Arboviral diseases and malaria in Australia, 2013–14: 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 2013–14 season (1 July 2013 to 30 June 2014) and includes data from human notifications, sentinel chicken, vector and virus surveillance programs. The National Notifiable Diseases Surveillance System received notifications for 8,898 cases of disease transmitted by mosquitoes during the 2013–14 season. The Australasian alphaviruses Barmah Forest virus and Ross River virus accounted for 6,372 (72%) 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 have been amended. There were 94 notifications of imported chikungunya virus infection and 13 cases of imported Zika virus infection. There were 212 notifications of dengue virus infection acquired in Australia and 1,795 cases acquired overseas, with an additional 14 cases for which the place of acquisition was unknown. Imported cases of dengue were most frequently acquired in Indonesia (51%). No cases of locally-acquired malaria were notified during the 2013–14 season, though there were 373 notifications of overseas-acquired malaria. In 2013–14, arbovirus and mosquito surveillance programs were conducted in most jurisdictions. Surveillance for exotic mosquitoes at international ports of entry continues to be a vital part of preventing the spread of vectors of mosquito-borne diseases such as dengue to new areas of Australia, with 13 detections of exotic mosquitoes at the ports of entry in 2013–14. *Commun Dis Intell* 2016;40(3):E401–E436.

Keywords: arbovirus; Barmah Forest virus, chikungunya, dengue, disease surveillance, epidemiology, flavivirus, Kunjin virus, Japanese encephalitis, West Nile virus, malaria, mosquito-borne, mosquitoes, 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 2013 to 30 June 2014. 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 through the Communicable Diseases Network Australia (CDNA). Members of NAMAC have expertise in virus and disease surveillance, epidemiology, virology, vector ecology, vector and disease 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 and outlines research priorities. NAMAC assists in the prevention, detection, management and control of outbreaks of arboviruses or malaria and provides advice on the risk posed to Australia by these viruses or exotic vectors that may be imported from overseas. NAMAC members participate in or advise 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 case 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 2014 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). The report includes information on the following nationally notifiable pathogens that are transmitted by mosquitoes:

- alphaviruses (BFV, RRV, and CHIKV);
- flaviviruses (DENV, JEV, WNV/KUNV, MVEV, YFV and unspecified, including Zika virus (ZIKV)); and
- malaria.

CHIKV infection was made nationally notifiable in 2015, though a national case definition was implemented from 2010. Prior to this, CHIKV infections were notified under the disease category arbovirus NEC, and all notifications have now been included under CHIKV in NNDSS.

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 2013–14 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 ($n<20$ notifications for the year) 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 (ABS) 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 to that year (2014 population applied to the 2013–14 financial year). Additional spatial analyses were performed using the ABS Statistical Area level 3 classifications,[3] and using ABS defined ratios to allocate notifications by their postcode of residence to a statistical area. Analyses were conducted using Microsoft Excel® and Stata SE version 13. The nonparametric test for trend in Stata was used to analyse trends in notifications over time where relevant, using $P<0.05$ to indicate a significant trend. Maps were produced using Arc GIS (ESRI).

Additional information on the details of some notifications were obtained from state and territory public health surveillance managers. Data on sentinel chicken surveillance, vector (including detection of exotic mosquitoes at International ports of entry, hereafter referred to as the border) and virus surveillance are also reported.

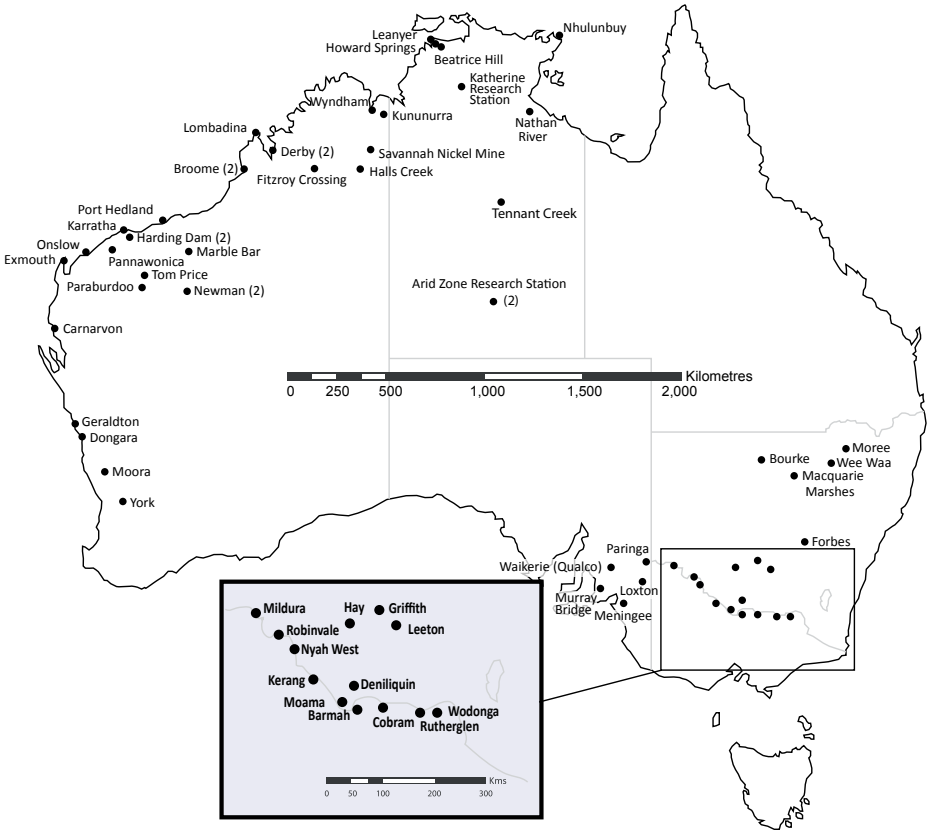
Vertebrate, vector and climate surveillance in states and territories

Sentinel chicken flavivirus surveillance programs aim to provide early warning of the endemic arboviruses MVEV and KUNV as well as exotic flaviviruses such as JEV.[4] 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 1).[5] Detailed descriptions of the sentinel chicken, vector and virus surveillance programs, as well as contact details for jurisdictional arbovirus reference or research laboratories are included in the Appendix.

Results

During the 2013–14 season, there were 8,898 notifications of mosquito-borne diseases in humans (Table 1). This represented a 3% increase from the mean of 8,628.4 notifications for the previous 5 years.

Map 1: Location of sentinel chicken sites, Australia, 2013–14



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.[6] 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).[7] 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 that allow for confirmation based on these tests, leading to over diagnosis particularly during the off-season.[8] Importantly, the case definitions have been reviewed by the Case Definitions Working Group of CDNA, and these changes were implemented on 1 January 2016.[9]

Local transmission of the alphavirus CHIKV has not occurred in Australia, but the infection is regularly reported in travellers returning from overseas. The 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.[10] Humans are amplification hosts for CHIKV and other vertebrates are not required for transmission to occur. There is the potential for transmission of CHIKV in areas where a suitable mosquito vector exists. Internationally, CHIKV is most commonly transmitted by *Aedes aegypti* and *Ae. albopictus.* In Australia, *Ae. aegypti* is present in parts of Northern, Central and South West Queensland and *Ae. albopictus,* which is found on Cocos Island, Christmas Island and in some areas of the Torres Strait Islands.[11] Other Australian mosquito species have been shown to be competent vectors of CHIKV in the laboratory,[12] but any role in field transmission is likely to be minor compared with either *Ae. aegypti* or *Ae. albopictus.*[13]

Barmah Forest virus infections

There were 1,803 notifications of BFV infections during the 2013–14 season, representing a rate of 7.7 per 100,000 population, a decrease from the mean of 2,060.6 cases (9.1 per 100,000) for the previous 5 years (Table 1, Figure 1). Queensland reported the largest number of notifications of BFV infection (n=1,115) while the highest rate was reported in the Northern Territory (52.7 per 100,000 population) (Figure 2). Rates in 2013–14 were below the 5-year mean for all states and territories. It is important to note that seasonal trends vary between and within states and territories

Table 1: Number of notified human cases, notification rate* and 5-year mean for mosquito-borne disease, Australia, 2013–14, by disease and state or territory

		ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Aust
Barmah Forest virus infection	Cases 2013–14	2	254	129	1,115	20	1	25	257	1,803
	5-year mean cases	3.2	381.2	136.4	1,099.2	69.0	2.0	76.4	293.2	2,060.6
	Rate 2013–14	0.5	3.4	52.7	23.6	1.2	0.2	0.4	10.0	7.7
	5-year mean rate	0.9	5.2	58.0	24.1	4.2	0.4	1.4	12.0	9.1
Chikungunya virus infection	Cases 2013–14	0	22	2	8	5	0	20	37	94
	5-year mean cases	0.0	9.6	2.8	5.0	2.8	0.6	14.4	13.0	48.2
	Rate 2013–14	–	–	–	–	–	–	–	–	–
	5-year mean rate	–	–	–	–	–	–	–	–	–
Dengue virus infection	Cases 2013–14	20	421	69	461	82	23	414	531	2,021
	5-year mean cases	15.6	206.4	40.2	448.2	31.8	6.4	159.6	352.2	1,260.4
	Rate 2013–14	–	–	–	–	–	–	–	–	–
	5-year mean rate	–	–	–	–	–	–	–	–	–
Flavivirus unspecified†	Cases 2013–14	0	4	0	27	0	0	1	0	32
	5-year mean cases	0.0	0.2	0.2	3.6	0.2	0.0	5.8	0.0	10.0
	Rate 2013–14	–	–	–	–	–	–	–	–	–
	5-year mean rate	–	–	–	–	–	–	–	–	–
Japanese encephalitis virus infection	Cases 2013–14	0	0	0	2	0	0	0	0	2
	5-year mean cases	0.0	0.2	0.0	0.2	0.2	0.0	0.0	0.2	0.8
	Rate 2013–14	–	–	–	–	–	–	–	–	–
	5-year mean rate	–	–	–	–	–	–	–	–	–
West Nile virus/Kunjin virus infection	Cases 2013–14	0	0	0	2	0	0	1	0	3
	5-year mean cases	0.0	0.2	0.6	0.6	0.0	0.0	0.0	0.0	1.4
	Rate 2013–14	–	–	–	–	–	–	–	–	–
	5-year mean rate	–	–	–	–	–	–	–	–	–
Malaria	Cases 2013–14	8	105	17	88	8	5	84	58	373
	5-year mean cases	11.8	92.4	17.2	133.0	13.2	7.6	90.8	67.6	433.6
	Rate 2013–14	–	–	–	–	–	–	–	–	–
	5-year mean rate	–	–	–	–	–	–	–	–	–
Murray Valley encephalitis virus infection	Cases 2013–14	0	0	0	0	0	0	0	0	0
	5-year mean cases	0.0	0.6	0.6	0.4	0.4	0.0	0.0	2.2	4.2
	Rate 2013–14	–	–	–	–	–	–	–	–	–
	5-year mean rate	–	–	–	–	–	–	–	–	–
Ross River virus infection	Cases 2013–14	5	509	434	1,845	111	19	161	1,485	4,569
	5-year mean cases	10.6	766.4	286.4	1,904.0	436.0	19.8	451.0	934.6	4,808.8
	Rate 2013–14	1.3	6.8	177.4	39.1	6.6	3.7	2.8	57.9	19.5
	5-year mean rate	2.9	10.6	124.1	42.0	26.4	3.9	8.0	39.2	21.4
Yellow fever	Cases 2013–14	0	0	0	0	0	0	0	0	0
	5-year mean cases	0	0	0	0.3	0	0	0	0	0
	Rate 2013–14	–	–	–	–	–	–	–	–	–
	5-year mean rate	–	–	–	–	–	–	–	–	–
Total 2013–14		35	1,315	651	3,549	226	48	706	2,368	8,898

* 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 14 January 2015.

NEC Not elsewhere classified.

Figure 1: Notifications of Barmah Forest virus infection, Australia, 1 July 2008 to 30 June 2014, by month and year, and state or territory

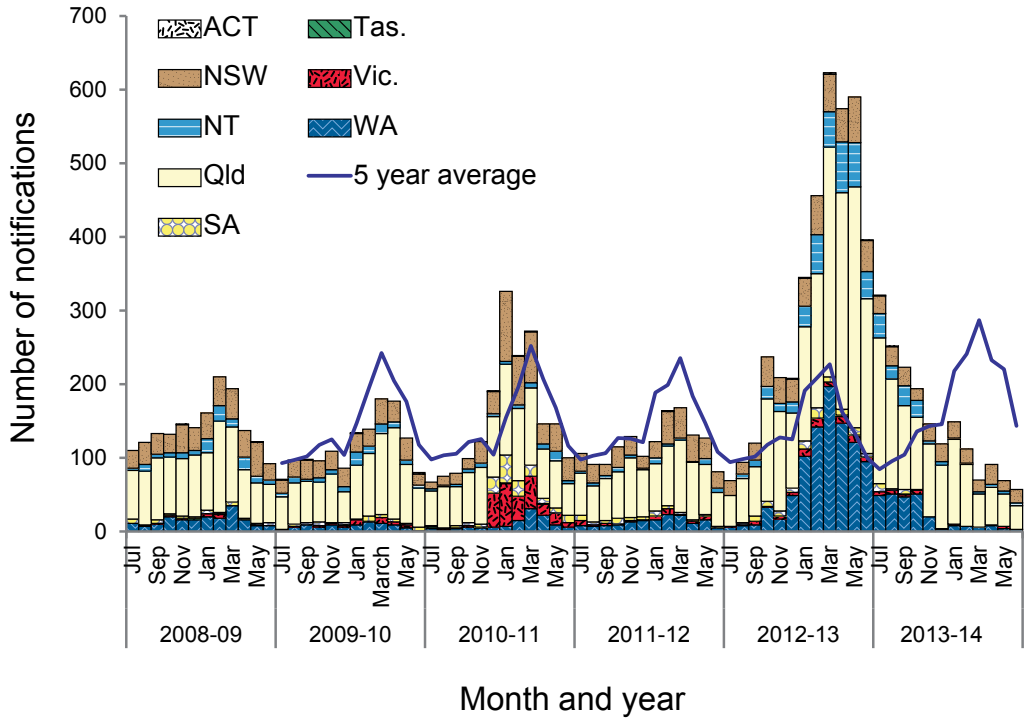
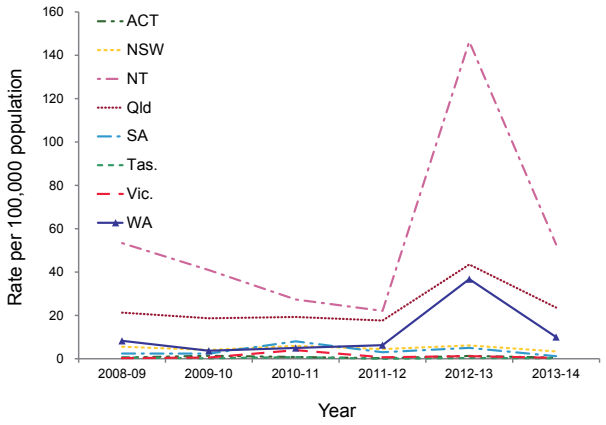


Figure 2: Notification rate for Barmah Forest virus infection, Australia, 1 July 2008 to 30 June 2014, by year and state or territory

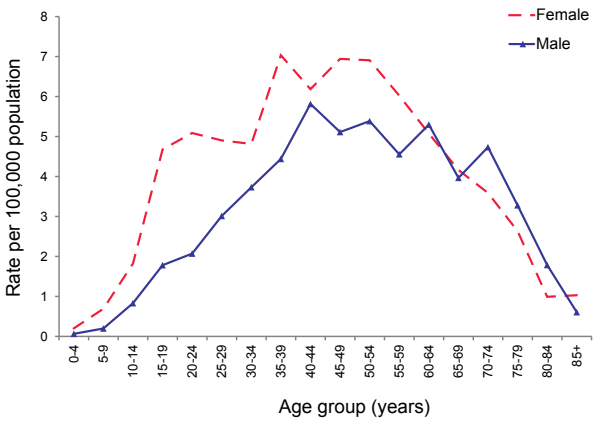


according to differences in mosquito vectors, hosts and climate. In addition, comparisons between regions are likely to be influenced by accuracy of case-ascertainment, which may vary between jurisdictions because of some differences in reporting criteria and the quality of diagnostic tests used, with false positive IgMs a long term issue.

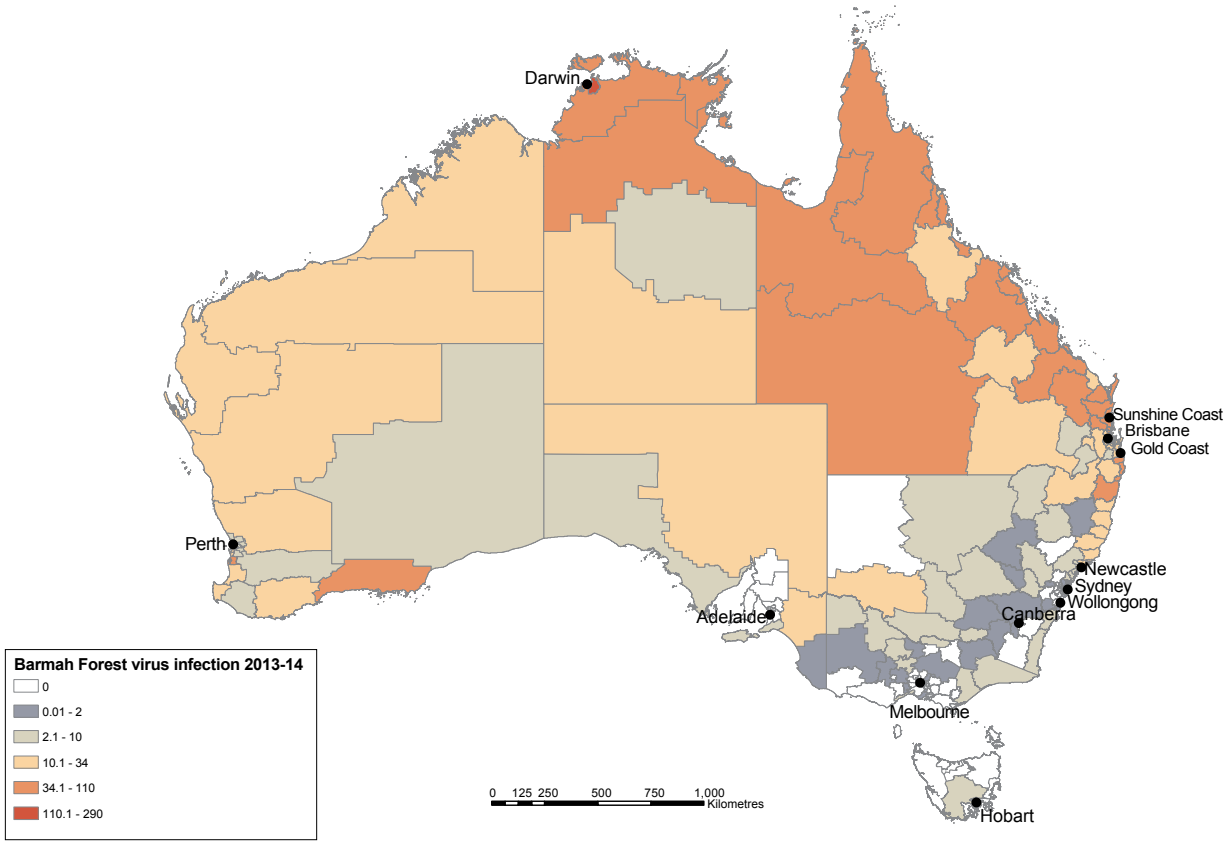
Rates of BFV in 2013–14 by Statistical Area Level 3 were highest in Litchfield, surrounding Darwin, (133 per 100,000), Innisfail in Queensland (85 per 100,000) and Nambour-Pomona on the Sunshine Coast, Queensland (81 per 100,000) (Map 2). Rates were lower in 2013–14 than in the previous year in almost all Statistical Areas with some exceptions, including Burnett (west of Bundaberg and Maryborough, Queensland) and Gascoyne (Western Australia).

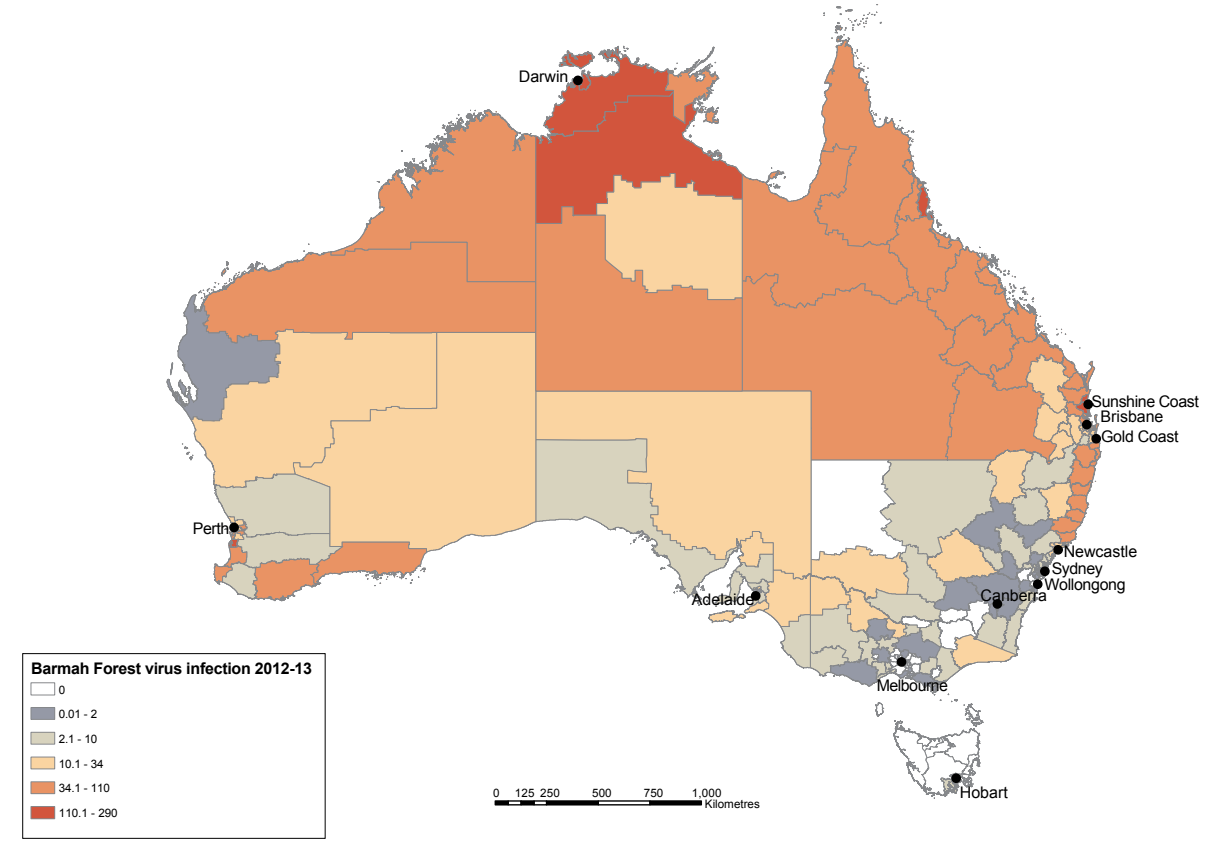
In 2013–14, BFV notifications were most common among adults, with notification rates peaking in the 35–59 years age groups for women and 40–54 years age groups for men (Figure 3). There was a secondary peak in younger females in the age groups between 15 and 34 years, similar to that observed in 2012–13. In 2013–14, 42% of cases were male, which was similar to 2012–13 (41%) but lower than the 5 years prior to that (51% to 53%).

Figure 3: Notification rate for Barmah Forest virus infection, Australia, 2013–14, by age group and sex (n=1,803)



Map 2: Notification rates for Barmah Forest virus infection, 2013–14, and 2012–13, by Statistical Area Level 3





BFV infections are unexpected outside of the warmer months when suitable mosquito vectors are abundant. In 2013–14, infections were most frequently notified between July and January. This was due to the continuation of an epidemic of false positive IgM diagnoses that was reported previously, and which began in October 2012 and was associated with inaccuracies with the commercial BFV serological test kits (Figure 1).

Ross River virus infections

There were 4,569 notifications of RRV infection during the 2013–14 season, representing a rate of 19.5 per 100,000 population, compared with a 5-year mean of 4,808.8 notifications (21.4 per 100,000) (Table 1, Figure 4). Queensland reported the largest number of cases (n=1,845), while the highest rate was in the Northern Territory (177.4 per 100,000).

Rates of RRV were 1.4 and 1.5 times the 5-year mean in the Northern Territory and Western Australia respectively (Figure 5). Rates of RRV in 2013–14 were highest in Litchfield, surrounding Darwin (501 per 100,000), Esperance (238 per 100,000) and the Kimberley (215 per 100,000), and rates were higher across much of Western and Northern Australia than in 2012–13 including in Litchfield (surrounding Darwin), Katherine (Northern Territory), the Kimberley and the Pilbara (Western Australia), Noosa and Nambour-Pomona (Queensland) (Map 3).

RRV was most commonly reported among adults, with notification rates peaking in the 35–49 years age groups (Figure 6). In 2013–14, 47% of notifications were in males, similar to previous years.

As in previous years, there was a marked seasonal trend in RRV notifications, with the largest number notified between February and May (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, as for BFV, comparisons between regions are likely to be influenced by accuracy of case-ascertainment, which may vary between jurisdictions because of some differences

Figure 5: Notification rate for Ross River virus infection, Australia, 1 July 2008 to 30 June 2014, by year and state or territory

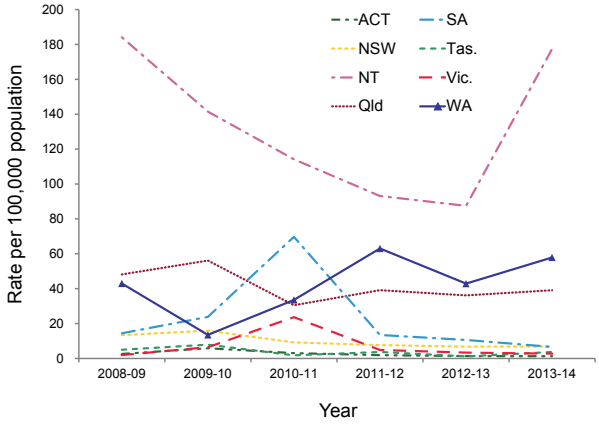
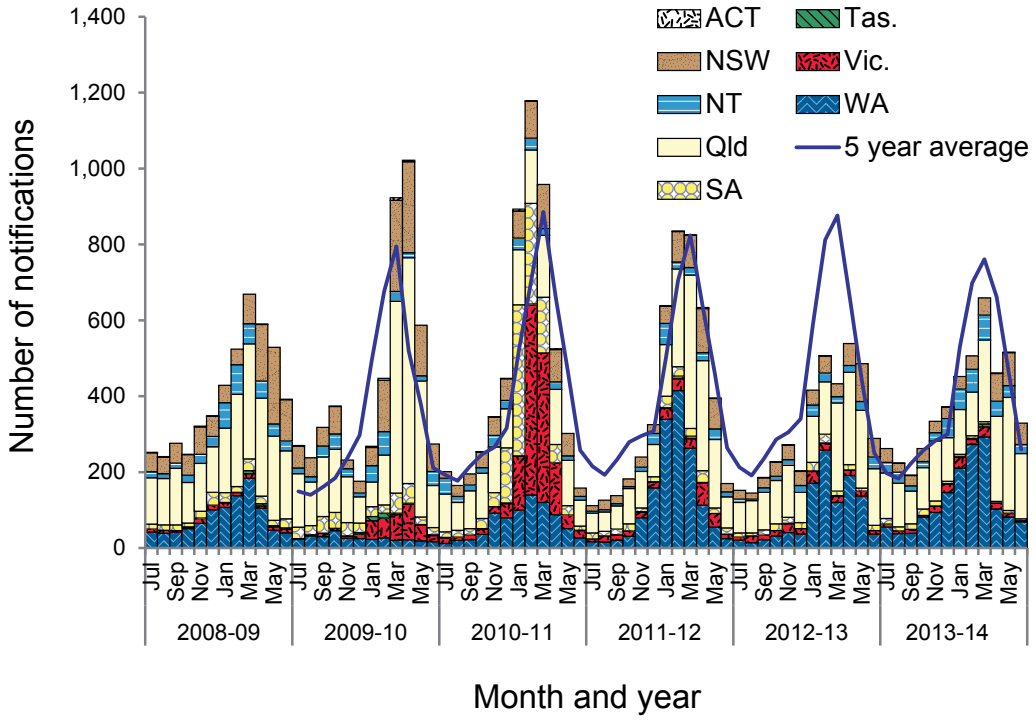
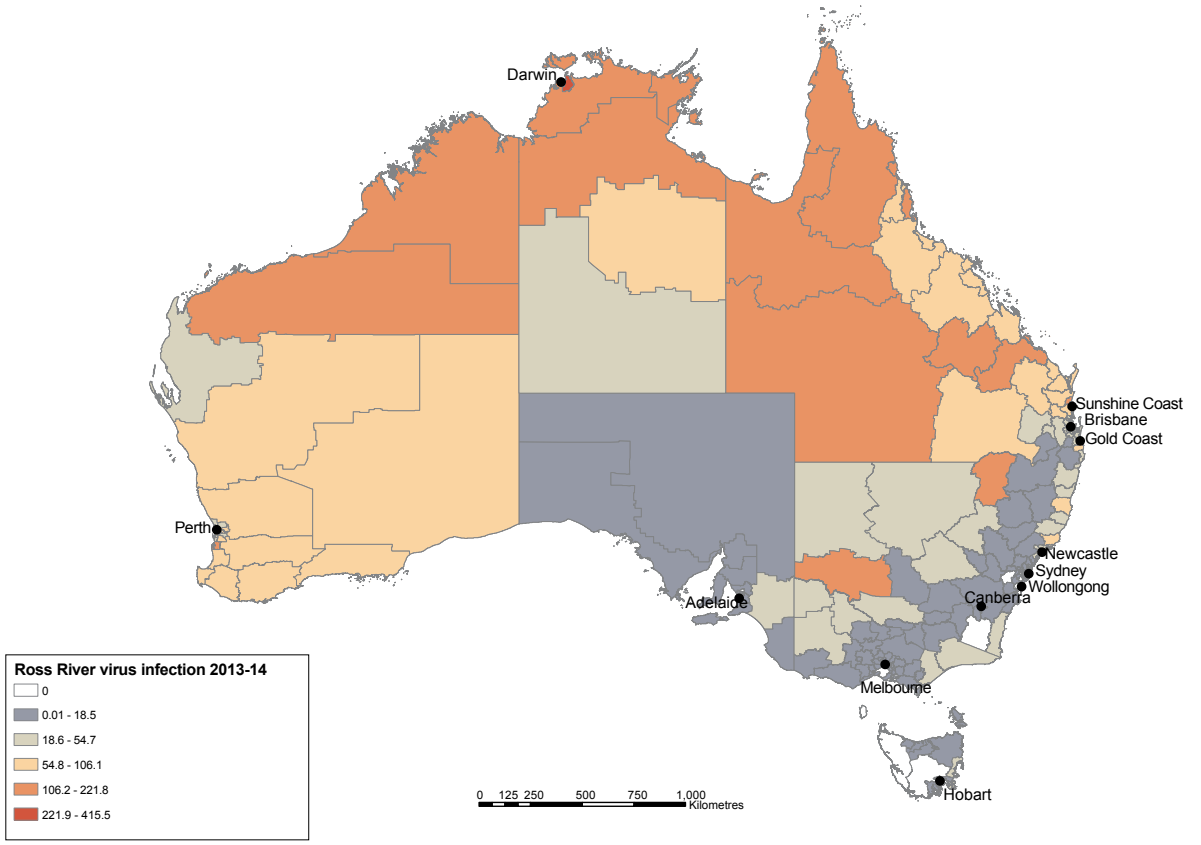
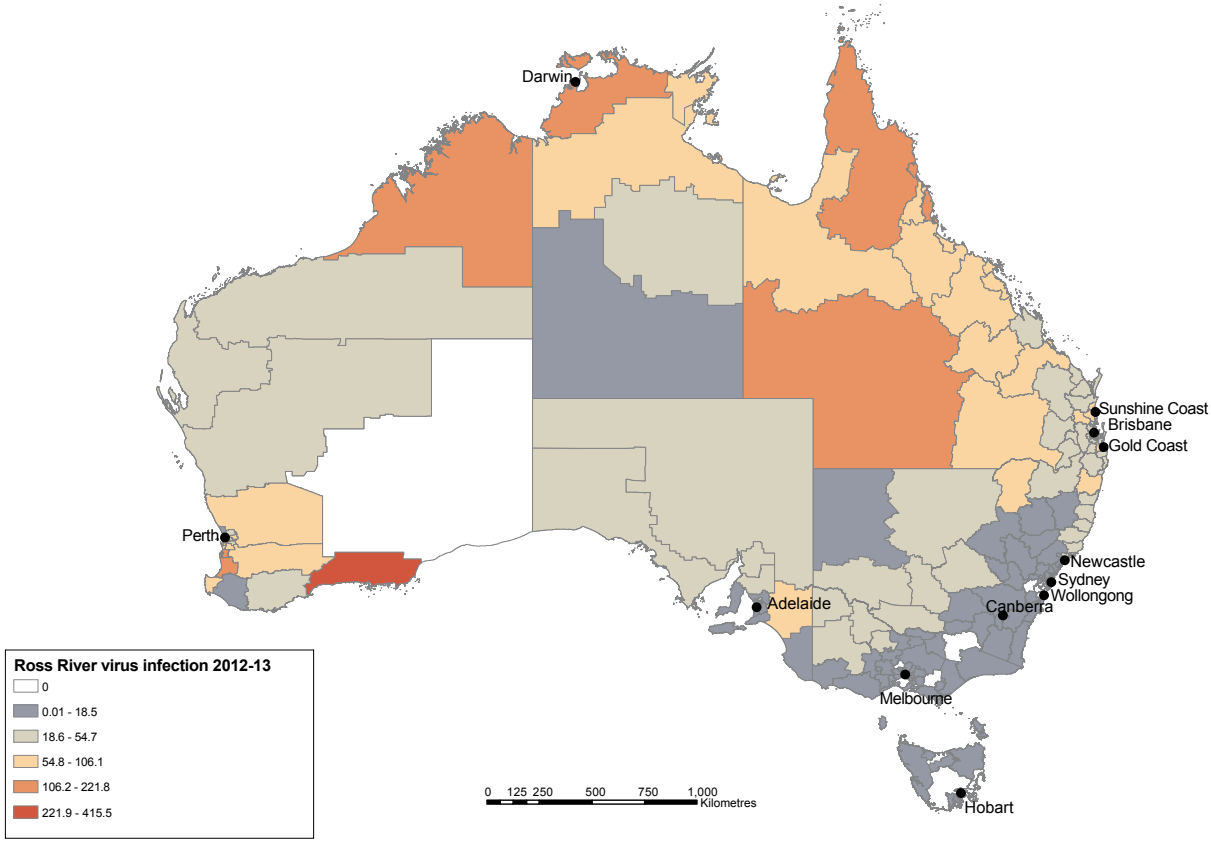


Figure 4: Notifications of Ross River virus infection, 1 July 2008 to 30 June 2014, by month and year and state or territory



Map 3: Notification rates for Ross River virus infection, 2013–14 and 2012–13, by Statistical Area Level 3





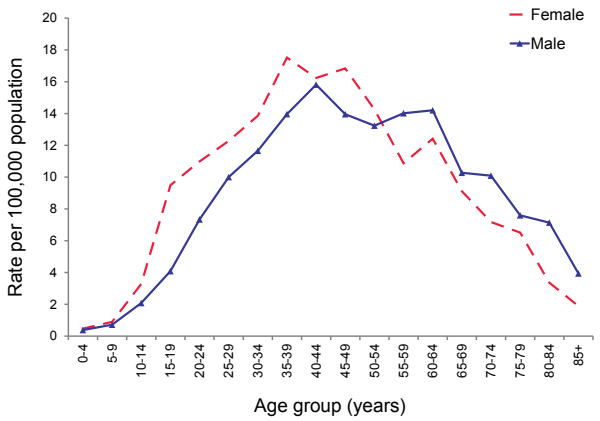
in reporting criteria and the quality of diagnostic tests used, with false positive IgM diagnoses a long term issue.[8,14]

Chikungunya virus infection

There were 94 notifications of CHIKV infection during the 2013–14 season compared with a 5–year mean of 48.2 cases, and similar to the 96 cases in 2012–13 (Table 1, Table 2, Figure 7) when the largest number ever were reported. All cases were acquired overseas, with specific information supplied on the country or region of acquisition for 78% (73/94) of these cases while the remainder were reported as overseas-acquired, but the specific country was not known (Table 2). For cases with a known country of acquisition, the most frequently reported countries of acquisition in 2013–14 were Indonesia (47 cases, 64%) and India (10 cases, 14%). Outbreaks of chikungunya were reported from multiple countries in the South Pacific during 2013–14,[15] but there were only 9 importations from the region (7 from Tonga and 2 from Papua New Guinea). An outbreak in Tonga was first reported in April 2014 on PacNet, the Pacific Public Health Surveillance Network early warning system.[16]

CHIKV infection was most frequently notified among young and middle aged adults (Figure 8). The median age was 46 years and 45% per cent of cases were male.

Figure 6: Notification rate for Ross River virus infection, Australia, 2013–14, by age group and sex (n=4,568)*



* Sex for 1 notification was not available and this notification is excluded.

Flaviviruses

This section provides information on several flaviviruses notified to NNDSS including DENV, MVEV, WNV/KUNV and JEV. Other flaviviruses, including ZIKV 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

Figure 7: Notifications of chikungunya virus infection, Australia, 2013–14, by month and year and state or territory

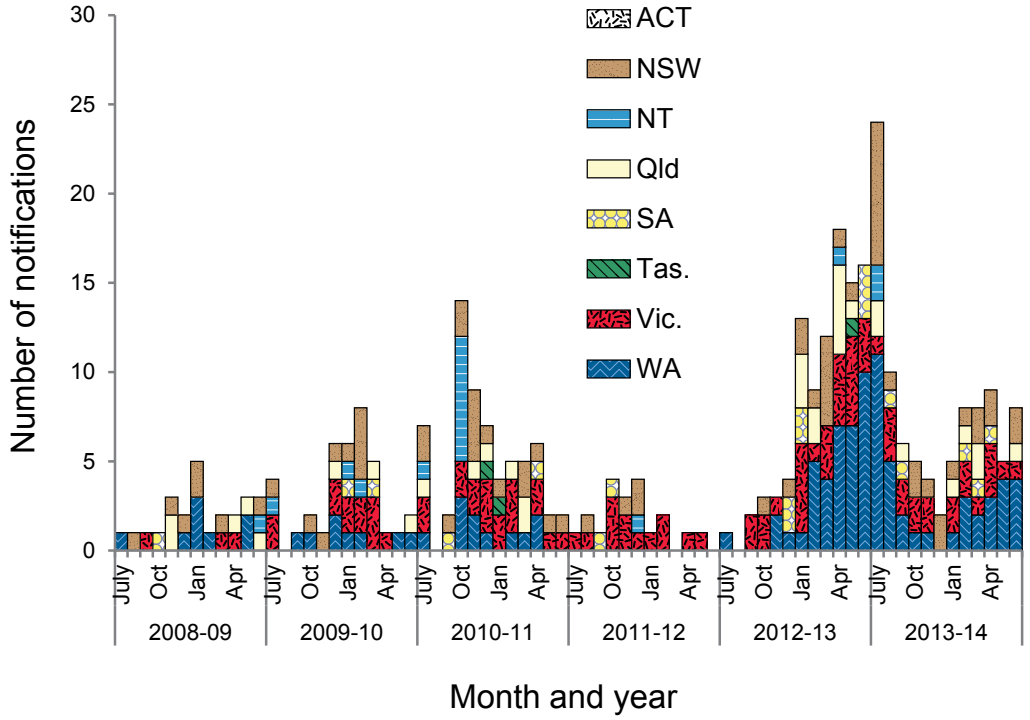
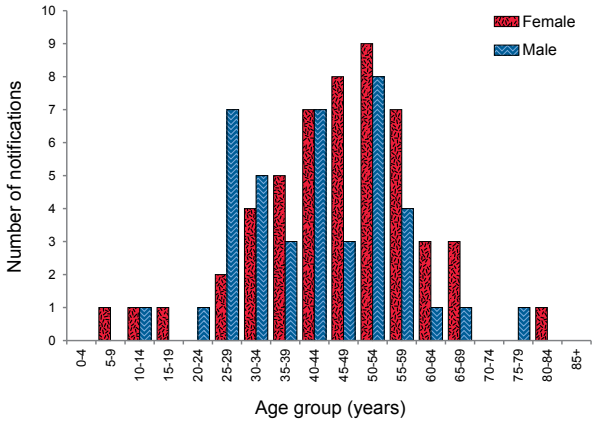


Table 2: Notifications of chikungunya virus infection, Australia, by year and country or region of acquisition

Country or region of acquisition	2009–10	2010–11	2011–12	2012–13	2013–14
Indonesia	7	32	2	34	47
India	14	11	6	2	10
Tonga	0	0	0	0	7
Philippines	1	0	2	2	3
Papua New Guinea	0	2	0	13	2
Singapore	0	1	0	0	2
Thailand	0	2	3	2	1
Nepal	0	0	0	0	1
Other countries/regions	14	13	5	4	0
Overseas-country unknown	1	2	2	39	21
Total	37	63	20	96	94

Figure 8: Notifications of chikungunya virus infection, Australia, 2013–14, by age and sex



outbreaks. The clinical illness is characterised by mild to severe febrile illness with fever, headache, muscle or 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 restricted to areas of northern Queensland where the key mosquito vector, *Ae. aegypti* is present in sufficient numbers and with human populations of sufficient density.[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. *Cx. 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 areas of Queensland where there is a risk of acquiring JEV 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 the potential for transmission in the areas of north Queensland where the vector *Ae. aegypti* is present.

Dengue virus infection

There were 2,021 notifications of DENV infection during the 2013–14 season. Of these, 212 cases were acquired in Australia, while the majority (1,795 cases) acquired the infection overseas (Table 3, Figure 9). For the remaining 14 cases, no information on place of acquisition was supplied.

Figure 9: Notifications of dengue virus infection, Australia, 1 July 2008 to 30 June 2014, by month, year and place of acquisition

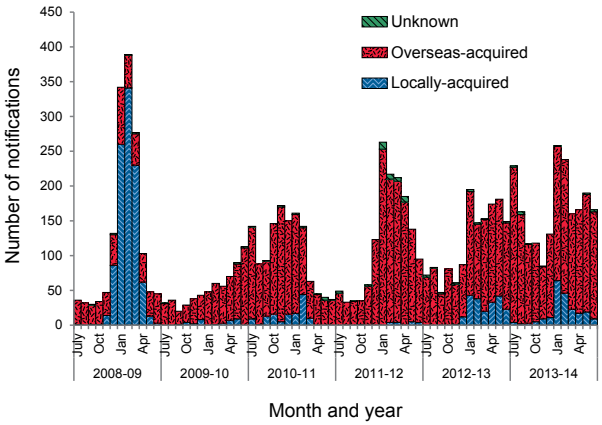


Table 3: Notifications of dengue virus infection, Australia, 1 July 2008 to 30 June 2014, by year, state or territory and place of acquisition

Place of acquisition	Year	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Aust.
Locally-acquired*	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
	2013–14	0	2	0	202	2	0	5	1	212
Overseas-acquired	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
	2013–14	14	417	69	259	80	23	403	530	1,795
Unknown	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
	2013–14	6	2	0	0	0	0	6	0	14
Total	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
	2013–14	20	421	69	461	82	23	414	531	2,021

* 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.

In 2013–14, the median age of cases was 39 years (range 0 to 85 years), and 51% (n=1,023) of cases were male.

Locally-acquired dengue virus infection

The 212 notified cases of DENV infection acquired in Australia during 2013–14 was the same number as that notified in 2012–13. Of these, 202 were reported by Queensland and 10 from other states.

In Queensland, a single case of locally-acquired dengue is considered to be an outbreak. Five dengue outbreaks were identified by Queensland Health in the 2013–14 season, all located in the north of the state. A total of 206 dengue notifications were known to have been associated with these outbreaks, with cases in each outbreak ranging from 8 to 135 (note: data extracted from the Queensland notifiable disease system; these numbers do not match exactly with the 202 reported from NNDSS due to differences in the dates used for data extraction). Four of the 5 outbreaks were serotype 1, including the largest. The remaining outbreak was serotype 3, which had 12 associated notifications. From 2010 to 2014, dengue serotype 1 has been the identified serotype in nearly 60% of dengue outbreaks in Queensland and 73% of all locally-acquired dengue notifications that were typed. In 2013–14, 57% of locally-acquired dengue notifications were typed.

Eight notifications of locally-acquired dengue from other states were listed in NNDSS as being acquired in Queensland. Two other locally-acquired cases were reported that were not associated with outbreaks in Queensland:

- a case that was acquired in or near Point Sampson, Western Australia from an unknown source. Extensive investigations did not find any evidence of a local vector and there were no

further cases. This was the first locally-acquired case in Western Australia since the 1940s, and was thought most likely to have resulted from the importation of an infected mosquito on cargo or luggage, which bit the patient, but did not survive to lay eggs.[20]

- a laboratory-acquired infection in New South Wales.

Overseas-acquired dengue virus infection

There were 1,795 notifications of DENV infection acquired overseas during the 2013–14 season (Table 3), 1.9 times the 5-year mean of overseas-acquired infections (963.4). All states and territories reported increased numbers of overseas-acquired DENV infection compared with the long-term average. The ratio of notifications in 2013–14 compared with the 5-year mean ranged from 1.2 in the Australian Capital Territory to 3.6 in Tasmania.

A specific country or region of acquisition was supplied for 89% (1,602/1,795) of cases listed as overseas-acquired (Table 4). Indonesia was the country of acquisition for more than half of the overseas acquired cases for which a specific country or region was available (51%, n=817). The infecting DENV serotype was determined for 46% (n=820) of overseas-acquired dengue cases (an increase from 42% in 2012–13, and 23% in 2011–12). DENV 1 (n=432) was the most frequently reported serotype in 2013–14 for overseas-acquired cases (Table 4).

Flavivirus (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, according to the Protocol for making a change to the National Notifiable Diseases List in Australia, which is available on the Department of Health website. 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 32 notifications of flavivirus (unspecified) in 2013–14, 3.2 times the 5-year mean of 10.0 notifications. Thirteen of these notifications were for Zika virus (ZIKV) infection acquired in the Pacific Islands countries or territories; the Cook Islands (12 cases) and Samoa (1 case) (Table 5). Outbreaks of ZIKV in the Pacific Islands were first reported in Yap State Micronesia in 2007,[21] and then on PacNet[16] in February 2013 in the Cook Islands, and later New Caledonia and French Polynesia. These outbreaks continued to mid-2014.

The largest number of notifications were from Queensland (n=27). In Queensland, an extensive panel of flaviviruses is used for testing. Flaviviruses 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 2 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 2013–14. Both cases were notified by Queensland:

- a 70-year-old man who acquired the infection in the Philippines, after travelling between January and July 2013. The case had a non-encephalitic illness, and recovered fully;
- a 47-year-old male who acquired the infection in Taiwan, after travelling for a total of 37 days in June and July 2013. The case had a non-encephalitic illness, and recovered fully.

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.[22]

There were 3 notifications of WNV/KUNV infection in Australia in 2013–14 compared with an average of 1.4 cases per year during the past 5 years.

The cases in 2013–14 were:

- a 49-year-old man who acquired the infection in Djibouti and notified by Victoria;
- a 26-year-old man who acquired the infection in Papua New Guinea and notified by Queensland;
- a 38-year-old man who acquired the infection in Timor-Leste and notified by Queensland.

Murray Valley encephalitis virus infection

There were no notifications of MVEV infection in Australia in 2013–14. MVEV infection is a rare disease in Australia, with an average of 4.2 cases per year during the past 5 years.

Table 4: Overseas-acquired cases of dengue virus infection, Australia, 2013–14, by serotype and country of acquisition

Country or region	Total number	Percentage of cases*	Serotype 1	Serotype 1 and 3	Serotype 1 and 4	Serotype 2	Serotype 3	Serotype 4	Unknown/ untyped
Indonesia	817	51	259	1	0	52	61	24	420
Thailand	170	11	26	0	0	17	7	5	115
Fiji	109	7	3	0	0	10	26	0	70
Malaysia	66	4	11	0	0	14	1	3	37
Philippines	63	4	8	0	0	11	2	8	34
Timor-Leste	60	4	21	0	0	0	4	0	35
India	47	3	3	0	0	5	1	1	37
Vanuatu	35	2	2	0	1	0	12	1	19
Sri Lanka	31	2	5	0	0	0	0	2	24
Vietnam	23	1	0	0	0	2	0	4	17
South-East Asia, nfd	22	1	2	0	0	1	0	0	19
Cambodia	16	1	1	0	0	0	3	0	12
Singapore	14	1	6	0	0	1	0	1	6
Papua New Guinea	14	1	0	0	0	2	3	0	9
Bangladesh	12	1	0	0	0	1	1	0	10
Nauru	11	1	0	0	2	0	5	0	4
Myanmar, The Republic of the Union of	8	0	2	0	0	0	1	0	5
Tonga	8	0	0	0	0	0	1	0	7
North Africa, nfd	6	0	1	0	0	2	0	1	2
French Polynesia	5	0	1	0	0	0	0	0	4
Pakistan	5	0	0	0	0	0	1	0	4
Solomon Islands	5	0	0	0	0	0	0	0	5
Kiribati	5	0	0	0	0	0	0	0	5
Kenya	3	0	0	0	0	0	0	0	3
Colombia	3	0	1	0	0	0	0	0	2
Tanzania	3	0	0	0	0	2	0	0	1
Other countries†	41	3	4	0	2	3	2	2	28
Overseas-country unknown	193		76	0	0	32	23	21	41
Total	1,795		432	1	5	155	154	73	975

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

† Each country with less than 3 cases.

nfd Not further defined.

Table 5: Notifications of flavivirus (unspecified), Australia, 2013–14

Virus species	Country of acquisition	State or territory	Month	Confirmation status
Kokobera	Place of acquisition unknown	Qld	Aug	Confirmed
Kokobera	Australia	Qld	Apr	Confirmed
Unspecified	Thailand	Qld	July	Confirmed
Unspecified	Indonesia	Qld	July	Confirmed
Unspecified	Place of acquisition unknown	Qld	July	Confirmed
Unspecified	Place of acquisition unknown	Qld	Aug	Confirmed
Unspecified	Place of acquisition unknown	Qld	Aug	Confirmed
Unspecified	Place of acquisition unknown	Qld	Aug	Confirmed
Unspecified	Vietnam	Qld	Oct	Confirmed
Unspecified	Papua New Guinea	Qld	Nov	Confirmed
Unspecified	India	Qld	Dec	Probable
Unspecified	Indonesia	Qld	Jan	Confirmed
Unspecified	Vanuatu	Qld	Feb	Confirmed
Unspecified	Fiji	Qld	Feb	Confirmed
Unspecified	Cook Islands	Qld	Mar	Confirmed
Unspecified	Philippines	Qld	Mar	Confirmed
Unspecified	Sub-Saharan Africa, nfd	Qld	Apr	Confirmed
Unspecified	Indonesia	Qld	May	Confirmed
Unspecified	Central and West Africa, nfd	Qld	May	Confirmed
Zika	Cook Islands	NSW	Apr	Confirmed
Zika	Cook Islands	NSW	Mar	Confirmed
Zika	Cook Islands	NSW	Mar	Confirmed
Zika	Cook Islands	NSW	Apr	Confirmed
Zika	Cook Islands	Qld	Mar	Confirmed
Zika	Cook Islands	Qld	Mar	Confirmed
Zika	Cook Islands	Qld	Mar	Confirmed
Zika	Cook Islands	Qld	Mar	Confirmed
Zika	Cook Islands	Qld	Mar	Confirmed
Zika	Cook Islands	Qld	Apr	Confirmed
Zika	Cook Islands	Qld	Apr	Confirmed
Zika	Cook Islands	Vic.	Apr	Confirmed
Zika	Samoa	Qld	Feb	Probable

nfd Not further defined.

Yellow fever

There were no notifications of yellow fever in 2013–14. 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. The last cases acquired on mainland Australia were during an outbreak in north Queensland in 2002.[25] 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 373 notifications of malaria during 2013–14 (Table 1, Figure 10), a 14% decrease compared with the mean of 433.6 notifications during the past 5 years. This was consistent with the trend of significant decline in the number of notifications since 2004–05 (test for trend, $P=0.001$) (Figure 11), and consistent with the steady decline in malaria incidence globally between 2000 and 2015.[26] There were no locally-acquired cases of malaria in Australia in 2013–14, and complete information on the overseas country or region of acquisition was supplied for 92% of cases (343/373). India was the most frequently reported place of acquisition (15%, 56/373), followed by the Sudan (12%, 43/373) (Table 6). Malaria was most frequently reported among people aged 25–29 years, with 67 notified cases in this age group (Figure 12). Similar to previous years, the majority of cases were male (72%, n=246), and males predominated in every age group except in those aged under 5 years and those aged 80–84 years.

The infecting species was reported for 98% (366/373) of notifications during 2013–14. *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.

Figure 11: Notifications of malaria, Australia, 1991–92 to 2013–14

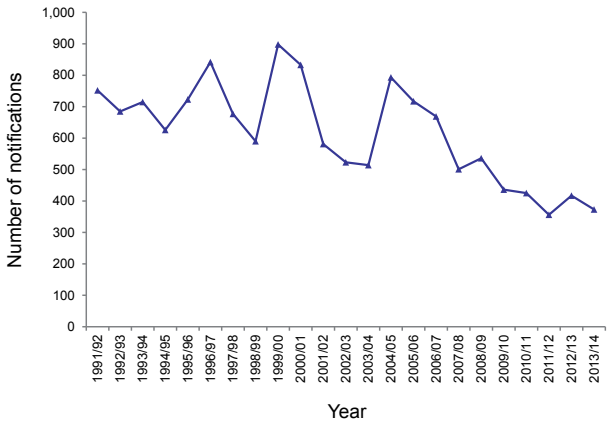
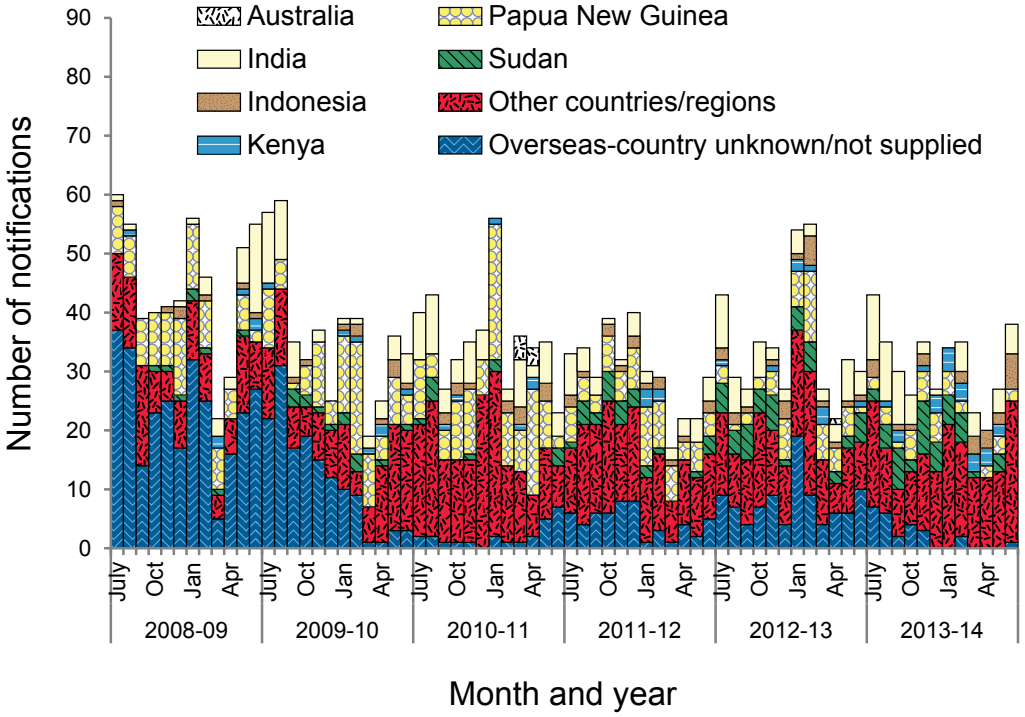


Figure 10: Notifications of malaria, Australia, 1 July 2008 to 30 June 2014, by month, year and place of acquisition*



Note: 'Other countries/regions' each had less than 20 notified cases in 2013–14.

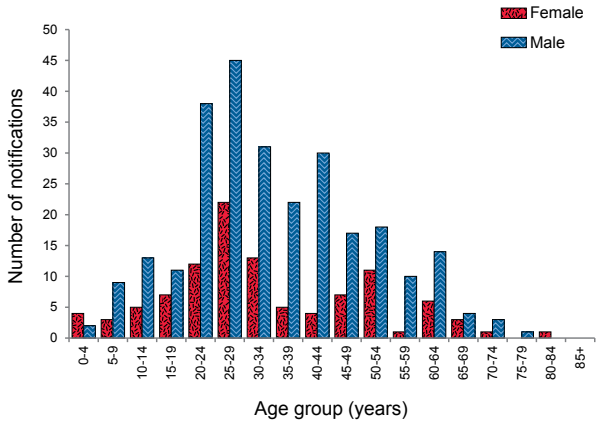
Table 6: Cases of malaria, Australia, 2013–14, by *Plasmodium* species and country or region of acquisition

Country or region of acquisition	Plasmodium falciparum	Plasmodium malariae	Plasmodium ovale	Plasmodium vivax	Mixed species infections	*Plasmodium* spp	Total	% of all cases
India	2	0	0	51	2	1	56	15
Sudan	31	1	7	2	1	1	43	12
Papua New Guinea	10	1	1	22	0	0	34	9
Indonesia	7	1	3	11	1	0	23	6
Kenya	16	3	2	0	0	1	22	6
Ghana	14	0	1	1	1	0	17	5
Uganda	11	1	1	4	0	0	17	5
Sierra Leone	13	0	2	0	0	0	15	4
Nigeria	10	0	1	0	0	1	12	3
Tanzania	11	0	0	0	0	0	11	3
Pakistan	0	0	0	8	0	1	9	2
Sub-Saharan Africa, nfd	8	1	0	0	0	0	9	2
Zambia	4	0	3	0	0	0	7	2
Mozambique	3	0	2	0	0	0	5	1
Solomon Islands	0	0	0	5	0	0	5	1
Burundi	4	0	0	0	0	0	4	1
Congo, Republic of	4	0	0	0	0	0	4	1
Southern and East Africa, nfd	3	0	0	0	0	1	4	1
Zimbabwe	4	0	0	0	0	0	4	1
Other countries/regions*	22	2	3	14	0	1	42	11
Australia	0	1	0	0	0	0	1	0
Overseas-country unknown	16	0	3	8	2	0	29	8
Total	193	11	29	126	7	7	373	100
% of all cases	52	3	8	34	2	2	100	

* Each with less than 4 cases.

nfd Not further defined.

Figure 12: Notifications of malaria, Australia, 2013–14, by age group and sex



Sentinel chicken, arbovirus detections in mosquitoes and mosquito abundance monitoring

New South Wales

The season began with 150 pullets and a total of 2,871 samples was received from the 10 flocks in New South Wales over the 6-month period in 2013–14 (Map 1). This represented 5,742 enzyme-linked immunosorbent assay (ELISA) tests (excluding controls and quality assurance samples), with each specimen being tested for MVEV and KUNV antibodies. There were 4 seroconversions; 1 KUNV from Forbes (bleed taken 11 February 2014), 1 KUNV from Griffith (12 February 2014), 1 KUNV from Leeton (30 March 2014), and 1 MVEV from Deniliquin (31 March 2014).

For 2013–14 the climatic conditions leading up to the season for the inland were of well below average rainfall for the last 6 months of 2013. In contrast, rainfall was above average for most of the inland during the first 6 months of 2014. The Forbes hypothesis[27] was not suggestive of a potential MVEV epidemic for the 2013–14 season, however the Nichols' theory[28] was not exclusive of possible activity. The dry conditions produced fewer mosquito numbers with a total trapped of around 100,000, being about 30,000 down from the previous season. Human notifications 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, weather patterns were mostly similar to the inland, however, the dry conditions continued for the north coast into the first three months of 2014, and mosquito numbers were below average. Coastal disease notifications of RRV and BFV were 27% below the long-term average.

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

Northern Territory

In 2013–14, there were 433 laboratory confirmed cases of RRV in the Northern Territory, which was the highest notification rate since 1990–91. Most (n=345) cases were recorded in the Darwin region, and occurred between December and May, with 26 cases also reported in July. It is uncertain how many notified cases were false positive diagnoses and the high number of cases did not coincide with high numbers of *Ae. vigilax* or *Cx. annulirostris*, except for in July, when *Ae. vigilax* numbers were elevated, and January, when *Cx. annulirostris* peaked. In the Darwin region there were 136 cases reported in Darwin urban, 111 in rural Darwin (Litchfield Shire) and 63 in Palmerston. This represents a rate (cases per 100,000 population) of 163 in Darwin urban (population: 83,304), 197 in Palmerston (population: 31,996) and 530 in rural Darwin (population: 20,935). Population figures are based on Australian Bureau of Statistics figures from June 2013.

In the regions, 21 RRV disease cases were recorded in the East Arnhem region, 40 in the Katherine region, 6 in the Barkly and 14 in the Alice Springs region.

In the 2013–14 season, Northern Territory sentinel chickens seroconverted to MVEV in April in the Katherine region, to KUNV in May in the Darwin, Katherine and Barkly regions and again to KUNV in July in the Darwin region. No MVEV or KUNV disease cases were reported in the Northern Territory in 2013–14. In parallel with the sentinel chicken surveillance program, the flavivirus surveillance trial using honey bait cards (or FTA cards) was continued. None of the cards tested positive for flaviviruses.

The dengue mosquito *Ae. aegypti*, was detected in Tennant Creek in late 2011. This triggered a coordinated and intensive program, consisting of 8 rounds of property by property surveys and treatment of all receptacles to eliminate this exotic mosquito. The dengue mosquito elimination program in Tennant Creek was successfully completed on 30 April 2014. Further details are available from the Northern Territory Medical Entomology annual reports, available on the Northern Territory government web site (http://www.health.nt.gov.au/Medical_Entomology/index.aspx).

Queensland

Torres Strait *Aedes albopictus* Prevention and Control Program

The exotic Asian tiger mosquito, *Ae. albopictus* was first found on the outer islands of Torres Strait in April 2005.[29]

This mosquito is a competent vector of a number of arboviruses including DENV and CHIKV, and represents a serious nuisance biting mosquito. Since 2005, the Australian Government has funded Queensland Health for 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. Harbourage treatment on Horn and Thursday islands remained the focus of the program. Whilst this provided good control of *Ae. albopictus*, relatively high numbers of *Ae. aegypti* persisted, particularly on Thursday Island.

Harbourage treatment with synthetic pyrethroids remains the key component of the *Ae. albopictus* suppression strategy in the Torres Strait and has proven successful at reducing numbers of mosquitoes collected and also preventing establishment on the mainland. While these intervention techniques are proving very effective at controlling *Ae. albopictus*, the continued presence of *Ae. aegypti* in relatively high numbers on Thursday Island remains a cause for concern. Vector control teams inspected the majority of premises on Thursday Island during the reporting period (up to 850 properties per trip with a total of 6 trips conducted) and undertook source reduction to address this.

Human-bait sweep-net sampling did not detect *Ae. albopictus* at any of the sites across the Northern Peninsula area. However, a total of 1,249 potential breeding sites were identified and treated during yard inspections in Seisia, New Mapoon and Bamaga, and at least 320 larval samples were collected from water-holding containers in these communities.

North Queensland

Ongoing container-inhabiting mosquito surveillance in Cairns and Townsville by public health units through a network of traps in various suburbs did not detect *Ae. albopictus* in either location during the reporting period.

The sugar-baited FTA card based arbovirus surveillance conducted in the Northern Peninsula Area of Cape York by the Australian Government Department of Agriculture did not detect JEV during the reporting period.

Central Queensland

Surveillance across Rockhampton using Biogents, gravid *Aedes* traps (GATs) and ovitraps in early 2014 confirmed the presence of *Ae. aegypti* across a number of urban locations. Notably, the exotic species *Cx. gelidus* was identified in the Yeppoon area for the first time in May/June 2014. Larval surveys/GATs did not detect *Ae. aegypti* in Childers or Apple Tree Creek in February 2014. However, *Ae. aegypti* was again observed in Gin Gin in the greater Bundaberg region.

Southern Queensland

GATs deployed in the South Burnett towns of Murgon, Wondai, Kumbia, Nanango, Kingaroy and Blackbutt only detected *Ae. aegypti* in Wondai.

Ae. aegypti were detected in both Roma and Charleville during a trial of ovitraps and GAT traps in south-west Queensland. All 3 sites in Charleville and 2 of 3 in Roma detected *Ae. aegypti*. In Roma, *Ae. aegypti* were only collected in GATs while *Ae. aegypti* were present in both GATs and ovitraps in Charleville. The novel urban surveillance program using ovitraps and GATs in the Brisbane local government area did not detect *Ae. aegypti* or *Ae. albopictus*. The trial of sugar-baited FTA card virus surveillance across Gold Coast City, Brisbane City and Sunshine Coast Regional councils demonstrated the utility of this virus detection system for councils who monitor mosquito populations at peri-urban sites. RRV or BFV were not detected at any locations.

In South East Queensland, the 2013–14 season was similar to the previous season, with a very dry first half. Large but discrete rain events were observed in summer and autumn, but overall rainfall remained very low. Total rainfall at Brisbane Airport from 1 July to 30 June was 549 mm, just 46% of long term average. Whilst February is normally the wettest month of the year, Brisbane Airport recorded 15 mm, only 9% of the average rainfall and, most unusually, many saltmarshes had completely dried out by mid-March. This may explain the huge number of *Ae. vigilax* that hatched across the region after widespread rain in late March, a phenomenon that has been observed previously after saltmarshes become dry. A mild autumn prolonged the activity of mosquitoes into early

winter, and most local governments with aerial spraying programs observed sufficient hatching of saltmarsh mosquitoes after the mid-June tide peak to unusually conduct an aerial treatment in June. The dry season ensured that *Ae. vigilax* was the dominant species in coastal areas, but *Cx. annulirostris* and a few of other freshwater species were active later in the season.

South Australia

The mosquito populations along the River Murray during the season exhibited 2 distinct patterns associated with geographic location of the trap sites. Traps located north of Mannum in the Mid-Murray council were typified by low mosquito numbers over the majority of the season. A slight increase in mosquito numbers was observed in samples from this group of adult traps retrieved in March, with numbers then dropping off in April. The composition of the mosquito community varied across upper river councils. The mosquito species *Anopheles annulipes, Coquillettidia linealis, Cx. annulirostris, Cx. molestus* and *Cx. quinquefasciatus* all formed significant components of the mosquito community in at least 1 of the upper river councils. Spring peaks in mosquito populations were observed in 2 of the 3 upper river councils. These were distinguished from previous seasons by the virtual absence of the Southern Salt Marsh mosquito *Ae. camptorhynchus*, a species that typically overwinters as larvae and emerges in spring. In the northern councils, some locally rare mosquitoes were also recorded this season including *Ae. eidsvoldensis, Mansonia uniformis, Ae. alternans, Ae. sagax*, and *Ae. vittiger*.

The mosquito populations at Mannum and to the south of this town retained distinct spring peaks of *Ae. camptorhynchus* through to November with some areas also experiencing a late season flush in mosquito numbers attributed to heavy February rainfall.

Overall, a total of 46,713 adult mosquitoes were collected from the 35 regular monitoring sites in the season. The total number of mosquitoes caught this season represented an overall increase of 45% compared with the previous season's total mosquito catch. However, this increase was not uniform across all councils. In the 3 northernmost councils there was a decrease in the total mosquitoes caught across the councils by 55% while in the 3 southernmost councils there was an increase of 64% on the total number of mosquitoes caught in the previous season (although Alexandrina council actually experienced a decline of around 25%). The overall mosquito catch within the Mid-Murray Council was around the same as the previous season.

The University of South Australia (Uni SA) also conducted mosquito surveillance trapping at 6 locations on 16 occasions from September 2013 to April 2014 for the City of Salisbury in the Adelaide northern metropolitan suburbs of Globe Derby Park and St Kilda during the season. In this region, the mosquito season can be characterised by 2 distinct features. Firstly, there was a peak in *Ae. camptorhynchus* abundance in March 2014. This was likely triggered by the high rainfall in February–March 2014. Secondly, *Ae. vigilax* numbers in the late summer and autumn of 2014 continued to remain low, but overall numbers showed a slight increase compared with the previous season. *Ae. vigilax* numbers peaked at approximately 98 mosquitoes per trap in early March 2014. This peak was possibly constrained by high tides not occurring until mid-March to April 2014.

The *Ae. camptorhynchus* abundance pattern during spring was similar to that during 2012–13 although slightly higher in numbers compared with the previous season. However, as previously mentioned, a distinct peak of the species was observed in March 2014 in response to heavy rainfall in late February 2014. *Ae. vigilax* abundance has been lower over the last 3 monitoring seasons compared to the previous years, indicating that the improved and complementary larval control activities of South Australian Department of Health and Ageing (SA Health) and Uni SA in the area have been successful in reducing the mosquito numbers.

No sentinel chicken seroconversions for MVEV or KUNV were recorded during the 2013–2014 season.

This season, sugar-baited FTA cards were trialled by Uni SA in the traditional Encephalitis Vector Survey CO_2 baited traps set within each client council, and in a number of additional regional and metropolitan locations. In addition to this research, 3 passive CO_2 baited box traps were deployed for the first time along the River Murray at Renmark, Mannum and Murray Bridge. Arboviruses were detected in a number of regional and metropolitan locations between January and March 2014 (Table 7).

Table 7: Virus and sentinel chicken surveillance in Australia for selected regions, by surveillance method and virus genus, 2013–14

State or territory	Region	Flaviviruses			Alphaviruses		
		Number 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	0/157			N/A		
NSW	Deniliquin	1 MVEV /331			N/A		
NSW	Forbes	1 KUNV/330			N/A		
NSW	Griffith	1 KUNV/315			N/A		
NSW	Hay	0/345			N/A		
NSW	Leeton	1 KUNV / 328			N/A		
NSW	Macquarie Marshes	0/212			N/A		
NSW	Moama	0/255			N/A		
NSW	Moree	0/300			N/A		
NSW	Wee Waa	0/298			N/A		
NT	Darwin region	4/279	7 May 2014	30 Jul 2014	N/A		
NT	East Arnhem region	0/53			N/A		
NT	Katherine region	3/110	2 Apr 2014	6 May 2014	N/A		
NT	Barkly region	2/45	13 May 2014	13 May 2014	N/A		
NT	Alice Springs region	0/95			N/A		
SA	Paringa	0/35			N/A		
SA	Loxton	0/35			N/A		
SA	Waikerie (Qualco)	0/35			N/A		
SA	Murray Bridge	0/35			N/A		
SA	Meningie	0/35			N/A		
Vic.	Mooroopna	0/144			N/A		
Vic.	Mildura	0/444			N/A		
Vic.	Robinvale	0/265			N/A		
Vic.	Nyah West	0/428			N/A		
Vic.	Kerang	0/411			N/A		
Vic.	Barmah	0/381			N/A		
Vic.	Cobram	0/495			N/A		
Vic.	Wodonga	0/307			N/A		

Table 7 cont'd: Virus and sentinel chicken surveillance in Australia for selected regions, by surveillance method and virus genus, 2013–14

State or territory	Region	Flaviviruses			Alphaviruses		
		Number 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	0/130			N/A		
WA	Kununurra	0/148			N/A		
WA	Savannah Nickel Mine	0/119			N/A		
WA	Halls Creek	0/255			N/A		
WA	Fitzroy Crossing	0/141			N/A		
WA	Derby	1/489	16 May 2014	16 May 2014	N/A		
WA	Lombadina	0/45			N/A		
WA	Broome	1/58	26 Sept 2013	26 Sept 2013	N/A		
WA	Roebuck Plains	9/156	25 July 2013	28 May 2014	N/A		
WA	Port Hedland	0/67			N/A		
WA	Karratha	0/245			N/A		
WA	Harding Dam	0/568			N/A		
WA	Marble Bar	0/95			N/A		
WA	Pannawonica	0/228			N/A		
WA	Tom Price	0/203			N/A		
WA	Paraburdoo	0/237			N/A		
WA	Onslow	0/154			N/A		
WA	Ophthalmia Dam	4/222	22 May 2014	17 June 2014	N/A		
WA	Newman	0/238			N/A		
WA	Exmouth	0/262			N/A		
WA	Carnarvon	0/222			N/A		
WA	Moora	0/156			N/A		
WA	Geraldton	0/206			N/A		
WA	Dongara	0/174			N/A		
WA	York	0/80			N/A		

Table 7 cont'd: Virus and sentinel chicken surveillance in Australia for selected regions, by surveillance method and virus genus, 2013–14

State or territory	Region	Flaviviruses			Alphaviruses		
		Number positive or seroconverted/number tested*	First positive date	Last positive date	Number positive or seroconverted/number tested*	First positive date	Last positive date
Sugar-baited FTA cards							
NSW	Ballina				1 RRV /8,328		
NSW	Bankstown				1 BFV & 1 RRV /2,443		
NSW	Coffs Harbour				1 RRV /2,448		
NSW	Georges River				4 BFV, 5 RRV /9,932		
NSW	Griffith				1 BFV, 3 RRV /28,622		
NSW	Leeton				2 BFV /11,935		
NSW	Port Macquarie				1 BFV, 5 RRV /3,938		
NSW	Port Stephens				2 RRV /19,126		
NSW	Tweed Heads				4 RRV /10,030		
NT	Darwin region	0/80			N/A		
Qld	Northern Peninsula Area†	Nil					
SA	Goolwa	Stratford	Jan	Jan	BFV RRV	Feb	Feb
SA	Goolwa North				BFV	Feb	Feb
SA	Mypolonga	Stratford	Jan	Jan	RRV	Feb	Feb
SA	Adelaide Hills (Mylor-Hahndorf)	Stratford	Jan	Jan			
SA	Tailem Bend				BFV	Feb	Feb
SA	Paringa				BFV	Feb	Feb
SA	Renmark				BFV RRV	Jan	Feb
SA	Murray Bridge				RRV	Mar	Mar
SA	Globe Derby Park				RRV	Feb	Feb
SA	Bedford Park				RRV	Jan	Jan
SA	Port Adelaide				BFV RRV	Jan	Feb
SA	Thebarton				RRV	Feb	Feb
SA	Richmond				RRV	Feb	Feb
SA	Enfield				BFV	Feb	Feb

Table 7 cont'd: Virus and sentinel chicken surveillance in Australia for selected regions, by surveillance method and virus genus, 2013–14

State or territory	Region	Flaviviruses			Alphaviruses		
		Number positive or seroconverted/number tested*	First positive date	Last positive date	Number positive or seroconverted/number tested*	First positive date	Last positive date
Virus isolation/polymerase chain reaction detection from mosquitoes							
NSW	Blacktown	0/1,470			3 RRV /1,470		
NSW	Georges River	11 STRV /9,932			3 BFV & 6 RRV /9,932		
NSW	Gosford	0/2,378			1 BFV /2,378		
NSW	Griffith	1 STRV /28,622			1 RRV /28,622		
NSW	Leeton	0/11,935			1 RRV /11,935		
NSW	Port Stephens	2 EHV /19,126			2 BFV & 17 RRV /19,126		
NT	Darwin region	N/A					
Qld	Northern Peninsula Area, Cape York JEV surveillance†	Nil					
Vic.	Inland North West	0/1,924			0/1,924		
Vic.	Inland North East	0/2,347			0/2,347		
Vic.	Gippsland – Lake Wellington	0/2,285			1 RRV/2,285		
WA	Kununurra	0/8,690			0/8,690		
WA	Wyndham	3 KUNV/5,810			2 SINV/5,810		
WA	Roebourne area	0/3,458			0/3,458		
WA	Mt Magnet	0/31			0/31		
WA	Cue	0/242			0/242		
WA	Peel region	0/24,142			1 RRV & 6 BFV/24,142		
WA	Leschenault region	0/17,130			6 RRV & 2 BFV/17,130		
WA	Capel-Busselton region	0/18,269			11 RRV & 1 BFV/18,269		

* For virus detections/isolations, the number tested is the number of individual mosquitoes or chickens tested, unless otherwise noted. The number tested is not always known.

† Surveillance only conducted from 28 January to 22 April 2014.

Note: Sentinel chickens are not screened for antibodies to Alphaviruses

Victoria

Through the routine sentinel chicken program, weekly blood samples were tested from the 9 flocks between November 2013 and April 2014. No seroconversions for flaviviruses were detected during the season, which involved testing of 3,319 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, 31,433 mosquitoes were collected between November and April and submitted for species identification and arbovirus detection. Mosquito abundance at inland sites was low throughout the season, except in the North West (including Kerang and Mildura) where following above average rainfall in summer and autumn, moderate numbers of *Cx. australicus* and *Cx. annulirostris* were detected. *Cx. annulirostris* was the dominant species at approximately half (13 of 23) of inland sites, accounting for between 24% to 66% of collections. Other species that dominated catches included *Cx. australicus*, *Cx. quinquefasciatus*, *Ae. notoscriptus* 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. In Gippsland, mosquito abundance was highest in spring and early summer with moderate to high numbers of *Ae. camptorhynchus* detected (Table 8 shows the definition of 'High' and other numerical categories). Mosquito abundance peaked in early January 2013 with very high levels detected. A reduction in mosquito abundance was detected for the remainder of the season, until mid-April, where high numbers were recorded.

Virus isolation was conducted on over 7,000 pools of mosquito samples (a total of 48,095 mosquitoes). A single RRV isolate was cultured from a pool of *Ae. camptorhynchus* collected in Gippsland in November 2013. The RRV isolate was phylogenetically related to the well-documented, eastern Australian RRV lineage.[30]

Western Australia

Above average rainfall was observed in northern parts of Western Australia between October 2013 and February 2014. Tropical Cyclones Alessia and Christine in particular influenced rainfall patterns in November and December 2013. Numerous sites in the Kimberley, Pilbara and Gascoyne observed their wettest January on record. Monsoonal activity was weaker than usual in northern Western Australia in March, however, typical rainfall patterns returned in April and May 2014. In the south-west of Western Australia, rainfall was above average at the commencement of the season, and then declined to below or very much below average from October 2013 to April 2014, particularly during the summer period. Temperatures were generally warmer than average for most of the season. Tides impacted saltmarsh breeding sites with the exception of summer months when they had less impact than predicted.

The level of flavivirus activity in sentinel chickens in northern Western Australia in 2013–14 was low.[31] Seroconversions were detected in 15 of the 4,798 samples tested (0.3%), which was above the level of activity in 2012–13,[32] but still low. Low level activity associated with the end of the 2012–13 season was detected in the West Kimberley region and continued to October 2013. Flavivirus activity commenced late in the 2013–14 season, following generally above average rainfall between November 2013 and February 2014, followed by 2 months of very much below average or average rainfall in March and April in the Kimberley region. The first seroconversion for the season occurred in mid-May, when a KUNV seroconversion was detected in the Derby flock in the West Kimberley region. In the same month, antibodies to KUNV were detected at Ophthalmia Dam in the Pilbara region, followed by seroconversions to KUNV (3), MVEV (2) and an unknown flavivirus infection at Roebuck Plains, in the West Kimberley region. Flavivirus activity continued in June in the Ophthalmia Dam chicken flock. Overall, 11 flavivirus seroconversions were detected in sentinel chickens in the 2013–14 season in Western Australia, and the majority (63.6%) were due to KUNV infection. Activity of MVEV was only detected at Roebuck Plains in the West Kimberley region. In addition, KUNV was the only flavivirus isolated from mosquitoes collected in the Northeast Kimberley region in April 2014. The Western Australian Department of Health initially released a media alert in early May reminding travellers and residents to take precautions against mosquito bites following late season flooding in the Pilbara and Gascoyne regions. Detection of antibodies to flaviviruses in sentinel chickens triggered a second media release in mid-June. No human cases of MVE or KUNV disease were reported in the 2013–14 season in Western Australia.

Table 8: Key mosquito vector abundance in selected regions of Australia in 2013–14, by species, state or territory, region and month

Species	State or territory	Region/ locality	Month											
			Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Saltwater														
Aedes vigilax	NSW	North Coast	–	–	–	–	–	LOW	HIGH	HIGH	HIGH	HIGH	MED	
Ae. vigilax	NSW	Mid-North Coast	–	–	–	–	–	LOW	HIGH	HIGH	HIGH	MED	LOW	
Ae. vigilax	NSW	Central Coast	–	–	–	–	–	MED	HIGH	HIGH	MED	MED	LOW	
Ae. vigilax	NSW	Sydney – Georges River	–	–	–	–	–	HIGH	HIGH	HIGH	MED	LOW		
Ae. vigilax	NSW	Sydney – Homebush	–	–	–	–	HIGH	HIGH	HIGH	HIGH	HIGH	MED		
Ae. vigilax	NSW	Sydney – Western	–	–	–	–	–	LOW	MED	LOW	LOW	LOW		
Ae. vigilax	NT	Darwin region	HIGH	LOW	MED	MED	HIGH	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Ae. vigilax	NT	East Arnhem region	N/A	LOW	LOW	LOW	N/A	HIGH	HIGH	HIGH	LOW	N/A	LOW	LOW
Ae. vigilax	Qld	Brisbane inland–Indooroopilly Island	–	–	–	LOW	LOW	MED	LOW	MED	LOW	LOW	LOW	–
Ae. vigilax	Qld	Brisbane coastal–Bracken Ridge	LOW	LOW	LOW	MED	HIGH	MED	HIGH	HIGH	HIGH	HIGH	LOW	LOW
Ae. vigilax	Qld	Brisbane coastal–Virginia	LOW	LOW	MED	HIGH	HIGH	HIGH	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH
Ae. vigilax	Qld	Brisbane coastal–Albion	–	–	–	LOW	LOW	MED	HIGH	HIGH	LOW	HIGH	LOW	LOW
Ae. vigilax	Qld	Brisbane coastal–Hemmant	–	–	LOW	MED	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
Ae. vigilax	Qld	Brisbane coastal–Lota	–	–	LOW	LOW	LOW	LOW	LOW	MED	LOW	HIGH	LOW	LOW
Ae. camptorhynchus *Ae. vigilax*	SA (SK1,SK2)	St Kilda	–	–	LOW	HIGH	HIGH	LOW	LOW	LOW	HIGH	MED		
Ae. camptorhynchus *Ae. vigilax*	SA (GD1,GD2, GD6)	Globe Derby Park	–	–	HIGH	HIGH	MED	MED	LOW	LOW	HIGH	HIGH		
Culex molestus	SA (A3,A4)	Goolwa	–		HIGH	LOW	–*	LOW	LOW	LOW	LOW	LOW		
Ae. camptorhynchus	Vic.	Gippsland / Lake Wellington	–	–	HIGH	LOW	HIGH	HIGH	HIGH	LOW	MED	MED		

Table 8 cont'd: Key mosquito vector abundance in selected regions of Australia in 2013–14, by species, state or territory, region and month

Species	State or territory	Region/ locality	Month											
			Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Ae. vigilax	WA	Kununurra	–	–	–	–	–	–	–	–	–	LOW		
Ae. vigilax	WA	Wyndham	–	–	–	–	–	–	–	–	–	LOW		
Culex sitiens	WA	Wyndham	–	–	–	–	–	–	–	–	–	LOW		
Ae. vigilax	WA	Roebourne area	–	–	–	LOW	–	–	LOW	–	–	–	–	–
Ae. camptorhynchus	WA	Peel region	MED	HIGH	HIGH	HIGH	MED	LOW	LOW	Nil	LOW	LOW	HIGH	MED
Ae. vigilax	WA	Peel region	Nil	Nil	Nil	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Ae. camptorhynchus	WA	Leschenault region	LOW	HIGH	HIGH	HIGH	HIGH	MED	LOW	Nil	Nil	LOW	HIGH	HIGH
Ae. vigilax	WA	Leschenault region	Nil	Nil	Nil	Nil	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Ae. camptorhynchus	WA	Capel-Busselton region	MED	HIGH	HIGH	VERY HIGH	HIGH	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Freshwater														
Culex annulirostris	NSW	Inland – Riverina	–	–	–	–	HIGH	HIGH	VERY HIGH	VERY HIGH	HIGH	–	–	–
Cx. annulirostris	NSW	Inland – Murray region	–	–	–	–	LOW	LOW	HIGH	HIGH	LOW	–	–	–
Cx. annulirostris	NSW	Inland, West & Nth West	–	–	–	–	LOW	LOW	LOW	LOW	LOW	–	–	–
Cx. annulirostris	NT	Darwin region	MED	MED	LOW	LOW	LOW	HIGH	HIGH	MED	LOW	LOW	MED	MED
Cx. annulirostris	NT	East Arnhem region	N/A	LOW	MED	MED	N/A	HIGH	HIGH	HIGH	MED	N/A	LOW	MED
Cx. annulirostris	NT	Katherine region	N/A	N/A	N/A	N/A	N/A	LOW	HIGH	LOW	MED	LOW	Low	N/A
Cx. annulirostris	NT	Barkly region	N/A	N/A	N/A	N/A	N/A	LOW	LOW	MED	LOW	LOW	N/A	N/A
Cx. annulirostris	NT	Alice Springs region	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW
Ae. camptorhynchus	SA	Wellington	–	–	VERY HIGH	HIGH	HIGH	MED	LOW	LOW	LOW	LOW	–	–
Ae. camptorhynchus	SA	Tailem Bend	–	–	MED	LOW	MED	HIGH	LOW	LOW	LOW	LOW	–	–
Ae. camptorhynchus	SA	Murray Bridge	–	–	HIGH	MED	HIGH	LOW	LOW	LOW	LOW	LOW	–	–
Ae. camptorhynchus	SA	Mannum	–	–	HIGH	MED	LOW	LOW	LOW	LOW	MED	LOW	–	–
Ae. camptorhynchus	SA	Meningie	–	–	VERY HIGH	HIGH	MED	LOW	LOW	LOW	LOW	HIGH	–	–

Table 8 cont'd: Key mosquito vector abundance in selected regions of Australia in 2013–14, by species, state or territory, region and month

Species	State or territory	Region/ locality	Month											
			Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Culex molestus	SA	Swan Reach	–	–	LOW	LOW	LOW	HIGH	LOW	LOW	LOW	LOW	–	–
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	LOW	–	–
Cx. molestus	SA	Waikerie	–	–	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	–	–
Cx. annulirostris	SA	Kingston on Murray			LOW	LOW	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	–	–	LOW	LOW	LOW	LOW	LOW	LOW	LOW	LOW	–	–
An. annulipes *Cx. annulirostris*	SA	Renmark/Paringa	–	–	LOW	HIGH	LOW	LOW	LOW	LOW	MED	LOW	–	–
Cx. annulirostris	Vic.	North West	–	–	–	–	LOW	LOW	LOW	LOW	MED	MED	–	–
Cx. annulirostris	Vic.	North East	–	–	–	–	LOW	LOW	LOW	LOW	LOW	LOW	–	–
Cx. annulirostris	WA	Kununurra	–	–	–	–	–	–	–	–	–	HIGH	–	–
Cx. palpalis	WA	Kununurra	–	–	–	–	–	–	–	–	–	LOW	–	–
Aedes normanensis	WA	Kununurra	–	–	–	–	–	–	–	–	–	LOW	–	–
Cx. annulirostris	WA	Wyndham	–	–	–	–	–	–	–	–	–	HIGH	–	–
Culex palpalis	WA	Wyndham	–	–	–	–	–	–	–	–	–	LOW	–	–
Ae. normanensis	WA	Wyndham	–	–	–	–	–	–	–	–	–	LOW	–	–
Cx. annulirostris	WA	Roebourne area	–	–	–	LOW	–	–	LOW	–	–	–	–	–
Ae. normanensis	WA	Roebourne area	–	–	–	Nil	–	–	LOW		–	–	–	–
Cx. annulirostris	WA	Mt Magnet	–	–	–	–	–	–	–	–	Nil	–	–	–
Cx. annulirostris	WA	Cue	–	–	–	–	–	–	–	–	LOW	–	–	–

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)

* Trap fail

– Denotes no data collected.

In the south-west of Western Australia, vector abundance was initially high and then declined to low abundance in summer and autumn, likely due to reduced impact of high tides and very low rainfall.[31] The first arbovirus detection for the season was RRV in the Peel region and at Capel in early October 2013, prompting the Western Australian Department of Health to issue a media release advising residents and travellers of the increased risk of mosquito-borne disease. The minimum infection rate for RRV was greatest when it reached 7.7 per 1,000 mosquitoes[33] at Capel on 10 October 2013. RRV was also detected in the Leschenault region and at Busselton later in the season, and detections continued through to mid-February 2014. The first detection of BFV was in the Peel region in late October 2013, and this virus was also subsequently detected in the Leschenault region and Capel. The minimum infection rate for BFV peaked at 8.0 per 1,000 mosquitoes in early February in the Leschenault region. The majority of alphavirus detections were from *Ae. camptorhynchus* (74%). Detections of RRV in mosquitoes occurred during the time that roughly 60% of human cases were notified, and human cases occurred when vector abundance was low. It was recently suggested that the large number of notified RRV cases that occur outside the peak risk season may be due to issues with the superseded case definition, the low positive predictive value of IgM positive only tests in the off-season and inconsistencies between notification methodologies of different testing laboratories.[8]

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-2013-14.ashx)

Tasmania

No viruses were isolated in 2013–14 from mosquitoes trapped during ad hoc collections undertaken in the Sorrell Council region.

Exotic mosquito detections at the border

Between July 2013 and June 2014 there were 13 exotic mosquito detections made by the Australian Government Department of Agriculture and Water Resources at the Australian border (Table 9). This represents an increase compared with the 2012–13 period where there were 7 exotic mosquito detections. This increase was due to an increase in the number of exotic mosquito detections at international airports. Four detections were made via inspection of imported cargo while the remaining 9 detections resulted from routine vector monitoring activities performed at international ports. The 4 exotic mosquito detections associated with imported cargo reinforce that imported used tyres and exposed machinery remain a high risk pathway for the introduction of exotic mosquitoes. The 2 *Ae. albopictus* detections in Darwin in November and December 2013 occurred a week apart however, the detections were made at different port areas and were not deemed to be related (i.e. 2 separate introductions). There was a significant increase in the detections of exotic mosquitoes, particularly *Ae. aegypti* at international airports in southern Australia during this period. Perth, Adelaide and Melbourne International Airports all experienced exotic detections within the baggage handling areas. Initial DNA analyses concluded the *Ae. aegypti* mosquitoes detected at the airports did not originate from Queensland populations and likely originated from a common origin in South East Asia. Extensive treatments and enhanced surveillance were conducted in response to these detections involving the relevant state health jurisdiction, the airport authority and the Australian Government Department of Agriculture and Water Resources. Pathway analysis is underway and the Department of Agriculture and Water Resources, in conjunction with the Australian Government Department of Health, is progressing enhanced emergency measures and on-board verification of aircraft disinsection in response to these detections at international airports. NAMAC has also established a working group to develop national best practice guidelines and response protocols for managing exotic mosquito detections / incursions.

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 2013 to 30 June 2014, 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.

Table 9: Exotic mosquito detections at the border, Australia, 2013–14

Date	Species	Location	Method of detection	Source / origin	Action/ mitigation	Surveillance results
Aug 2013	*Ae. albopictus* (larvae)	Perth / Fremantle (Port)	Cargo inspection	Imported used tyres from Japan	Tyres chlorinated and fumigated. Increased trapping and ground surveillance conducted.	No further exotic mosquitoes detected.
Aug 2013	*Ae. albopictus* (larvae)	Darwin (East Arm wharf)	Cargo inspection	Machinery parts imported in an open top container from Indonesia	Ultra low volume fogging, receptacle treatment surveys and continued increased trapping. Imported goods fumigated	No further exotic mosquitoes detected.
Nov 2013	*Ae. albopictus* (1 adult)	Darwin (Port)	CO_2 baited Biogents trap	Unknown/unable to identify source	Ultra low volume fogging, receptacle treatment surveys and continued increased trapping.	No further exotic mosquitoes detected.
Dec 2013	*Ae. albopictus* (1 adult)	Darwin (East Arm wharf)	CO_2 baited Biogents trap	Unknown/unable to identify source	Ultra low volume fogging, receptacle treatment surveys and continued increased trapping.	No further exotic mosquitoes detected.
Dec 2013	*Ae. aegypti* (larvae)	Townsville (Port)	Cargo inspection	Imported used oversize tyres from Papua New Guinea	Tyres chlorinated and fumigated. Early intervention meant no further action required	No further exotic mosquitoes detected.
Feb 2014	*Ae. aegypti* (larva)	Brisbane (Port)	Cargo inspection	Used machinery from Papua New Guinea	Chlorination of water and fumigation of imported goods. Further actions not deemed necessary.	No further exotic mosquitoes detected.
Feb 2014	*Ae. aegypti* (adults and larvae)	Perth (Airport)	Ovitraps, Biogents traps and ground surveys	DNA suggests SE Asian origin	Thermal fogging, residual harbourage treatments, receptacle treatment surveys and increased trapping.	Sporadic detections continued to July 2014.
Mar 2014	*Ae. aegypti* (adult, pupae and larvae)	Adelaide (Airport)	Ovitraps, Biogents trap and ground surveys	DNA suggests SE Asian origin	Ultra low volume fogging, residual harbourage treatments, receptacle treatment surveys and increased trapping.	No further exotic mosquitoes detected.
Mar 2014	*Ae. aegypti* (adult, pupae and larvae)	Melbourne (Airport)	Ground surveys,	DNA suggests SE Asian origin	Thermal fogging, residual harbourage treatments, receptacle treatment surveys and increased trapping.	No further exotic mosquitoes detected.
Apr 2014	*Ae. aegypti* (1 adult)	Perth (Airport)	Octenol baited Biogents trap	DNA suggests SE Asian origin	Residual harbourage treatments, receptacle treatment surveys and increased trapping.	Sporadic detections continued to July 2014.
Apr 2014	*Ae. albopictus* (1 adult)	Perth (Airport)	Sticky ovitrap	Unknown/unable to identify source.	Thermal fogging, breeding site surveys and increased trapping.	Sporadic detections continued to July 2014.
May 2014	*Ae. aegypti* (1 adult)	Perth (Airport)	Octenol baited Biogents trap	DNA suggests SE Asian origin	Thermal fogging, residual harbourage treatments, receptacle treatment surveys and increased trapping.	One further detection in July 2014
May 2014	*Cx. gelidus* (1 adult)	Perth (Airport)	Sticky ovitrap	Unknown/unable to identify source.	Thermal fogging, residual harbourage treatments, receptacle treatment surveys and increased trapping.	One further detection in July 2014

In 2013–14, the number of notifications of BFV infection and the population rates declined markedly compared with the previous year, following the recognition of the 'epidemic' of false positive IgM diagnoses that was reported previously, and which began in October 2012. On recommendation from NAMAC, the Case Definitions Working Group of CDNA undertook a review of surveillance case definition for BFV infection and for RRV infection. Under the revised case definition, a single IgM positive result will no longer constitute 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 revised case definitions because there is insufficient information on the diagnosis method available in NNDSS. Therefore, the historical data prior to the change of case definition will continue to be considered unreliable. The new case definition was implemented on 1 January 2016.

There were only a small number of ZIKV infections reported in Australia in 2013–14. All were acquired in Pacific Island countries (12/13 in the Cook Islands). These infections were not thought to be cause for serious public health concern at the time, due to the high rate of asymptomatic infection, and that symptomatic cases were generally mild, notwithstanding the reports of a possible association with Guillain-Barré syndrome.[34] Subsequent to the 2013–14 season, ZIKV spread rapidly through many countries in the Americas after being first confirmed in Brazil in May 2015.[35,36] The virus was thought to have been introduced to Brazil during the August 2014 World Sprint Championship canoe race, held in Rio de Janeiro, which attracted participants from 4 Pacific Island nations, including French Polynesia, with active ZIKV transmission.[37] An increase in microcephaly in Brazil with geographical and temporal links to ZIKV was reported in November 2015, and the World Health Organization declared the clusters of microcephaly and neurological disorders a Public Health Event of International Concern on 1 February 2016.[38] There is strong scientific consensus that the virus can be transmitted *in utero* and can cause severe birth defects such as microcephaly,[39] and that it can cause Guillain-Barré syndrome.[40,41]

During 2013–14, there was a sharp increase in notifications of CHIKV infection, with nearly twice as many notifications as the 5-year mean. Indonesia continues to be the major source country for CHIKV infections in Australia. Recent widespread emergence and re-emergence of CHIKV, DENV and ZIKV in the south Pacific have had serious impacts for local populations. CHIKV infection was first reported in the Pacific Islands in February 2011 in New Caledonia, and in 2013 and 2014, it emerged in Papua New Guinea, New Caledonia, Yap State, Tonga, American Samoa Tokelau, Samoa, and in French Polynesia where an outbreak affected up to 25% of the local population. There is no evidence of any local transmission of CHIKV in Australia to date, but these outbreaks in the South Pacific have been cause for particular concern in areas of Queensland where there is a risk of local transmission. In July 2014, Queensland Health released the Queensland Chikungunya Management Plan 2014–2019, available on the Queensland Health web site (https://www.health.qld.gov.au/publications/clinical-practice/guidelines-procedures/diseases-infection/governance/chikungunya-management-plan.pdf).

With a number of detections of *Ae. aegypti* and *Ae. albopictus* at international airports around Australia during the year, there is the threat of establishment of these vectors of dengue and chikungunya. There is also the risk of isolated cases where transient incursions of infected mosquitoes occur, as seen in Western Australia in 2013–14, and previously reported in the Northern Territory in 2010.[42] Used tyres and exposed machinery continue to be a high risk pathway for the introduction of exotic mosquitoes. The NAMAC guidelines under development to manage exotic mosquito incursions will be an important tool to ensure the use of best practice around the country.

The prevention of incursion of DENV vectors into densely populated areas of South-East Queensland where imported DENV cases are regularly notified, is a continuing priority in Queensland. Despite regular seasonal outbreaks relating to transmission from imported cases, mosquito and infection control measures undertaken by public health authorities and by residents have ensured that DENV has not become endemic in north Queensland. The Queensland Dengue Management Plan 2010–15 provides clear guidance on ongoing prevention, sporadic case response and outbreak management.[18]

The number of imported cases of dengue in Australia continues to increase each year, reflecting the continuing increase in dengue in important source countries such as Indonesia, and elsewhere in South East Asia. While there is progress towards development of a dengue vaccine, efficacy in prevention of infection by the most promising candidate is disappointing, and the results on whether it can prevent hospitalisations with severe dengue are mixed.[43] Along with the failure of traditional prevention through vector control in endemic countries, this highlights the need for development

and application of novel strategies such as the use of *Wolbachia* to prevent transmission of dengue in mosquitoes infected with the bacterium.[44]

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 the Australian Health Protection Principal Committee, 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.

Appendix

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, rainfall and temperature obtained from the Bureau of Meteorology 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.

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.[45]

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 tested for MVEV and KUNV in a combined program between the Northern Territory Department of Health, the virology laboratories of the Northern Territory Department of Primary Industries and Fisheries 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, 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 2013–14, sentinel chickens were bled between December 2013 and August 2014.

In addition, ad hoc virus isolation from mosquitoes is carried out when MVEV or KUNV disease cases are reported. The Northern Territory Mosquito Borne Disease Control Program assists regional authorities with mosquito monitoring and provides some funding for direct mosquito control. In 2013–14, routine adult mosquito trapping consisted of 14 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 Bureau of Meteorology is used in conjunction with chicken and vector surveillance. Rainfall patterns, daily rainfall records and rain threshold models are used to assist in predicting mosquito and virus activity.

Queensland

Mosquito monitoring is performed by some local councils, primarily for salt water and fresh water mosquitoes. Some councils perform surveillance for container-inhabiting mosquitoes in domestic and commercial premises as part of a joint Queensland Health and local government initiative. This surveillance comprises various methods including the use of Biogents traps, GATs, ovitraps and larval survey.

Evaluation of ovitraps and GATs in the south western towns of Charleville and Roma was undertaken to determine the water retention capacity of various CIM surveillance tools and to ascertain the most appropriate system for the region. These towns were selected as *Ae. aegypti* had previously been detected in both locations. Each town had a set of 4 traps (GAT, standard ovitrap, double ovitrap and large ovitrap) placed at 3 locations. The relevant local government set the traps and collected the data. The trial commenced in February and continued to April 2014.

Also of note, a novel urban surveillance program using ovitraps and GATs was deployed for the first time in the Brisbane metropolitan region across 200 sites. Eggs collected in ovitraps were identified using real time polymerase chain reaction (RT-PCR) by Queensland Health Forensic and Scientific Services (van den Hurk et al., unpublished data).

The Torres Strait *Aedes albopictus* prevention and control program conducted by Cairns Public Health Unit targets mosquito habitat to minimise the threat of a mainland *Ae. albopictus* incursion from Torres Strait region. This is an ongoing program with recurrent funding from the Australian Government Department of Health. As part of the program, selected *Ae. albopictus* harbourage sites were treated with residual pyrethroid insecticide at high risk locations on both Thursday and Horn islands, the main population and transport hubs in Torres Strait. Lethal tyre traps were deployed near sea cargo depots on Thursday and Horn islands and the airport on Horn Island to control gravid container inhabiting mosquitoes.

On the mainland, human-bait sweep-net sampling was conducted on at least 60 selected suitable sites across the 5 Northern Peninsula Area communities; Seisia, New Mapoon, Bamaga, Injinoo and Umagico. House-to-house yard inspections for larval sampling were also conducted in Seisia, New Mapoon and Bamaga.

The Cairns office of the Australian Government Department of Agriculture carried out sugar-baited FTA card based arbovirus surveillance utilising passive box traps in the Northern Peninsula Area of Cape York mainly targeting JEV during the high risk period of January to May.

A Mosquito and Arbovirus Research Committee-funded project evaluated a sugar-based virus surveillance system using passive box traps in peri-urban locations across south-east Queensland. Passive box traps containing sugar feeding stations with FTA cards were deployed at 2 locations in each of Brisbane City, Sunshine Coast Regional and Gold Coast City council areas between December 2013 and March 2014. Cards were analysed by real-time TaqMan RT-PCR (van den Hurk et al. 2014) for the presence of RRV and BFV.

South Australia

Across South Australia, mosquito management activities are conducted in partnership between SA Health, the Uni SA, 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 Uni SA's Mosquitoes and Public Health Research Group conducted mosquito surveillance trapping at 35 locations on 11 occasions from September 2013 to April 2014 for 7 South Australian local councils along the River Murray (Renmark Paringa Council, Berri Barmera Council, the District Council of Loxton Waikerie, the Mid-Murray Council, the Rural City of Murray Bridge, the Coorong District Council and Alexandrina Council).

The South Australian Sentinel Surveillance Program (SASSP) operated from September 2013 to March 2014. The SASSP consists of 5 backyard flocks of 5 chickens located along the River Murray in South Australia 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 ad hoc in Sorell Council region, (which includes mosquito breeding areas, is fairly populous, and is close to Hobart). This is undertaken 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 samples are sent to Westmead Hospital for species identification and viral isolation.

Victoria

The Victorian Department of Human Services contracts the Victorian Department of Economic Development, Jobs, Transport and Resources to conduct sentinel chicken surveillance, mosquito species identification and arbovirus detection during the arbovirus season from November to April. The routine 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 MVEV 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 routine 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, one 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 on 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 Southern Oscillation Index and rainfall deciles, and Indian Ocean Dipole using respectively the Forbes,[27] and Nicholls[28] and Bennett models.

Western Australia

During 2013–14 the University of Western Australia Arbovirus Surveillance and Research Laboratory (ASRL) was funded 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. 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-seven sentinel chicken flocks (of up to 12 chickens) were located at major towns and communities in the Kimberley, Pilbara, Gascoyne, Mid West and Wheatbelt regions of Western Australia (Map 1). The Western Australian flavivirus sentinel chicken program operated all year around. Blood samples were collected from the chickens by environmental health officers or trained volunteers at fortnightly intervals during the peak flavivirus 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.[46]

To supplement information provided by the flavivirus sentinel chicken program, adult mosquitoes were collected by the ASRL from the north-east Kimberley region of northern Western Australia in April 2014. In addition, the Western Australian Department of Health collected adult mosquitoes in the Pilbara region in October 2013 and January 2014 and the Murchison region in March 2014. 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 on a regular basis in the Peel, Leschenault and Capel-Busselton regions for surveillance of RRV and BFV. In the 2013–14 season, mosquito homogenates from these regions were tested by both virus isolation and RT-PCR.

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