Further details are available from the Northern Territory Medical Entomology annual reports (http://www.health.nt.gov.au/Medical_Entomology/index.aspx).

Table 7: Key mosquito vector abundance in selected regions, Australia, 2012–13, by species, state or territory, region and month

Species	State or territory	Region or locality	Month											
			July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Saltwater														
Aedes vigilax	NSW	North Coast	–	–	–	–	LOW	LOW	MED	MED	LOW	LOW	LOW	–
Ae. vigilax	NSW	Mid–North Coast	–	–	–	–	–	LOW	LOW	MED	LOW	LOW	LOW	–
Ae. vigilax	NSW	Central Coast	–	–	–	–	–	MED	HIGH	HIGH	LOW	LOW	LOW	–
Ae. vigilax	NSW	Sydney – Georges River	–	–	–	–	–		HIGH	HIGH	HIGH			–
Ae. vigilax	NSW	Sydney – Homebush	–	–	–	–	LOW	LOW	MED	HIGH	MED	HIGH		–
Ae. vigilax	NSW	Sydney – Western	–	–	–	–	–	LOW	LOW	LOW	LOW			–
Ae. vigilax	NT	Darwin region	LOW	LOW	LOW	MED	HIGH	HIGH	LOW	LOW	LOW	LOW	HIGH	MED
Ae. vigilax	NT	East Arnhem region	LOW	LOW	LOW	LOW	LOW	–	–	VERY HIGH	HIGH	HIGH	LOW	LOW
Ae. vigilax	Qld	Brisbane inland–Indooroopilly Island	–	LOW	LOW	LOW	LOW	MED	HIGH	HIGH	HIGH	LOW	LOW	–
Ae. vigilax	Qld	Brisbane coastal–Bracken Ridge	LOW	LOW	LOW	LOW	LOW	HIGH	VERY HIGH	VERY HIGH	HIGH	HIGH	LOW	LOW
Ae. vigilax	Qld	Brisbane coastal–Virginia	LOW	LOW	LOW	LOW	LOW	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	LOW	LOW
Ae. vigilax	Qld	Brisbane coastal–Albion	–	–	–	–	LOW	LOW	HIGH	HIGH	MED	HIGH	LOW	–
Ae. vigilax	Qld	Brisbane coastal–Hemmant	LOW	LOW	LOW	–	LOW	HIGH	VERY HIGH	HIGH	HIGH	HIGH	LOW	LOW
Ae. vigilax	Qld	Brisbane coastal–Lota	–	–	–	LOW	LOW	LOW	HIGH	MED	HIGH	HIGH	LOW	LOW
Ae. camptorhynchus *Ae. vigilax*	SA	St. Kilda	–	–	LOW	MED	MED	MED	LOW	LOW	MED	LOW	–	–
Ae. camptorhynchus *Ae. vigilax*	SA	Globe Derby Park	–	–	HIGH	HIGH	LOW	LOW	LOW	MED	HIGH	LOW	–	–
Culex molestus	SA	Goolwa	–	–	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	–	–

Table 7 *continued*: Key mosquito vector abundance in selected regions, Australia, 2012–13, by species, state or territory, region and month

Species	State or territory	Region or locality	Month											
			July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Ae. camptorhynchus	Vic.	Gippsland / Lake Wellington	–	–	–	–	HIGH	VERY HIGH	HIGH	HIGH	MED	VERY HIGH	–	–
Ae. vigilax	WA	Broome region	–	–	–	–	–	–	–	–	HIGH	–	–	–
Ae. vigilax	WA	Derby/Willare region	–	–	–	–	–	–	–	–	HIGH	–	–	–
Ae. camptorhynchus	WA	Peel region	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	MED	LOW	LOW	LOW	MED	HIGH
Ae. vigilax	WA	Peel region	NIL	NIL	NIL	LOW	HIGH	HIGH	HIGH	HIGH	HIGH	MED	LOW	LOW
Ae. camptorhynchus	WA	Leschenault region	HIGH	HIGH	HIGH	HIGH	MED	HIGH	MED	LOW	MED	LOW	LOW	HIGH
Ae. vigilax	WA	Leschenault region	NIL	NIL	NIL	LOW	MED	MED	HIGH	HIGH	MED	LOW	LOW	NONE
Ae. camptorhynchus	WA	Capel-Busselton region	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	LOW	LOW	LOW	LOW	HIGH
Freshwater														
Culex annulirostris	NSW	Inland – Riverina	–	–	–	–	HIGH	HIGH	VERY HIGH	VERY HIGH	HIGH	LOW	–	–
Cx. annulirostris	NSW	Inland – Murray region	–	–	–	–	LOW	LOW	LOW	LOW	LOW	LOW	–	–
Cx. annulirostris	NSW	Inland, West and North West	–	–	–	–	LOW	LOW	LOW	LOW	LOW	LOW	–	–
Cx. annulirostris	NT	Darwin region	MED	MED	LOW	LOW	LOW	LOW	LOW	MED	LOW	MED	HIGH	HIGH
Cx. annulirostris	NT	East Arnhem region	LOW	LOW	MED	MED	LOW	–	–	MED	HIGH	HIGH	HIGH	LOW
Cx. annulirostris	NT	Katherine region	–	–	–	–	LOW	LOW	LOW	LOW	–	–	–	–
Cx. annulirostris	NT	Barkly region	–	–	–	NIL	NIL	NIL	LOW	LOW	LOW	LOW	LOW	NIL
Cx. annulirostris	NT	Alice Springs region	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
	Qld	Brisbane inland–Oxley	LOW	LOW	LOW	LOW	LOW	LOW	LOW	HIGH	MED	MED	LOW	LOW
	Qld	Brisbane inland–Indooroopilly Island	–	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	MED	LOW	LOW
	Qld	Brisbane inland–The Gap	–	LOW	LOW	LOW	LOW	LOW	LOW	MED	HIGH	MED	LOW	LOW
Ae. camptorhynchus	SA	Wellington	–	–	HIGH	HIGH	HIGH	MED	LOW	LOW	LOW	LOW	–	–
Ae. camptorhynchus	SA	Tailem Bend	–	–	LOW	LOW	LOW	MED	LOW	LOW	LOW	LOW	–	–

Table 7 *continued*: Key mosquito vector abundance in selected regions, Australia, 2012–13, by species, state or territory, region and month

Species	State or territory	Region or locality	Month											
			July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Ae. camptorhynchus	SA	Murray Bridge	–	–	HIGH	LOW	LOW	LOW	LOW	LOW	LOW	LOW	–	–
Ae. camptorhynchus	SA	Mannum	–	–	HIGH	LOW	LOW	LOW	LOW	LOW	LOW	LOW	–	–
Ae. camptorhynchus	SA	Meningie	–	–	HIGH	LOW	LOW	LOW	LOW	LOW	LOW	MED	–	–
Culex molestus	SA	Swan Reach	–	–	LOW	LOW	LOW	LOW	LOW	MED	LOW	HIGH	–	–
Cx. annulirostris	SA	Blanchetown	–	–	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	–	–
Anopheles annulipes *Cx. annulirostris*	SA	Morgan	–	–	LOW	LOW	LOW	LOW	LOW	–	LOW	LOW	–	–
Cx. molestus	SA	Waikerie	–	–	LOW	LOW	LOW	LOW	MED	LOW	LOW	LOW	–	–
Cx. annulirostris	SA	Kingston on Murray	–	–	LOW	LOW	–	–	LOW	LOW	LOW	LOW	–	–
An. annulipes *Cx. annulirostris*	SA	Loxton	–	–	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	–	–
An. annulipes *Cx. annulirostris* *Cx. quinquefasciatus*	SA	Berri	–	–	MED	HIGH	LOW	LOW	LOW	LOW	LOW	LOW	–	–
An. annulipes *Cx. annulirostris*	SA	Renmark/Paringa	–	–	LOW	LOW	LOW	LOW	LOW	MED	LOW	LOW	–	–
Ae. camptorhynchus	SA	Wellington	–	–	HIGH	HIGH	HIGH	MED	LOW	LOW	LOW	LOW	–	–
Cx. annulirostris	Vic.	North West	–	–	–	–	LOW	MED	LOW	LOW	LOW	LOW		
Cx. annulirostris	Vic.	North East	–	–	–	–	LOW	LOW	LOW	LOW	MED	LOW	–	–
Cx. annulirostris	WA	Broome region	–	–	–	–	–	–	–	–	VERY HIGH	–	–	–
Aedes normanensis	WA	Broome region	–	–	–	–	–	–	–	–	LOW	–	–	–
Cx. annulirostris	WA	Derby/Willare region	–	–	–	–	–	–	–	–	MED	–	–	–
Ae. normanensis	WA	Derby/Willare region	–	–	–	–	–	–	–	–	HIGH	–	–	–

Calculated as an average for traps across the region and rated as:

LOW (<50)	MEDIUM (50–100),	HIGH (101–1,000)	VERY HIGH (1,001–10,000)	EXTREME (>10,000)

– No data because trapping not undertaken.

Table 8: Virus and sentinel chicken surveillance in selected regions, Australia, 2012–13, by surveillance method and virus genus

State or territory	Region	Flaviviruses			Alphaviruses		
		Number of positive or seroconverted/ number tested*	First positive date	Last positive date	Number positive or seroconverted/ number tested*	First positive date	Last positive date
Sentinel chickens							
NSW	Bourke	0/243			N/A		
NSW	Deniliquin	0/259			N/A		
NSW	Forbes	0/330			N/A		
NSW	Griffith	0/284			N/A		
NSW	Hay	0/315			N/A		
NSW	Leeton	0/299			N/A		
NSW	Macquarie Marshes	0/275			N/A		
NSW	Menindee	0/146			N/A		
NSW	Moama	0/132			N/A		
NSW	Moree	0/251			N/A		
NT	Darwin region	1/225 flavivirus unidentified	2 May 2013	2 May 2013	N/A		
NT	East Arnhem region	0/63			N/A		
NT	Katherine region	0/84			N/A		
NT	Barkly region	0/56			N/A		
NT	Alice Springs region	0/56			N/A		
SA	Paringa	0/15			N/A		
SA	Loxton	0/15			N/A		
SA	Waikerie (Qualco)	0/20			N/A		
SA	Murray Bridge	0/10			N/A		
SA	Meningie	0/5			N/A		
Vic.	Mooroopna	0/293			N/A		
Vic.	Mildura	0/315			N/A		
Vic.	Robinvale	0/238			N/A		
Vic.	Nyah West	0/358			N/A		
Vic.	Kerang	0/338			N/A		
Vic.	Barmah	0/315			N/A		
Vic.	Cobram	0/379			N/A		
Vic.	Wodonga	0/294			N/A		
Vic.	Rutherglen	0/382			N/A		

Table 8 *continued*: Virus and sentinel chicken surveillance in selected regions, Australia, 2012–13, by surveillance method and virus genus

State or territory	Region	Flaviviruses			Alphaviruses		
		Number of positive or seroconverted/ number tested*	First positive date	Last positive date	Number positive or seroconverted/ number tested*	First positive date	Last positive date
WA	Wyndham	0/24			N/A		
WA	Kununurra	1/30	17 Aug 2012	17 Aug 2012	N/A		
WA	Savannah Nickel mine	0/136			N/A		
WA	Halls Creek	0/180			N/A		
WA	Fitzroy Crossing	0/135			N/A		
WA	Derby	0/510			N/A		
WA	Lombadina	0/62			N/A		
WA	Beagle Bay	2/21	22 Jul 2012	30 Aug 2012	N/A		
WA	Broome	0/30			N/A		
WA	Roebuck Plains	2/127	9 Aug 2012	30 May 2013	N/A		
WA	Port Hedland	0/93			N/A		
WA	Karratha	0/270			N/A		
WA	Harding Dam	1/455	6 June 2013	6 June 2013	N/A		
WA	Marble Bar	0/77			N/A		
WA	Pannawonica	0/262			N/A		
WA	Tom Price	0/159			N/A		
WA	Paraburdoo	0/210			N/A		
WA	Onslow	0/163			N/A		
WA	Ophthalmia Dam	0/219			N/A		
WA	Newman	0/252			N/A		
WA	Exmouth	0/312			N/A		
WA	Carnarvon	0/206			N/A		
WA	Moora	0/102			N/A		
WA	Geraldton	0/160			N/A		
WA	Dongara	0/163			N/A		
WA	York	0/139			N/A		
WA	Leonora	0/11			N/A		

Table 8 *continued*: Virus and sentinel chicken surveillance in selected regions, Australia, 2012–13, by surveillance method and virus genus

State or territory	Region	Flaviviruses			Alphaviruses		
		Number of positive or seroconverted/ number tested*	First positive date	Last positive date	Number positive or seroconverted/ number tested*	First positive date	Last positive date
Flinders Technology Associates cards							
NSW	Leeton	1EHV/303 (Flinders Technology Associates cards not routinely used in 2012–13)					
NT	Darwin region	1/150 card – MVE	18 Apr 2013	18 Apr 2013	0/150		
Qld	Badu	NIL			1/8 cards RRV	18 Feb 2013	29 Feb 2013
Qld	Seisia	NIL			1/8 cards RRV	18 Feb 2013	31 May 2013
Qld	Rockhampton	NIL			2/7 cards RRV and BFV	5 May 2013	31 May 2013
Qld	Charleville	NIL			1/6 cards BFV	28 May 2013	1 May 2013
Qld	Longreach/ Emerald	NIL			4/6 cards RRV	21 May 2013	30 May 2013
Qld	Mareeba	NIL			1/6 cards RRV	19 April 2013	29 May 2013
Qld	Townsville	NIL			4/7 cards RRV and BFV	21 Feb 2013	21 May 2013
Virus isolation from mosquitoes							
NSW	Ballina	1 EHV, 1 STRV /9,801					
	Bankstown	2 EHV, 3 STRV /10,554					
	Blacktown	1 EHV, 4 STRV /3,892					
	Byron Bay	2 STRV /5,291			1 RRV/5,291		
	Georges River	2 EHV /12,914					
	Gosford	1 EHV/3,232					
	Hawkesbury	3 EHV, 2 STRV /2,299					
	Homebush	1 STRV/6,909					
	Lake Macquarie	2 STRV/1,622					
	Penrith	1 STRV/2,750					
	Port Macquarie	2 EHV/3,059					
	Wyong	1 EHV, 2 STRV/1,620					
NT	Darwin region	0/4,641			0/4,641		

Table 8 *continued*: Virus and sentinel chicken surveillance in selected regions, Australia, 2012–13, by surveillance method and virus genus

State or territory	Region	Flaviviruses			Alphaviruses		
		Number of positive or seroconverted/ number tested*	First positive date	Last positive date	Number positive or seroconverted/ number tested*	First positive date	Last positive date
Vic.	Inland North West	0/7,355			0/7,355		
Vic.	Inland North East	0/8,104			0/8,104		
Vic.	Gippsland – Lake Wellington	0/17,174			0/17,174		
Vic.	Melbourne	0/1,661			0/1,661		
Vic.	Geelong	0/4,040			0/4,040		
WA	Broome region	1 KOKV/10,979			10 RRV, 4 BFV/10,979		
WA	Derby/Willare region	1 KOKV/4,898			6 RRV, 4 BFV/4,898		
WA	Peel region	2 EHV/37,635			6 RRV, 1 BFV/37,635		
WA	Leschenault region	0/22,116			8 RRV, 2 BFV/22,116		
WA	Capel-Busselton region	0/13,399			9 BFV/13,399		

* The number tested is the number of individual mosquitoes or chickens tested, unless otherwise noted.

BFV Barmah Forest virus

EHV Edge Hill virus

KOKV Kokobera virus

RRV Ross River virus

STRV Stratford virus

Sentinel chickens are not screened for antibodies to alphaviruses.

Western Australia do not test all of the mosquitoes collected (sub-sample of to up to 500 per trap in northern Western Australia, and up to 350–500 depending on mosquito abundance in the south-west of Western Australia are tested). Therefore the number of mosquitoes shown as tested does not reflect the actual number of mosquitoes collected.

Queensland

The exotic Asian tiger mosquito, *Ae. albopictus* was found on the outer islands of Torres Strait in April 2005.[28] This mosquito is a competent vector for a number of arboviruses including DENVs and CHIKV, and represents a serious nuisance biting mosquito. Since 2005, the Australian Government has funded Queensland Health to conduct a mosquito elimination program in the Torres Strait. The initial aim of the program was to eliminate *Ae. albopictus* from the Torres Strait islands but this was revised in May 2008 to a cordon sanitaire approach (a barrier designed to prevent spread) focused on Thursday and Horn islands.

During the reporting period, surveillance and control activities were carried out on Thursday Island, Horn Island, and the Northern Peninsula Area (NPA), Cape York from July 2012 to May 2013. *Ae. albopictus* were detected in low numbers on several occasions on Thursday and Horn islands, but were not detected in the NPA.

The main focus of the program in 2012–13 was to suppress *Ae. albopictus* populations and possibly eliminate the species from Horn Island and Thursday Island, both regarded as the gateway to the mainland of Australia due to their strategic location and transport networks. Consistent monitoring of mosquito densities and distribution on the 2 islands showed up to a 60-fold decline in the number of adult *Ae. albopictus* after intensive intervention that included residual pyrethroid treatment of vegetated peri-domestic harbourage sites. The control operation also included repeated house-to-house yard inspections on at least 800 properties for removal or treatment of water-holding receptacles. At least 3,000 receptacles were inspected and treated on each field visit. The yard inspections also constituted part of the mosquito surveys and *Aedes* larval samples were collected from all positive receptacles for identification. A decline in the Breteau Index of up to 10-fold was recorded for *Ae. albopictus* on the 2 islands during the wet seasons of the reporting period, demonstrating a dramatic impact of the control program. Despite a reduction in container breeding sites as part of the Thursday Island control program, the numbers of *Ae. aegypti* remain relatively high, although some decline in population density was observed.

Murray Valley encephalitis virus surveillance trial

A trial of sugar-based virus surveillance conducted between February and May 2013 saw traps deployed at the following sites; Badu Island (Torres Strait), Bamaga and Seisia (Cape York), Mareeba and Townsville (north Qld), Rockhampton, Longreach and Emerald (central Qld), Charleville and St George (south west Qld). Sugar-baited FTA cards were collected and processed on 64 separate occasions over the trial period. Arboviruses were detected on 14 occasions: RRV on 11 occasions and BFV on 3 occasions. Neither MVEV nor KUNV were detected. The trial provided further evidence of the efficacy and efficiency of this system.

Container inhabiting mosquito surveillance

Ongoing weekly surveillance in Cairns via a network of traps across various suburbs did not detect *Ae. albopictus* during the reporting period. Surveillance for *Ae. aegypti* undertaken in Townsville using BG traps consistently detected *Ae. aegypti* across the season and city.

Ae. aegypti larvae were collected in May 2013 from Longreach and Alpha in the Central West, but repeated larval surveys in coastal Yeppoon throughout late 2012–early 2013 did not detect *Ae. aegypti*. Brief surveys were also conducted during July 2012 in Benaraby and Bororen with no *Ae. aegypti* detected in either location. Ovitraps and BG traps deployed in Biloela and Emerald between November 2012–May 2013 detected *Ae. aegypti* at both locations throughout the season. Ovitraps in Gladstone confirmed its presence in late 2012.

In the Bundaberg region, yard inspections conducted in April and May 2013 confirmed the presence of *Ae. aegypti* in the town of Gin Gin, but similar surveys did not detect *Ae. aegypti* in the towns of Wallaville, Sharon or South Kolan. Surveillance of 257 premises by local and state government in the North Burnett regional towns of Biggenden, Mt Perry, Monto, Eidsvold, Mundubbera and Gayndah detected *Ae. aegypti* in all towns except Mt Perry and Eidsvold (despite this species being detected in Eidsvold during surveys conducted in 2010–2011).

In January 2013, mosquito surveillance (house to house surveys) was conducted in South Burnett. Towns surveyed included Kingaroy (24 premises visited), Nanango (21 premises visited), Wondai (21 premises visited) and Murgon (18 premises visited). In total, 84 premises were surveyed and 157 samples were collected. BG traps were also placed in Kingaroy. *Ae. aegypti* was detected in Wondai and Murgon; this was the first time that *Ae. aegypti* has been detected in the South Burnett Regional Council region. In response, South Burnett Regional Council allocated additional funding towards the prevention of the spread of *Ae. aegypti* and engaged an independent consultant to assist with surveillance and control activities. Extensive survey and domestic treat-

ment of infested containers was conducted within Wondai and Murgon and Public Health Orders were issued, if required. The Council has also undertaken a number of community prevention campaigns, including media releases.

In the Brisbane region, property inspections were conducted in 75 commercial or Industrial premises across the Brisbane City area with no detections of *Ae. aegypti* or *Ae. albopictus*.

Fresh water and salt mash surveillance

In South-East Queensland, there was a dramatic contrast between the first half of the summer season and the second half. Rainfall from July to December was below average and most saltmarshes remained dry until the first major tide in mid-November. A king tide in mid-December saw the return of *Ae. vigilax*. From January to April, rainfall was above average, including the deluge and flooding associated with ex-tropical cyclone Oswald during late January. Both saltmarsh and freshwater species reacted accordingly, with some light traps in Brisbane collecting more than 2,000 *Ae. vigilax* per trap night in January, February and March. By mid-April, the saltmarshes were saturated and remained so wet that numbers of this species decreased; although freshwater *Culex annulirostris* and other species continued activity until May. The very high rainfall associated with Cyclone Oswald produced devastating flooding in the Burnett area and a number of councils in the south-east supported mosquito management efforts in Bundaberg and Mundubbera.

South Australia

Mosquito populations along the River Murray during the 2012–13 season north of Mannum in the Mid-Murray council were typified by a modest early season peak in *Cx. annulirostris* and *An. annulipes* in September and October, followed by another spike mid to late in the season during February to March. Mosquito catches (including peak catches) in the upper river (Renmark-Paringa, Loxton-Waikerie and Berri-Barmera Councils) were all well below average for the corresponding time of year, indicating a season of low mosquito abundance. Like the previous season, these areas also lacked any significant numbers of the spring mosquito *Ae. camptorhynchus* at any time of the season. In the northern Riverland councils, very small catches of some of the less common *Aedes* species were recorded, such as *Ae. eidsvoldensis, Ae. sagax and Ae. vittiger*.

In Adelaide's northern metropolitan areas of Globe Derby and St Kilda, *Ae. camptorhynchus* numbers were slightly higher than the previous season (2011–12) but still lower compared with the season of 2010–11. Adelaide experienced summer rainfall well below average, (receiving only 50% to 60% of the average rainfall). *Ae. vigilax* numbers in the late summer and autumn of 2013 continued to remain low, but numbers increased slightly towards the end of the season compared with the previous season. *Ae. vigilax* numbers peaked at approximately 68.2 per trap in mid-March 2013. This peak was possibly driven by high tides occurring in mid-March to April 2013.

Adelaide received 35.0 mm compared with the long-term average of 62.2 mm, making it the driest summer since 2009/2010. Both maximum and minimum temperatures were overall warmer than average throughout the summer.

The frequency of bleeds of the sentinel chickens varied from flock to flock this season due to varying set up dates. No seroconversions to MVEV or KUNV were recorded during the reporting period.

Tasmania

No viruses were isolated in 2012–13 from mosquitoes trapped during ad hoc collections undertaken in the Sorrell Council region.

Victoria

Through the standard sentinel chicken program, weekly blood samples were tested from the 9 flocks between November 2012 and March 2013. No seroconversions to flaviviruses were detected during the season, which involved testing of 3,122 samples.

Mosquito monitoring in Victoria was conducted through the Victorian Arbovirus Disease Control Program by 10 Local Government Areas. Across the standard mosquito monitoring program, 34,979 mosquitoes were collected between November and April and submitted for species identification and arbovirus detection. Mosquito abundance was low at all monitoring locations along the Murray River (except for Gannawarra) from November until February. High rainfall in February was associated with moderate to high numbers of mosquitoes through most of the monitoring sites along the Murray and inland rivers, except at Wodonga in the far east of the State. *Cx. annulirostris* was the dominant species at most inland sites, accounting for between 39% and 71% of collections. Other species that dominated catches included *Ae. notoscriptus*, *Anopheles annulipes*, *Coquillettidia linealis* and *Ae. bancroftianus*.

Coastal mosquito populations are monitored in the Gippsland and Bellarine Peninsula areas, with the Wellington Shire Council participating in the standardised mosquito monitoring program with weekly submissions. Mosquito abundance oscillated throughout the season, with high numbers *Ae. camptorhynchus* detected in Gippsland during all months from December through to March. Mosquito abundance peaked at the end of December 2012 and again at the end of April 2013. Mosquito abundance exceeded 4,000 mosquitoes per trap on multiple occasions at 1 site.

In the 2012–13 season, no arboviruses were isolated from the 38,334 mosquitoes processed for virus isolation.

Western Australia

Above average rainfall was observed in northern parts of Western Australia between October and December 2012. Between January and March 2013 conditions were average or drier than usual in the Kimberley region, with the exception of the West Kimberley. During this time the West Kimberley and parts of the east Pilbara experienced above average rainfall and in some parts, the highest on record rainfall. Tropical cyclones Narelle and Peta caused heavy rainfall in the western Gascoyne, Pilbara and northern Interior in January. Seasonal thunderstorms resulted in more rain in March. Between April and June above to very much above average rainfall was recorded in the Kimberley and most of the Pilbara regions, with highest on record rainfall being recorded in the East Pilbara and northern Interior. Above average rainfall continued into May and June 2013 in northern parts of Western Australia.

In the south-west of Western Australia, rainfall was generally below average, with the exception of November and December 2012, when rainfall was above average. Warm conditions prevailed for most of the year, and tides regularly inundated mosquito vector breeding saltmarsh during the warm spring and summer period.

A total of 4,508 serum samples from 28 sentinel chicken flocks were tested for antibodies to flaviviruses during 2012–13.[29] Seroconversions to flaviviruses were detected in just 6 (0.1%) samples. Seroconversions at Beagle Bay (1 MVEV) in July and Kununurra (1 MVEV), Beagle Bay (1 KUNV) and Roebuck Plains Station (1 flavivirus infection that was not due to infection with MVEV or KUNV) in August were associated with activity continuing from the 2011–12 season.[7,30] The first activity associated with the 2012–13 wet season occurred in late May 2013 when a KUNV seroconversion was detected in a sentinel chicken at Roebuck Plains Station. Shortly afterwards, 1 KUNV infection was detected in the Harding Dam flock in June. This was a very late start to the flavivirus season, and was also the lowest level of activity observed since 1995–96 when just 2 seroconversions to KUNV were detected in March–April 1996.[31] Predominantly, alphaviruses (RRV and BFV) were isolated from mosquitoes collected in the West Kimberley region of Western Australia (Table 8). This was probably because the timing of adult mosquito collections in that region was just a few weeks following heavy rainfall, when saltmarsh and floodwater mosquito populations were high (Table 7).

The first media release for northern Western Australia was issued by the Western Australian Department of Health on 28 March 2013. This was a general media release issued prior to the holiday Easter season, and warned residents and travellers to the north of Western Australia of the increased risk of mosquito-borne disease in northern Western Australia. A second media release was issued on 25 June 2013 in response to the detections of KUNV in sentinel chickens in the Kimberley and Pilbara regions and heavy unseasonal rain.

Vector abundance was high in the south-west of Western Australia, particularly *Ae. camptorhynchus* in winter and spring, and *Ae. vigilax* during summer in the Peel and Leschenault regions (Table 5).[29] The first arbovirus isolate for the season was BFV from *Ae. camptorhynchus* collected at Capel in September 2012, and a further 8 isolates of BFV were detected in Capel-Busselton through to December, prompting the Department of Health to issue a media release about the increased risk of vectorborne disease. The first arbovirus detections in the Peel and Leschenault regions were RRV and BFV respectively, both in early December 2012. In total, there were 14 RRV, 12 BFV and 2 Edge Hill virus (EHV) detections (Table 8) as well as 1 isolate that was not an alphavirus or flavivirus (identity yet to be determined). The majority of isolations were from *Ae. camptorhynchus* (18) and *Ae. vigilax* (10), with a single RRV isolate from *Cx. annulirostris*. In 2012, the infection rate for RRV peaked at 19.1 per 1,000 mosquitoes,[32] whilst the peak infection rate for BFV was 3.6 per 1,000 mosquitoes in November 2012. Further detail can be found in the Western Australian annual reports (http://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/Mosquitoes/PDF/Arbovirus-AnnRpt-2012-13.ashx)

Exotic mosquito detections at the border

Between July 2012 and June 2013 there were 7 exotic mosquito detections made by the Australian Government Department of Agriculture and

Water Resources at the Australian border (Table 9). This represented an increase from the 2011–12 period where there were 5 exotic mosquito detections. Two detections were via inspection of imported cargo and 5 detections resulted from routine vector monitoring activities performed at international ports. The detection of *Ae. albopictus* at a Post Entry Quarantine Facility in Melbourne in December 2012 highlights that imported consignments of Lucky Bamboo remain a significant risk for the introduction of exotic mosquitoes. No *Ae. albopictus* mosquitoes were detected beyond the infested quarantine glasshouses with surveillance still being maintained by Kingston City Council and the Victorian Department of Health. The detection of *Ae. aegypti* at Brisbane International Airport in December 2012 was the first detection of an exotic mosquito in a Department of Agriculture and Water Resources vector monitoring trap at an International Airport. DNA analysis of the mosquito larvae suggested a likely North Queensland origin (potentially via a domestic leg of an international flight) however, South Est Asia could not be ruled out as a possible origin (A Weeks, unpublished results). *Ae. aegypti* were detected on 3 occasions at Darwin Seaport in April / May 2013 with the second detection in May (*Ae. aegypti* larvae and pupae) suspected to have originated from the single adult female *Ae. aegypti* detected earlier in May. Enhanced surveillance in surrounding areas did not detect exotic mosquitoes further afar from the initial detection site. *Ae. aegypti* larvae were detected in a sentinel tyre trap located at the port of Mackay in May 2013. Despite the known presence of this species in the Mackay region, it was the first time it has been detected in a trap at the port. Mackay Regional Council conducted precautionary residual treatments in response to the detection.

Discussion

NAMAC contributes to a One-Health approach to the control of arboviral disease and malaria, by uniting experts from a range of fields to provide strategic advice on the epidemiology, surveillance and management of these diseases. This report describes the epidemiology of arboviral diseases and malaria for the season 1 July 2012 to 30 June 2013, activities undertaken by health authorities in response to human cases, and evidence of virus activity. Sentinel chicken and vector monitoring continue to be an important part of the early warning system for arboviruses in Australia.

In 2012–13, the number of notifications of BFV infection and the population rates increased markedly compared with the previous year, with an epidemic of false positive IgM diagnoses from October 2012 due to an IgM test kit that was later recalled, as reported previously.[7,33] In 2012–13, cases were younger and a higher proportion were female. Cases were also more numerous in metropolitan areas than in previous years.

On NAMAC's recommendation, the CDWG of the CDNA undertook a review of surveillance case definitions for BFV and RRV infection. Under the revised case definition, which has been endorsed by CDNA, a single IgM positive result no longer constitutes laboratory evidence for infection, and where a single result is IgM and IgG positive, it may be notified as a probable case. A confirmed case will require IgG seroconversion or a significant increase in IgG antibody level (e.g. 4-fold or greater rise in titre). There is currently no plan to undertake a retrospective revision of notifications to apply the new case definitions because there is insufficient information on the diagnosis method available in NNDSS. Therefore, the historical data prior to the upcoming change of case definition will continue to be considered unreliable. The new case definition was implemented on 1 January 2016.

The particularly wet conditions experienced in many locations on the east coast in early 2013, in combination with arrival of cyclone Oswald and widespread flooding, provided challenging conditions for mosquito management programs. Despite these conditions, notifications of RRV remained below the 5-year mean nation-wide.

The prevention of incursion of dengue vectors into densely populated areas of South-East Queensland where imported dengue cases are regularly notified, is a continuing priority in Queensland. Despite frequent outbreaks relating to transmission from imported cases, mosquito and infection control measures undertaken by public health authorities and by residents have ensured that dengue has not become endemic in north Queensland.

Continued vigilance and the involvement of all relevant sectors enable the rapid detection of and early response to the threat of arboviral disease and malaria in Australia. The expert advice provided by NAMAC to AHPPC, CDNA and health departments has a vital role in mitigating mosquito-borne disease threats. Into the future, NAMAC strives for a reduction in the number of arbovirus cases in Australia, a strengthened disease prediction capacity to allow planning for response, and to retain, build and disseminate expertise and knowledge pertaining to mosquito-borne diseases.

Table 9: Exotic mosquito detections at the border, Australia, 2012–13

Date	Species	Location	Method of detection	Source or origin	Action or mitigation	Surveillance results
Aug 2012	*Ae. albopictus* (larvae)	Townsville (Seaport)	Cargo Inspection	New oversize tyres from Papua New Guinea	Tyre treatment (chlorination, residual insecticide and fumigation) and increased trapping. Early intervention meant risk was low.	No further detections
Dec 2012	*Ae. albopictus* (larvae, pupae, adults)	Melbourne (Post Entry Quarantine Facility)	Cargo inspection	Lucky bamboo imported from China	Glasshouses fogged; sterilisation of water and grow out containers; destruction of plants; harbourage treatments; receptacle treatment surveys and increased trapping and surveillance. Audits of the on-arrival treatments for the infested consignments were also conducted.	No further detections
Dec 2012	*Ae. aegypti* (larvae, eggs)	Brisbane (International Airport)	Ovitrap	Unconfirmed	Ultra low volume fogging; residual harbourage treatment; receptacle treatment/ surveys; increased trapping	No further detections
Mar 2013	*Ae. albopictus* (1 adult)	Cairns (Seaport)	CO_2 baited BG trap	Unknown/unable to identify source.	Ultra low volume fogging; mosquito harbourage treatments; receptacle treatment/ surveys; increased trapping	No further detections
Apr 2013	*Ae. aegypti* (5 adults)	Darwin (Seaport)	CO_2 baited BG trap	Unknown. (North Queensland excluded based on genetic analysis)	Ultra low volume fogging; harbourage treatments; receptacle treatment surveys and increased trapping	Single adult *Ae. aegypti* detected in the same BG trap location 9 days later
May 2013	*Ae. aegypti* (1 adult)	Darwin (Seaport)	CO_2 baited BG trap	Unknown (North Queensland excluded based on genetic analysis)	Ultra low volume fogging; receptacle treatment/ surveys; increased trapping	*Ae. aegypti* larvae and pupae detected in a tyre trap 11 days later
May 2013	*Ae. aegypti* (larvae, pupae)	Darwin (Seaport)	Sentinel tyre trap	Unknown (North Queensland excluded based on genetic analysis)	Receptacle treatment/ surveys; increased trapping	No further detections

Appendix

Sentinel chicken, vector and climate surveillance programs in the states and territories

Australian Capital Territory

There were no vertebrate, vector and climate surveillance programs in the Australian Capital Territory.

New South Wales

Surveillance mechanisms include mosquito monitoring, virus isolation from mosquitoes and sentinel chicken surveillance. The New South Wales Arbovirus Surveillance and Vector Monitoring Program is funded and coordinated by the NSW Ministry of Health (NSW Health), and laboratory services are contracted to the Institute of Clinical Pathology and Medical Research, Pathology West at Westmead Hospital. Mosquito trapping occurs from mid-spring to mid-autumn (November to April), and mosquitoes are collected weekly for species identification and quantification, and processed for isolation of arboviruses. Data on the Southern Oscillation Index (SOI), rainfall and temperature obtained from the Bureau of Meteorology (BOM) are used by members of the program to predict mosquito-breeding capabilities and potential arboviral activity, while climatic data are used to predict MVEV outbreaks. Sentinel chickens are operated along with mosquito monitoring and isolation at inland locations of major population centres at risk of MVEV, while along the coast where MVEV does not occur, only mosquito monitoring and viral isolation are undertaken. FTA cards were not used routinely in 2012–13.

The 2012–13 season began on 29 October 2012 with the first bleed and ended on 30 April 2013 with the last. A total of 10 flocks each containing up to 15 Isa Brown pullets was deployed, with 1 flock each at Bourke, Deniliquin, Forbes, Griffith, Hay, Leeton, Macquarie Marshes, Menindee, Moama (near Mathoura), and Moree (Map).

The NSW Chicken Sentinel Program was approved by the Western Sydney Local Health Network Animal Ethics Committee. This approval requires that the chicken handlers undergo training to ensure the chickens are cared for appropriately and that blood sampling is conducted in a manner that minimises trauma to the chickens. The chickens are cared for and bled by local council staff and members of the public. Laboratory staff members are responsible for training the chicken handlers. A veterinarian (usually the Director of Animal Care at Westmead) must inspect all new flock locations prior to deployment to ensure animal housing is adequate. Existing flocks are inspected approximately every 2 years. The health of each flock is reported weekly, and is independently monitored by the Animal Ethics Committee via the Director of Animal Care. Full details of the bleeding method and laboratory testing regimen were detailed in the 2003–04 NSW Arbovirus Surveillance Program annual report.[34]

The results of chicken serology are disseminated via email to the relevant government groups as determined by NSW Health and are placed on the NSW Arbovirus Surveillance website. Confirmed positives are notified by telephone to NSW Health and CDNA.

Northern Territory

Sentinel chicken flocks in the Northern Territory are maintained, bled and analysed for MVEV and KUNV in a combined program between the Department of Health, the virology laboratories of the DPIF and volunteers.

Surveillance consists of monthly routine sentinel chicken surveillance during the high risk period for MVE, with flocks located in Leanyer (Darwin), Howard Springs, the Coastal Plains Research Station at Beatrice Hill (Darwin region), Katherine, Nhulunbuy, Nathan River, Tennant Creek and Alice Springs. When chickens from a flock show antibodies to MVEV during a prime risk period, a media warning is issued for the general region. These warnings advise Northern Territory residents and visitors of the need to take added precautions to avoid mosquito bites. In 2012–13, sentinel chickens were bled between November 2012 and June 2013.

In addition, *ad hoc* virus isolation from mosquitoes is carried out when MVEV or KUNV disease cases are reported. The NT Mosquito Borne Disease Control Program assists regional authorities with mosquito monitoring and provides some funding for direct mosquito control. In 2012–13, routine adult mosquito trapping consisted of 16 trapping sites throughout the Darwin urban area. In other Northern Territory regions, adult mosquito trapping is carried out in liaison with Environmental Health and mining companies, with 6 traps located in Nhulunbuy, 3 in Alyangula on Groote Eylandt, 4 in Katherine, 3 in Tennant Creek and 6 in Alice Springs. Climate information from the BOM is used in conjunction with sentinel chicken and vector surveillance. Rainfall patterns, daily rainfall records and rain threshold models are used to assist in predicting mosquito and virus activity.

Queensland

Queensland Health does not currently conduct state-wide surveillance for MVEV in vertebrate hosts, and does not maintain sentinel chicken flocks. However, Queensland Health recently undertook a second sugar-based arbovirus surveillance trial utilising passive box traps and FTA card technology. The trial evaluated the effectiveness of this system as a sustainable method for arbovirus surveillance in Queensland and was designed to ascertain the feasibility of field deployment, and determine the achievability of timely detection and reporting of virus activity. Passive box traps were deployed in 9 rural or remote locations between February and May 2013, comprising 64 total trap events. Traps were serviced by a combination of local government, public health unit and Australian Government Department of Agriculture staff, while laboratory analysis of FTA cards was performed at Queensland Health Forensic and Scientific Services using real-time TaqMan RT-PCR.[27] Cards were tested for the presence of MVEV, KUNV, RRV and BFV.

Mosquito monitoring using light traps is performed by some local councils, primarily for salt water and fresh water mosquitoes. Some councils and public health units perform surveillance for container inhabiting mosquitoes using various methods including larval surveys and trapping utilising ovitraps, BG traps and Gravid Aedes Traps in domestic and commercial premises as part of a joint Queensland Health and local government initiative. Cairns and Townsville Public Health Units conduct routine *Ae. aegypti* surveillance in urban locations. Cairns Public Health Unit undertakes the Commonwealth-funded *Ae. albopictus* prevention and control program in the Torres Strait and NPA in Cape York. The Technical Advisory Group continues to provide general strategic direction to the program and meets regularly to review progress.

South Australia

Across South Australia, mosquito management activities are conducted through a partnership between the South Australian Department of Health and Ageing (SA Health), the University of South Australia, and local government. The program is focused on the Riverland and Murraylands areas where arbovirus is endemic, and extends to a range of coastal areas in regional and metropolitan localities of the state. SA Health funds half of local government costs for mosquito surveillance and control on public land through the South Australian Mosquito Management Subsidy.

The Mosquitoes and Public Health Research Group at the University of South Australia provided mosquito surveillance and spot control services to 7 local governments along the Murray River in South Australia from September 2012 to April 2013, as well as to the City of Salisbury located in Adelaide's north west.

The establishment of South Australia's revised sentinel surveillance program was finalised during the 2012–13 mosquito season and consists of small dedicated sentinel flocks (5 chickens per flock) in Paringa, Loxton, Waikerie (Qualco), Murray Bridge and Meningie.

Tasmania

No state-wide systematic mosquito abundance, virus isolation or sentinel chicken surveillance activities are undertaken due to the relatively low risk of arbovirus transmission in the State. However, mosquito collections are undertaken in the Sorell Council region, (which includes mosquito breeding areas, is fairly populous, and is close to Hobart) during high risk periods over January to March, when tidal inundation floods salt marsh habitat, thereby leading to egg hatching and subsequent increased abundance of the main local vector, *Ae. camptorhynchus*. These are sent to Westmead Hospital for species identification and viral isolation.

Victoria

The Victorian Department of Health contracts the Victorian Department of Economic Development, Jobs, Transport and Resources (then Victorian Department of Primary Industries) to conduct sentinel chicken surveillance, mosquito species identification and arbovirus detection during the arbovirus season from November to April. The standard sentinel chicken monitoring program involves the weekly collection of blood samples from 20 chickens located at each of 9 sites in northern Victoria along the Murray River or in the surrounding region. This program has been in place in Victoria since the 1974 outbreak and acts as an early warning system for possible human infections with flaviviruses. Flocks are replaced annually. Seven councils undertake mosquito surveillance as part of the standard mosquito monitoring program, which involves the weekly trapping of mosquitoes at 4 sites within each area. Six councils are located along the Murray and Goulburn River and 1 is a coastal site in Gippsland. Collections are also received from 3 additional councils located on the Murray River, Bellarine Peninsula and Melbourne. Mosquitoes are sent in cold storage to the

Victorian Department of Economic Development, Jobs, Transport and Resources for identification, enumeration and virus isolation. The Victorian Arbovirus Taskforce examines the risk of outbreaks of MVEV using meteorological surveillance data such as the SOI and rainfall deciles, and Indian Ocean Dipole using the Forbes,[35] and Nicholls[36] and Bennett models, respectively.

Western Australia

The University of Western Australia Arbovirus Surveillance and Research Laboratory (ASRL) was funded in 2012–13 by the Western Australian Department of Health to coordinate the sentinel chicken program and mosquito surveillance and to provide confirmatory serological testing for other sentinel chicken programs in Australia as required.[37] The flavivirus sentinel chicken program in Western Australia was undertaken by the ASRL at The University of Western Australia, on behalf of the Western Australian Department of Health. The sentinel chicken surveillance program was approved by The University of Western Australia Animal Ethics Committee. Many state and local government authorities and community volunteers also took part in the program. Twenty-eight sentinel chicken flocks (of up to 12 chickens) were located at major towns and communities in the Kimberley, Pilbara, Gascoyne, Goldfields, Midwest and Wheatbelt regions of Western Australia (Map). Blood samples were 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, monthly samples were collected unless prolonged flavivirus activity warranted continued fortnightly sampling. Samples were transported to ASRL where they were tested for antibodies to flaviviruses using an epitope blocking ELISA.[38] In addition, adult mosquitoes were collected from the West Kimberley region of northern Western Australia in March 2013. These mosquitoes were identified to species and processed for virus isolation to investigate vector species and virus infection rates. In the south-west of Western Australia, adult mosquitoes were collected by the ASRL at the University of Western Australia on a regular basis in the Peel, Leschenault and Capel-Busselton regions for surveillance of RRV and BFV. Full details of the 2012–13 season are available in the ASRL annual report.[37]

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