Annual reports

Arboviral diseases and malaria in Australia, 2010-11: Annual report of the National Arbovirus and Malaria Advisory Committee

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Abstract

The National Notifiable Diseases Surveillance System (NNDSS) received notification of 9,291 cases of disease transmitted by mosquitoes during the 2010–11 season (1 July 2010 to 30 June 2011). The alphaviruses Barmah Forest virus and Ross River virus accounted for 7,515 (81%) of these. There were 133 notifications of dengue virus infection acquired in Australia and 1,133 cases that were acquired overseas, while for 10 cases, the place of acquisition was unknown. The number of overseas acquired cases of dengue continues to rise each year, and these are most frequently acquired in Indonesia. Sentinel chicken, mosquito surveillance, viral detection in mosquitoes and climate modelling are used to provide early warning of arboviral disease activity in Australia. In early 2011, sentinel chickens in south eastern Australia widely seroconverted to flaviviruses. In 2010–11, there were 16 confirmed human cases of Murray Valley encephalitis acquired in Australia. There was one human case of Kunjin virus infection. There were 7 notifications of locally-acquired malaria in Australia and 407 notifications of overseas-acquired malaria during the 2010–11 season. *Commun Dis Intell* 2013;37:E1–E20.

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

Introduction

This report describes the epidemiology of mosquito-borne diseases of public health importance in Australia during the season 1 July 2010 to 30 June 2011. It includes notified cases of disease caused by the alphaviruses (Barmah Forest virus, BFV, chikungunya virus, CHIKV and Ross River virus, RRV), flaviviruses (dengue virus, DENV, Murray Valley encephalitis virus, MVEV, Kunjin virus, KUNV, Japanese encephalitis virus, JEV and yellow fever virus) and malaria. Both locally acquired and overseas acquired cases are described. Vector, climate and vertebrate surveillance measures for arboviruses (in particular for MVEV) conducted by states and territories and at the border are also described.

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

Methods

Human cases of arbovirus infection and malaria are monitored using the National Notifiable Diseases Surveillance System (NNDSS). All Australian states and territories require doctors and/or pathology laboratories to notify cases of infectious diseases that are important to public health including several arboviruses and malaria. *The National Health Security Act 2007* (NHS Act 2007) provides the legislative basis for the national notification of communicable diseases and authorises the exchange of health information between the Commonwealth and the States and Territories. The NHS Act 2007 provides for the establishment of the National Notifiable Diseases List, which specifies the diseases about which personal information can be exchanged between the States and Territories and the Commonwealth. State and territory health departments transfer these notifications regularly to the NNDSS. The primary

responsibility for public health action resulting from a notification resides with state and territory health departments.

This report presents data extracted from NNDSS during June 2012 and analysed by date of diagnosis. This derived field is the onset date or, where the date of onset was not known, the earliest of the specimen collection date, the notification date, or the notification receive date. The data are from a 'snap-shot', thus numbers in this report may vary slightly from those reported elsewhere. Data in the snap-shot were confirmed with state and territory public health surveillance managers. Detailed notes on the interpretation of NNDSS are available in the 2010 NNDSS Annual report. Case definitions for the diseases included in this report are available at http://www.health.gov.au/casedefinitions. The report includes information on the following pathogens transmitted by mosquitoes, all which are nationally notifiable except CHIKV:

- alphaviruses (BFV, RRV, and CHIKV);
- flaviviruses (DENV, JEV, MVEV and yellow fever virus);
- arboviruses not elsewhere classified (NEC); and
- malaria.

Whilst CHIKV infection is not currently nationally notifiable, a national case definition was implemented from 2010, and NNDSS allows the collection of notifications of chikungunya virus infection as a separate infection. Prior to this, CHIKV infections were notified under the disease category arbovirus NEC and the Northern Territory continues this practice. All notifications of CHIKV infection under arbovirus NEC were counted under CHIKV infection in this report.

Crude notification rates or counts for the 2010–11 season were compared with rates or counts for that disease over the previous five years. Notification rates were not calculated for diseases that are primarily acquired overseas, because resident populations are not an appropriate denominator for these diseases. Rates are not provided for rare diseases ($n<20$ in the 2010–11 season), because these rates tend to have very 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 2011.[1] 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 (2011 population applied to the 2010–11 financial year).

Due to a limitation of surveillance systems, Queensland notifies mixed infections of malaria as a separate notification for each infecting organism. For the 2010–11 season, additional information was collected to enable these mixed infections to be reported as one case for the purpose of this report. In 2010–11, this resulted in five fewer notifications than if the adjustment was not made.

Additional information on the details of some notifications was obtained from state and territory public health surveillance managers. Data on sentinel animals and mosquito surveillance, control measures and detections of exotic mosquito vectors at the border were supplied by relevant agencies.

Vertebrate, vector and climate surveillance in States and Territories

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 New South Wales Ministry of Health, and laboratory services are contracted to Institute of Clinical Pathology and Medical Research (ICPMR), 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 Bureau of Meteorology (BOM) are used by members of the program to predict mosquito-breeding capabilities and potential arboviral activity, while climatic data are used to predict MVEV outbreaks.

Northern Territory

Surveillance consists of routine year round once per month sentinel chicken surveillance and *ad hoc* virus isolation from mosquitoes during the high risk months of February to June inclusive. The program is combined and coordinated by the Northern Territory Department of Primary Industries, Fisheries and Mines (DPIFM) and the Northern Territory Department of Health, with support from volunteers. Laboratory support is provided by Berrimah laboratories DPIFM. The Northern Territory Mosquito Borne Disease Control Program assists regional authorities with mosquito monitoring and provides some funding for direct mosquito

control in some major towns. Routine mosquito trapping consists of 22 trapping sites throughout the Darwin urban area, six in Nhulunbuy, three in Tennant Creek, five in Katherine, three in Alyangula on Groote Eylandt, and six in Alice Springs. In Alice Springs it is a cooperative program between Alice Springs Environmental Health, and the Medical Entomology unit in Darwin. Climate information from BOM is used in conjunction with animal and vector surveillance. Rainfall patterns, daily rainfall records and rain threshold models are used to assist in predicting mosquito and virus activity.

Queensland

Queensland does not currently conduct state-wide surveillance for MVEV in vertebrate hosts, and does not maintain sentinel chicken flocks. Queensland is introducing direct mosquito virus surveillance using honey trap saliva technology. Mosquito monitoring is performed by local councils, under the Joint Strategic Mosquito Management Framework and is funded by Queensland Health. Opportunistic virus isolations from mosquitoes or animals have been carried out by the University of Queensland, the Tropical Public Health Unit network within Queensland Health and Queensland Institute of Medical Research.

South Australia

Across South Australia, mosquito surveillance and control activities are conducted through a partnership between South Australia Health, the University of South Australia, Local Government and Biosecurity South Australia. The program is coordinated by the South Australian Department for Health and Ageing and consists of mosquito trapping in the Riverland and areas in the mid-north of the state, and virus isolation when required. Seasonal monitoring of mosquito population is undertaken along the Murray River; live collections for virus isolation are sampled in response to high vector numbers and are sent to Westmead Hospital for testing.

Tasmania

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

Victoria

The Victorian Department of Health contracts the Victorian Department of Primary Industries to conduct sentinel chicken surveillance from November to April. Flocks of 20 chickens are located at a range of locations mostly along the Murray, and are bled weekly from mid-October to April, and flocks are replaced annually. Six councils undertake mosquito surveillance, four traps are placed in each area and mosquitoes are collected weekly and sent live to DPI 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 using Forbes and Nicholls models.[2,3]

Western Australia

The University of Western Australia's Arbovirus Surveillance and Research Laboratory (ASRL) is funded by the Health Department of Western Australia to coordinate sentinel chicken program and mosquito surveillance, and provide confirmatory serological testing for other sentinel chicken programs in Australia. Thirty sentinel chicken flocks of up to 12 chickens are located at major towns and communities in the Kimberley, Pilbara, Gascoyne, Goldfields, Midwest and Central Coastal regions of Western Australia. Blood samples are collected from the chickens at fortnightly intervals during the peak MVEV risk season (December to June). At other times, monthly samples are collected unless prolonged flavivirus activity warrants continued fortnightly sampling. An annual program of mosquito trapping is undertaken towards the end of the wet season (March to April) when MVEV is active over a 3-4 week period. This provides important information on size and species composition of mosquito populations, vector species and virus infection rates.

Arbovirus research laboratories in Australia

CSIRO

Commonwealth Scientific and industrial Research Organisation (CSIRO)
CSIRO Australian Animal Health Laboratory
Private Bag 24 (5 Portarlington Road)
Geelong Victoria 3220
Switchboard: (03) 5227 5000

New South Wales

Institute of Clinical Pathology and
Medical Research
Westmead Hospital
Locked Bag 9001
Westmead, New South Wales 2145

Phone: (02) 9845 6255
(Vector surveillance, sentinel animal testing, human serology)

Northern Territory

Berrimah Veterinary Laboratory
39 Kessells Rd
Coopers Plains
PO Box 594 Archerfield Qld 4108
Phone: (07) 3274 9151

Queensland

Queensland Health Forensic and Scientific Services
Northern Territory Department of Primary Industries, Fisheries and Mines (DPIFM)
Makagon Rd, Berrimah, Darwin
Northern Territory 0828
Phone (08) 8999 2065

Victoria

Department of Primary Industries
Attwood Centre
475 Mickleham Road
Attwood Victoria 3049
Phone: (03) 9217 4200

Victorian Infectious Diseases Reference Laboratory (Human)
10 Wrecklyn St
North Melbourne Victoria 3051
Phone: (03) 9342 2600

Western Australia

PathWest Laboratory Medicine WA
Division of Microbiology and Infectious Diseases (Human)
Hospital Avenue
Nedlands Western Australia 6009
Phone: (08) 9346 3122

Arbovirus Surveillance and Research Laboratory

Discipline of Microbiology and Immunology (animal/vector)
School of Pathology and Laboratory Medicine
The University of Western Australia
35 Stirling Highway
Crawley Western Australia 6009
Phone: (08) 9346 2212

Results

During the 2010–11 season, there were 9,291 notifications of diseases transmitted by mosquitoes (Table 1). This represented an 18% increase from the mean of 7,894 notifications for the previous five years.

Alphaviruses

In Australia, the most frequently detected viruses in the genus *Alphavirus* are RRV and BFV. Infection with RRV or BFV can cause illness characterised by fever, rash and polyarthritis. These viruses are transmitted by numerous species of mosquito that breed in diverse environments (freshwater habitats, coastal regions, salt marshes, floodwaters, established wetlands and urban areas).[4] RRV and BFV occur exclusively in the Australasian region.[5]

The alphavirus CHIKV does not occur in Australia, but is regularly reported in travellers returning from overseas. Illness is characterised by an abrupt onset of fever, rash and severe joint pain. The acute disease lasts one to 10 days, but convalescence may include prolonged joint swelling and pain lasting months. Haemorrhagic manifestations may occur occasionally.[6] Humans are amplification hosts for CHIKV, and other vertebrates are not required for high levels of transmission to occur. Internationally, CHIKV is most commonly transmitted by *Aedes aegypti*, which occurs in northern Queensland and *Aedes albopictus* which is found on Cocos Island, Christmas Island and the Torres Strait Islands.[7] Other Australian mosquito species have been shown to be competent vectors of CHIKV in the laboratory.[8]

Ross River virus infections

There were 5,653 notifications of RRV infection during the 2010–11 season, representing a rate of 25.0 per 100,000 population, compared with a 5 year mean of 23.0 per 100,000 (Table 1). Queensland reported the largest number of cases (n=1,397), while the highest rate was in the Northern Territory.

Rates of RRV in South Australia trebled from 23.8 per 100,000 (n=391) in 2009–10 to 69.7 per 100,000 in 2010–11 (n=1,154) and were more than 4 times the five year mean of 17.1 per 100,000 (n=274.2 cases) (Figure 1). Rates in Victoria increased to 23.7 per 100,000 (n=1,334) from 6.4 per 100,000 in 2009–10 (n=353) and were more than 6 times the five year mean of 3.8 per 100,000 (n=204).

RRV was most commonly reported among middle-aged adults, peaking in the 35–54 year age-groups (RRV was most commonly reported among middle-aged adults, peaking in the 35–54 year age-groups (Figure 2). As in previous years, a little over half of all cases (54%) were female. The overall rate of RRV

Table 1: Number of notified cases of mosquito-borne disease and rate, Australia, 2010-11 and 5 year mean, by disease and state or territory

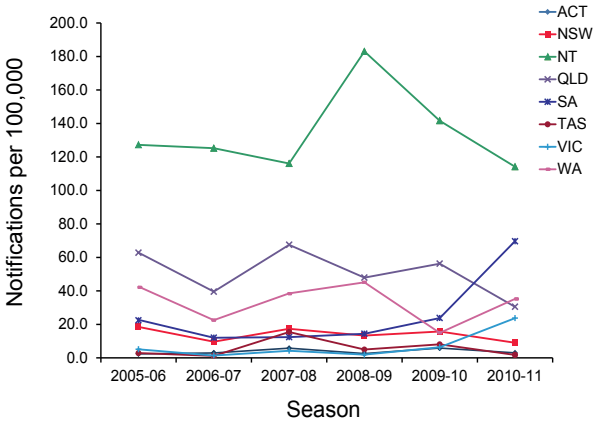
		ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Australia
Arbovirus NEC	Cases 2010–11	0	1	0	5	0	0	16	0	22
	5 year mean cases	0	0.6	1	9.4	0	0	5.2	0	16.2
	Rate 2010–11	-	-	-	-	-	-	-	-	-
	5 year mean rate	-	-	-	-	-	-	-	-	-
Barmah Forest virus infection	Cases 2010–11	3	427	63	885	134	4	223	123	1862
	5 year mean cases	5.4	486.8	97.8	915.4	73.6	1.7	26.8	143.6	1,750.4
	Rate 2010–11	0.8	5.8	27.3	19.3	8.1	0.8	4.0	5.2	8.2
	5 year mean rate	1.6	7.0	44.4	21.3	4.6	0.2	0.5	6.6	8.2
Chikungunya virus infection	Cases 2010–11	NN	15	8	7	2	2	18	11	63
	5 year mean cases	NN	3.6	0.0	1.6	0.6	0.0	4.0	3.2	13.0
	Rate 2010–11	-	-	-	-	-	-	-	-	-
	5 year mean rate	-	-	-	-	-	-	-	-	-
Dengue virus infection	Cases 2010–11	12	204	32	309	28	5	141	528	1259
	5 year mean cases	9.2	103.4	23.8	316.0	18.8	2.8	22.2	98.2	594.4
	Rate 2010–11	-	-	-	-	-	-	-	-	-
	5 year mean rate	-	-	-	-	-	-	-	-	-
Japanese encephalitis virus infection	Cases 2010–11	0	0	0	0	0	0	0	0	0
	5 year mean cases	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	Rate 2010–11	-	-	-	-	-	-	-	-	-
	5 year mean rate	-	-	-	-	-	-	-	-	-
Kunjin virus infection	Cases 2010–11	0	0	1	0	0	0	0	0	1
	5 year mean cases	0.0	0.0	0.4	0.7	0.0	0.0	0.2	0.3	1.8
	Rate 2010–11	-	-	-	-	-	-	-	-	-
	5 year mean rate	-	-	-	-	-	-	-	-	-
Malaria	Cases 2010–11	3	112	15	135	4	7	78	60	414
	5 year mean cases	9.6	109.8	30.4	188.2	26.4	12.6	105.6	88	570.6
	Rate 2010–11	-	-	-	-	-	-	-	-	-
	5 year mean rate	-	-	-	-	-	-	-	-	-
Murray Valley encephalitis virus infection	Cases 2010–11	0	2	2	0	2	0	0	9	15
	5 year mean cases	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Rate 2010–11	-	-	-	-	-	-	-	-	-
	5 year mean rate	-	-	-	-	-	-	-	-	-
Ross River virus infection	Cases 2010–11	11	658	263	1,397	1,154	9	1,334	827	5,653
	5 year mean cases	13.6	1,047.0	306.4	2,359.2	274.2	32.6	204.0	709.4	4,946.4
	Rate 2010–11	3.0	9.0	114.2	30.5	69.7	1.8	23.7	35.2	25.0
	5 year mean rate	3.9	14.9	138.6	54.8	17.1	6.5	3.8	32.7	23.0
Yellow fever	Cases 2010–11	0	0	0	2	0	0	0	0	2
	5 year mean cases	0	0	0	0	0	0	0	0	0
	Rate 2010–11	-	-	-	-	-	-	-	-	-
	5 year mean rate	-	-	-	-	-	-	-	-	-
Total 2010–11		29	1,419	384	2,740	1,324	27	1,810	1,558	9,291

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

NEC Not elsewhere classified

Notification rates for diseases that were primarily acquired overseas or for rare diseases (n<20 in 2010-11) are not presented.

Figure 1: Rates of Ross River virus infection, Australia, July 2005 to June 2011, by year and state or territory



in females was 26.7 per 100,000, while in males the rate was 23.2 per 100,000). As in previous years, a little over half of all cases (54%) were female. The overall rate of RRV in females was 26.7 per 100,000, while in males the rate was 23.2 per 100,000.

As in previous years, there was a marked seasonal trend in RRV notifications, with the largest number diagnosed in January (n=900), February (n=1,184) and March (n=964). This was an earlier start to the season than in previous years where the peak months have been February to April (Figure 3).

Barmah Forest virus infections

There were 1,862 notifications of BFV infections during the 2010–11 season, representing a rate of 5.2 per 100,000, which has decreased from the mean of 8.2 per 100,000 for the previous five years (Table 1). Queensland reported the largest number of notifications of BFV infection (n=885) while the highest rate was reported in the Northern Territory (27.3 per 100,000).

Figure 2: Rates of Ross River virus infection, Australia, 2010-11, by age-group and sex

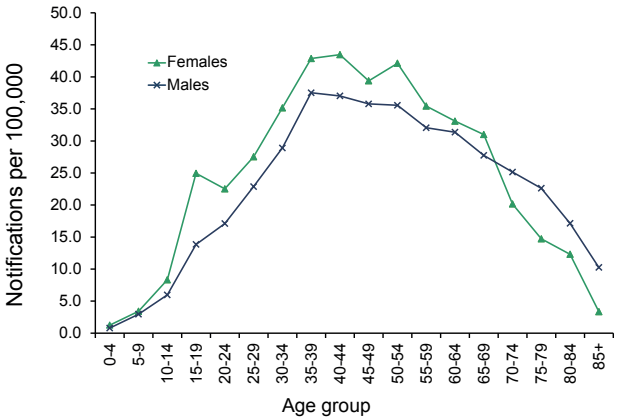
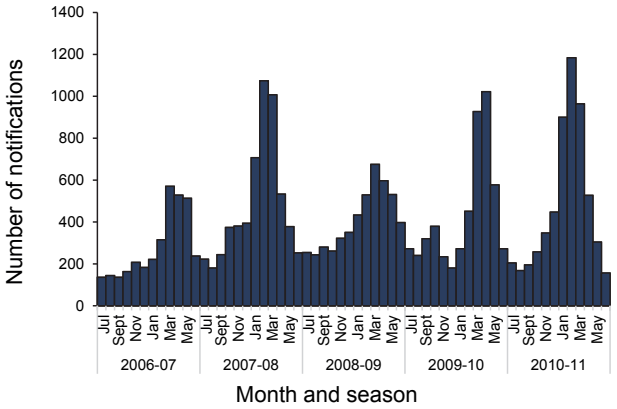


Figure 3: Number of notified cases of Ross River virus infection, Australia, July 2006 to June 2011, by month, year and state or territory



In South Australia, the 2010–11 notification rate was four times the five year mean, while in Victoria, the notification rate was six times the five year mean.

BFV infections were most commonly reported among middle aged adults, peaking in the 45-64 year-old age-groups, and 50% of cases were male (Figure 5).

In 2010–11, infections were most frequently diagnosed in January (n=326), February (n=238) and March (n=273), and this was an earlier than average start to the season compared with the previous five years when cases were most frequently reported between February and April (Figure 6). While BFV notifications showed a clear seasonal trend, this trend is less marked than for RRV infections. The higher than expected numbers of BFV notifications in winter is possibly an artefact, reflecting the possibility of false positive IgM diagnoses.).

Figure 4: Rates of Barmah Forest virus infection, Australia, July 2005 to June 2011, by year and state or territory

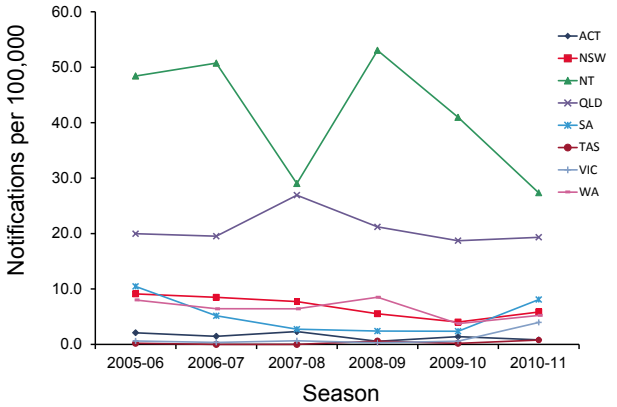


Figure 5: Rates of Barmah Forest virus infection, 2010-11, Australia, by age-group and sex

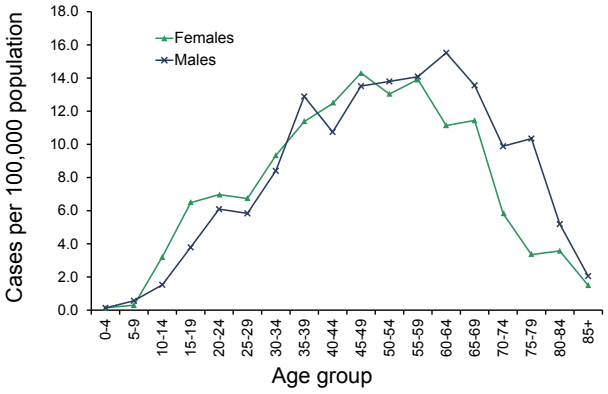


Figure 6: Number of notified cases of Barmah Forest virus infection, Australia, July 2006 to June 2011, by month, year and state or territory

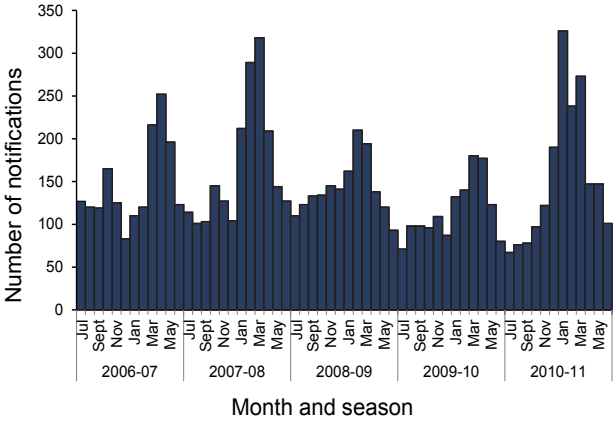
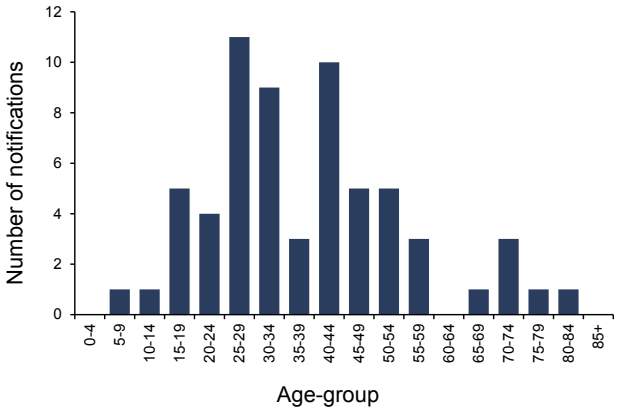


Figure 7: Number of notified cases of chikungunya virus infection, Australia, 2010-11, by age-group



In 2010–11, infections were most frequently diagnosed in January (n=326), February (n=238) and March (n=273), and this was an earlier than average start to the season compared with the previous five years when cases were most frequently reported between February and April (Figure 6). While BFV notifications showed a clear seasonal trend, this trend is less marked than for RRV infections. The higher than expected numbers of BFV notifications in winter is possibly an artefact, reflecting the possibility of false positive IgM diagnoses.

Chikungunya virus infection

CHIKV infection is a notifiable disease in all jurisdictions other than the Australian Capital Territory. There were 63 notifications of CHIKV infection during the 2010–11 season compared with a 5 year mean of 14 cases. All cases were acquired overseas, with complete information supplied on the country of acquisition for 55 of these. The most frequently reported countries of acquisition were Indonesia (32 cases) and India (11 cases). CHIKV infection was most frequently notified for young and middle aged adults, with the largest number of cases in the 25-29 year age-group (Figure 7).

Flaviviruses

This section provides information on flavivirus infection notified to NNDSS including DENV, MVEV, the Kunjin strain of West Nile virus (KUNV) and JEV. Other flavivirus infections may be notified under the Arbovirus (NEC) category.

DENV has four serotypes. The clinical illness is characterised by mild to severe febrile illness with fever, headache, muscle/joint pain and sometimes a rash. A minority of cases progress to severe dengue with haemorrhage and shock, more commonly on subsequent infection with a different type. *Ae. aegypti* is the major vector of dengue in Australia.

Infection with MVEV, KUNV or JEV is usually asymptomatic or produces a non-specific illness. A small percentage of cases progress to encephalomyelitis of variable severity. *Culex annulirostris* is the major vector of MVEV, JEV and KUNV. No specific treatment is available for these diseases and care is largely supportive. A vaccine is available to prevent JEV infection,[9] but there is no vaccine for DENV, MVEV or KUNV infection.

Dengue virus infection

There were 1,276 notified cases of DENV infection during the 2010–11 season. Of these, 133 were acquired in Australia, and 1,133 acquired the infection while overseas (Table 2). For the remaining 10 cases, no information on place of acquisition was available.

Locally-acquired dengue virus infection

There were 133 notifications of DENV infection acquired in Australia during 2010–11 representing a rate of 0.6 per 100,000 population, compared with 37 locally-acquired cases in 2009–10.

Local transmission of dengue in Australia is normally restricted to areas of northern Queensland where the key mosquito vector, *Ae. aegypti* is present.[10] 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.[11]

In 2010–11, 131 cases of dengue were acquired in Queensland, with 128 cases known to have either resided or travelled in North Queensland, while for the remainder the specific region of travel within Queensland could not be confirmed. Most cases were linked with known outbreaks (124/131). In 2010–11, Queensland Health reported 8 outbreaks of dengue in North Queensland, with 123 cases (100 DENV-2, 13 DENV-4 and 10 DENV-1).*[12] The largest outbreaks were in Townsville between 30 June and 17 December 2010 (31 cases, DENV-2), Cairns between July and September 2010 (19 cases, DENV-2) and Innisfail and Cairns between 16 January and 5 March 2011 (47 cases, DENV-2).[12] Each of these outbreaks was linked to single importations in infected travellers. Despite frequent outbreaks, mosquito and infection control measures undertaken by public health authorities and by residents have ensured that dengue has not become endemic in North Queensland.

In 2010–11, one case of dengue in the Northern Territory was thought to have been acquired near Darwin airport where the case worked in an industrial area.[13] The case was likely to have been bitten

* These numbers are based on data from Queensland Health as at 3 June 2011, and variance between that dataset and the data extracted from NNDSS in June 2012 is not unexpected (123 outbreak cases reported by Queensland Health versus 124 in NNDSS).

Table 2: Number of notified cases of dengue virus infection, Australia, 1 July 2005 to 30 June 2011, by year, state or territory and place of acquisition

Place of acquisition	Year	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Total
Locally-acquired†	2005–06	0	3	0	43	0	0	1	0	47
	2006–07	0	6	1	48	0	0	0	0	55
	2007–08	0	5	0	27	3	0	0	0	35
	2008–09	0	5	0	1006	1	0	3	1	1016
	2009–10	0	3	0	33	0	0	1	0	37
	2010–11	0	2	1	126	0	0	3	1	133
Overseas-acquired	2005–06	7	53	16	30	10	0	12	21	149
	2006–07	2	65	14	59	12	0	8	27	187
	2007–08	4	100	25	78	30	4	15	94	350
	2008–09	14	168	27	115	25	6	18	120	493
	2009–10	19	121	36	125	11	4	50	227	593
	2010–11	10	219	30	181	27	5	139	522	1133
Unknown	2005–06	0	0	0	2	0	0	0	0	2
	2006–07	0	0	0	5	0	0	1	0	6
	2007–08	0	0	0	4	2	0	0	0	6
	2008–09	0	0	0	4	0	0	1	0	5
	2009–10	0	2	0	1	0	0	1	0	4
	2010–11	2	1	1	2	1	0	0	3	10
Total	2005–06	7	56	16	75	10	0	13	21	198
	2006–07	2	71	15	112	12	0	9	27	248
	2007–08	4	105	25	109	35	4	15	94	391
	2008–09	14	173	27	1125	26	6	22	121	1514
	2009–10	19	126	36	159	11	4	52	227	634
	2010–11	12	222	32	309	28	5	142	526	1276

† Locally-acquired cases are acquired in Australia and not necessarily in the states or territory from which they are reported. Under the cross border notification protocol, cases are notified by their state or territory of residence, not the state or territory where the disease was diagnosed or acquired.

by an infected mosquito that was carried by a military aircraft that had returned from Bali just prior to the likely date of acquisition and had unloaded and parked less than 2km from the case's place of work.[13] There was one case of health-care associated dengue in Western Australia in 2010; a physician in Perth sustained a needlestick injury whilst taking blood, five days prior to symptom onset.[14]

Overseas-acquired dengue virus infection

There were 1,133 notifications of dengue virus infection acquired overseas during the 2010–11 season (Table 2), more than three times the 5 year mean for overseas-acquired infection (354.4). All jurisdictions reported increased numbers of notifications of overseas-acquired DENV infection from 2005–06, with the largest increases compared with the 5 year mean being in Victoria (6.7 times the 5 year mean) and Western Australia (5.3 times the 5 year mean).

The country of acquisition was available for 99.8% (n=1,131) of overseas-acquired cases. The median age of locally acquired cases and overseas-acquired cases was the same (38 years), and for both categories, 53% of cases were male. Indonesia was the country of acquisition for 66% of cases (n=747), and these were of all four dengue serotypes. The infecting DENV serotype was determined for 50% (n=570) of overseas-acquired dengue cases. DENV-1 (n=236) was the most frequently reported serotype.

The median age of locally acquired cases and overseas-acquired cases was the same (38 years), and for both categories, 53% of cases were male.

Japanese encephalitis virus infections

There were no cases of JEV infection notified to NNDSS in Australia during 2010–11. The last imported case was during the 2008–09 season and the last locally-acquired case was in 1998.[15,16]

Kunjin virus infection

There was one human case of KUNV infection reported in Australia during 2010–11. The case was a 60 year-old man from the Northern Territory who was IgM positive for KUNV and negative for MVEV, BFV and RRV. The infection was acquired in the Barkly region. The case was non encephalitic, and recovered.

Murray Valley encephalitis

In 2010–11, 15 cases of MVEV infection in Australia were notified to the NNDSS, compared with an average of 1.4 cases per annum for the previous five years. There was also a confirmed case in a Canadian resident who was diagnosed in Canada after being exposed in the Northern Territory and was thus not notified to NNDSS (Table 4). Two of the 16 confirmed cases died.

All cases in 2010–11 were acquired in Australia, and 13 of the 16 confirmed cases were acquired in areas where regular enzootic viral activity is reported (the Pilbara and Kimberley regions of Western Australia, and the northern two thirds of the Northern Territory), or where epizootic disease activity is not unexpected (the Midwest and Goldfields region of WA) (Table 4). Three confirmed cases were reported from south-eastern Australia where epizootic disease

Table 3: Overseas-acquired cases of dengue virus infection, Australia, 2010-11, by serotype and country of acquisition

Country	Total number of cases	Percentage of cases	Dengue virus serotype				
			DENV 1	DENV 2	DENV 3	DENV 4	Untyped
Indonesia	747	66	190	91	104	50	312
Thailand	123	11	7	24	11	2	79
India	41	4	12	1	0	0	28
Philippines	40	4	2	2	7	2	27
Vietnam	36	3	9	6	1	1	19
East Timor	22	2	1	5	0	1	15
Papua new Guinea	17	2	2	3	1	0	11
Malaysia	16	1	3	2	2	1	8
Cambodia	13	1	1	2	2	0	8
Sri Lanka	11	1	2	0	1	0	8
Other countries	65	6	7	10	1	0	47
Unknown country	2	0	0	1	0	0	1
Total	1133	100	236	147	130	57	563

Table 4: Confirmed cases of Murray Valley encephalitis infection acquired in Australia, 2010-11 (N=16), by region of infection

State/territory and region of infection	State/territory of residence	Month of onset	Sex	Age (years)	Comment
Western NSW	NSW	March	F	63	Non-encephalitic. Recovered.
Berri, SA	SA	March	M	47	Encephalitis. Recovered with residual disease.
Mannum, SA	SA	March	M	27	Encephalitis. Died.
Katherine region, NT	NSW	May	F	63	Encephalitis. Recovered.
Barkly region, NT	NT	March	M	33	Encephalitis. Recovered.
Barkly region, NT	NT	March	M	1	Encephalitis. Recovered.
Darwin/Katherine region, NT	Overseas (Canada)‡	May	F	19	Encephalitis. Died.
Kimberley, WA	WA	April	M	29	Encephalitis. Recovered with residual disease.
Midwest/Goldfields, WA	WA	April	M	25	Encephalitis. Recovered.
Pilbara, WA	WA	April	M	25	Encephalitis. Recovered with residual disease
Midwest, WA	WA	March	F	41	Encephalitis. Recovered with residual disease.
Midwest/Pilbara, WA	WA	March	M	61	Encephalitis. Died
Pilbara, WA	WA	March	F	50	Non-encephalitic. Recovered.
Kimberley, WA	WA	May	F	2	Encephalitis. Recovered with residual disease.
Pilbara, WA	WA	May	F	67	Encephalitis. Recovered with residual disease.
Pilbara, WA	WA	May	F	1*	Encephalitis. Recovered.

* 23 months of age

‡ This case in a Canadian resident was diagnosed in Canada and thus not notified to NNDSS and not included in Table 1, which listed only notified cases.

activity is rare or unknown (2 in South Australia and 1 in New South Wales). All cases had an onset date between March and May 2011.

Three further possible cases could not be laboratory confirmed and were not reported to the NNDSS. These were a possible case in a 39 year-old man who was hospitalised in Western Australia with clinically-diagnosed MVEV infection based on a consistent exposure history, clinical picture, and magnetic resonance imaging, a possible case in an asymptomatic family member of the confirmed case in New South Wales who was identified through active case finding, and a possible fatal case in a 69 year-old from north-western Victoria.[17,18]

Outbreaks of arboviral disease in horses in 2010–11

The outbreaks of MVEV infection in humans occurred in the context of widespread evidence of seroconversion in sentinel chickens to flaviviruses and outbreaks of arboviral disease causing neurological and muscular disease in horses due to both KUNV and RRV. Between January and June 2011, there were 982 clinically apparent cases of arboviral disease in horses and 91 horses died.[19] The first horse cases were investigated from early February, and new reports reached a peak in March and April and declined in mid-May.[20] Cases were widely distributed across Victoria and New South Wales, and were also reported from southeastern parts of South Australia and Queensland, and the southwestern areas of Western Australia.[20] In New South Wales, South Australia and Western Australia the majority of cases were due to KUNV infection, while in Victoria, RRV infections comprised more than half of all confirmed infections.[20] The KUNV cases in horses were due to a KUNV variant ($WNV_{NSW2011}$) which is likely to have been derived from previously described KUNV in Australia, rather than of exotic origin. The variant strain was found to be more neuroinvasive in mouse studies than KUNV.[21]

Yellow Fever

Two cases of yellow fever (YF) were notified in 2010–11, both from Queensland. The cases had recently returned from travel to YF endemic areas (one from Colombia and the other from Ghana), were IgM positive, had a clinically-compatible illness

and had received yellow fever vaccine in the previous 3 months. The cases met the CDNA national surveillance case definition. However, treating clinicians and the public health units considered that on the balance of probabilities, both were likely to have been vaccine related but that the possibility that they were true cases could not be excluded. A revised CDNA case definition for yellow fever which came into effect on 1 January 2013 will exclude vaccine-associated cases in future.

Vertebrate, vector and climate surveillance programs for flaviviruses in 2010-11

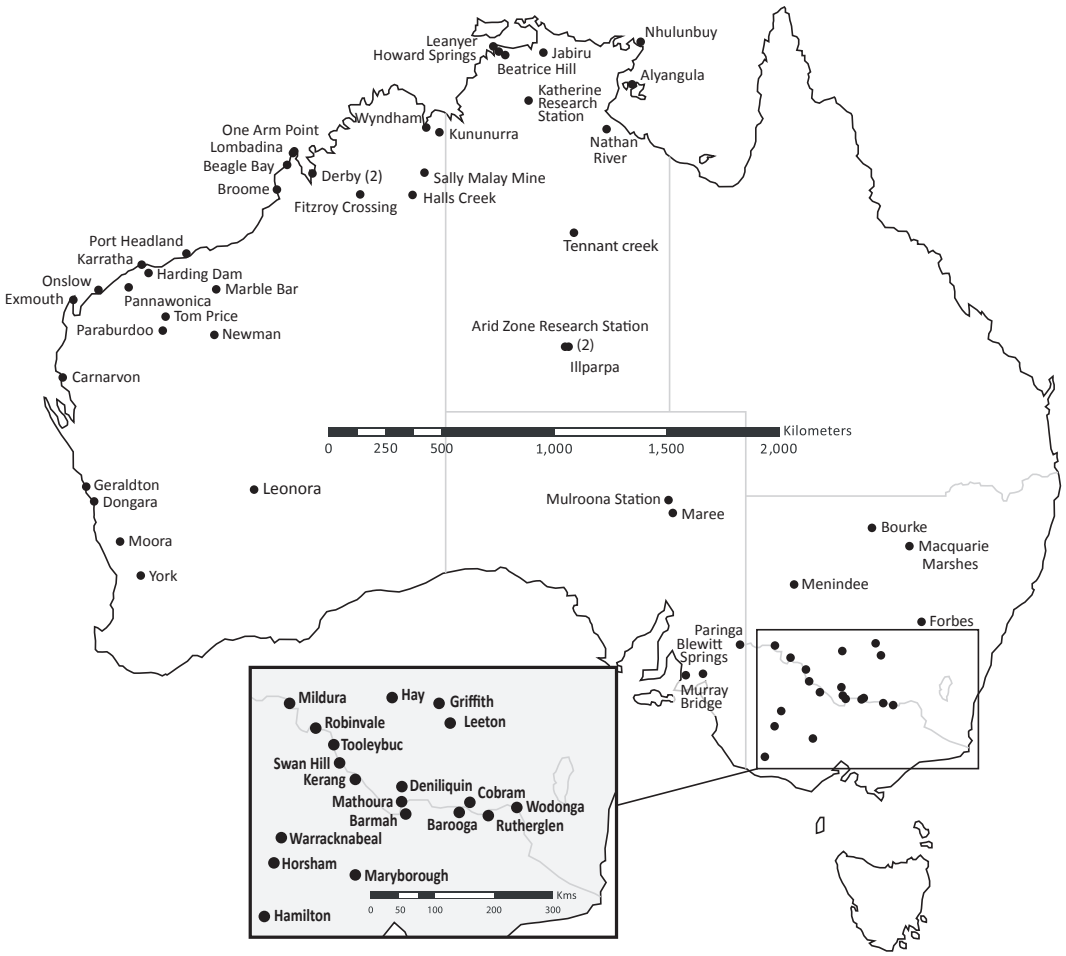
The sentinel chicken program is designed to detect flavivirus activity. In 2010–11, sentinel chicken flocks were located in the Northern Territory, New South Wales, South Australia, Victoria and Western Australia. The program aims to provide early warning of the endemic arboviruses MVEV and KUNV, as well as exotic arboviruses such as JEV.[22] Public health messaging or other response measures can be implemented when chickens from a flock seroconvert to a flavivirus of interest. Public Health messaging may advise residents or target groups such as campers or fishermen of the need to take added precautions to avoid mosquito bites.

Sentinel chickens are replaced at least annually and more frequently if birds die or large proportions seroconvert. Flocks are well distributed geographically to detect flavivirus activity and to provide a timely and accurate indication of risk to people (Map).[23]

New South Wales

The climatic conditions leading up to the 2010-2011 arboviral season for the New South Wales inland were of above, to well above average rainfall for the entire second half of 2010, plus above average rainfall along the Murray River valley for the first quarter of 2011. Both the Forbes' and Nicholls' MVEV climatic models indicated probable activity in southeastern Australia for the 2010-2011 season.[2] The elevated precipitation levels led to increased vector production with over 200,000 mosquitoes trapped at inland localities, being over six times that of the previous season. Two collections from Griffith

Map: Location of sentinel chicken flocks, Australia, 2010-11



yielded over 10,000 mosquitoes per trap. A considerable number of arboviruses were isolated from the collected mosquitoes, with 102 arboviral isolates (7 BFV, 13 RRV, 71 Sindbis Virus, 2 Edge Hill visus, 2 Kokobera virus and 7 KUNV).

For the coast, climatic conditions were mostly similar to those inland although the north coast had average rainfall through the late summer and temperatures became cool from March onwards, which resulted in reduced mosquito numbers. Overall mosquito collections were well below previous years, due largely to very small numbers of *Aedes vigilax*, the major coastal vector. As a result, arboviral activity was lower than in previous years. There was a total of seven isolates, including 4 BFV and 3 RRV.

The 2010–11 season began on 1 November 2010 with the first bleed and ended on 29 April 2011. For 2010–2011, a total of eight flocks each containing up to 15 Isa Brown pullets was deployed, with one flock each at Bourke, Deniliquin, Forbes, Griffith, Leeton, Macquarie Marshes, Menindee and Moama (near Mathoura) (Map).

The New South Wales sentinel chicken program was approved by the South West Area Health Service 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 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. 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 2003–2004 New South Wales Arbovirus Surveillance Program Annual Report.[24]

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

The 2010–11 season began with 118 pullets and five deaths were recorded during the program. A total of 2,300 samples were received from the eight flocks in New South Wales over the six-month period in 2010–2011. This represented 4,600 Enzyme-Linked ImmunoSorbant Assay (ELISA) tests (excluding controls and quality assurance samples), with each specimen being tested for MVEV and KUNV antibodies.

During the 2010–11 season, MVEV was first detected in February 2011 in the Macquarie Marshes and Bourke, and Kunjin in March 2011 in the Macquarie Marshes, Bourke and Forbes (Table 5).

Northern Territory

The sentinel chicken program in the Northern Territory is part of a national program involving Western Australia, New South Wales and Victoria and is designed to detect flavivirus activity (including the endemic arboviruses MVEV and KUNV, as well as exotic arboviruses such as JEV.[22] The current program in the Northern Territory commenced in January 1992 and replaced an earlier program run by Australian Quarantine Inspection Service (AQIS). Sentinel chicken flocks in the Northern Territory are maintained, bled and tested for flaviviruses in a combined program between the Department of Health, the virology laboratories of DPIFM and volunteers.

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

Table 5: Seroconversions to Murray Valley encephalitis virus and Kunjin virus in sentinel chicken flocks, New South Wales, 2010-11

Site	Seroconversions			First Positive Date	Last Positive Date
	MVEV	KUNV	Total		
Bourke	6	1	7	21 February 2011	21 March 2011
Forbes	1	2	3	17 March 2011	23 March 2011
Leeton	1	4	5	13 March 2011	17 April 2011
Macquarie marshes	2	3	5	21 February 2011	6 March 2011
Moama	0	1	1	6 April 2011	6 April 2011
Total	10	11	21		

Sentinel chickens are well located to detect flavivirus activity near the principal towns of the Northern Territory and hence provide timely and accurate indication of risk to people in those towns.

In the 2010–11 season, MVEV activity was detected in the Leanyer flock in April 2011, in the Adelaide River flock in May and June 2011, in the Tennant Creek flock in December 2010 and March 2011 and in the two Alice Springs flocks in April 2011 (Table 6).

KUNV activity was detected 22 times, and was present in all flocks between July 2010 and June 2011, except in the Alyangula and Alice Springs flocks (Table 6).

South Australia

Over the course of the 2010–11 summer period, South Australia was affected by the La Niña weather pattern which resulted in increased rainfall, elevated river levels and high levels of mosquito activity. Increased arboviral activity in both animals and humans was reported. In South Australia, notifications of mosquito-borne disease increased to the highest levels on record. For the first time since 1974, two cases of locally acquired MVEV infection were reported, with one resulting in the death of a 27 year old male.

Data obtained by the South Australian Health Department identified various regional and metropolitan locations as potential sources of infection, with a significant number of notifications being received from residents and visitors to the Riverland and Murraylands where mosquito-borne disease is endemic. Across South Australia, mosquito surveillance and control activities are conducted in partnership between the South Australian Health Department, University of South Australia, Local Government and Biosecurity SA. In response to predicted and emergent risks, seasonal mosquito monitoring and control activities were significantly expanded.

In South Australia in 2010–11, sentinel chicken flocks were established at Maree, Mulroona Station, Murray Bridge, Paringa, Blewitt Springs, and were screened between 10 November 2010 and 9 May 2011. The only seroconversion detected was in Paringa in April 2011.

In response to surveillance intelligence and disease notification data, the South Australian Health Department issued a number of health warnings and aggressively promoted the 'Fight the Bite' arbovirus prevention campaign. With the support of the South Australian Health Department, arbovirus prevention activities and mosquito control programs at the local government level were intensified, particularly in high risk areas.

Victoria

Flocks of chickens have been placed at ten locations (20 per flock) throughout the Murray River region in Victoria since the 1974 outbreak and act as an early warning system for possible human infection with flaviviruses. The chickens are bled weekly over the summer months (usually mid-October to April) and tested at the Department of Primary Industries.

Table 6: Seroconversions to Murray Valley encephalitis virus and Kunjin virus in sentinel chicken flocks, Northern Territory, 2010-11

Site	Seroconversions			First positive date	Last positive date
	MVEV	KUNV	Total§		
Howards Springs	0	3	4	29 Sep 2010	27 May 2011
Leanyer	1	6	7	21 July 2010	20 April 2011
Beatrice Hill	2	7	11	8 July 2010	2 June 2011
Jabiru	0	9	9	31 January 2011	13 June 2011
Nhulunbuy	0	2	4	25 July 2010	3 April 2011
Alyangula	0	0	2	25 August 2010	25 August 2010
Katherine Research Station	0	4	4	5 April 2011	28 May 2011
Nathan River	0	7	8	16 February 2011	4 May 2011
Tennant Creek	6	3	16	14 December 2010	8 May 2011
Arid Zone Research Station	2	0	3	14 April 2011	14 April 2011
Ilparpa	4	0	6	13 April 2011	13 April 2011
Total	15	41	74		

§ Includes seroconversions to flavivirus unspecified

In September 2010, parts of northern Victoria were affected by flood events following a number of years of drought conditions. There was also the possibility of future flooding events and increased humidity across Victoria during the 2010–11 summer. Given the predicted increase in mosquito breeding, the sentinel chicken program was brought forward with flocks placed on-site two weeks earlier than usual on 19 October 2010.

In January 2011, a major flood event occurred throughout the western and north western parts of the state. In response, additional adult mosquito and sentinel chicken surveillance was established in Hamilton, Horsham, Warracknabeal, Dimboola, Castlemaine and Bendigo (Map). This consisted of weekly adult mosquito trapping at two sites per council and weekly bleeding of the sentinel chickens. The chickens were on private properties, mainly show birds.

In February 2011, surveillance programs in the Murray Valley area detected the presence of MVEV in sentinel chickens. Antibodies to MVEV were first detected in the sentinel chicken flocks during week six of 2011 (beginning 6 February 2011). The flocks continued to seroconvert to flaviviruses through to week 18 (beginning 1 May 2011). MVEV activity was confirmed in chickens from Barmah, Bendigo, Cobram, Kerang, Mildura, Robinvale, Swan Hill, Toolamba and Tooleybuc (Table 7). Sixty-nine of the 260 sentinel chickens tested positive for flavivirus antibodies; 47 of these were MVEV specific.

The last detection of the virus was in Kerang in bloods collected on 9 May 2011 (Table 7).

Western Australia

The flavivirus sentinel chicken program in Western Australia is undertaken by the Arbovirus Surveillance and Research Laboratory (ASRL) at The University of Western Australia, on behalf of the Western Australian Department of Health. Many state and local government authorities and community volunteers also take part in the program. Thirty sentinel chicken flocks (of up to 12 chickens) are located at major towns and communities in the Kimberley, Pilbara, Gascoyne, Goldfields, Midwest and Central Coastal regions of Western Australia (Map). Blood samples are collected from the chickens by environmental health officers or trained volunteers at fortnightly intervals. Samples are transported to the ASRL where they are tested for antibodies to flaviviruses using an epitope blocking ELISA.[25]

Rainfall prior to commencement of the 2010–11 wet season was generally well above average in northern Western Australia. Ex-Tropical Cyclone Abele created record rainfall in the Gascoyne and surrounding districts in mid-December 2010. The monsoon

Table 7: Seroconversions to Murray Valley encephalitis virus and Kunjin virus in sentinel chicken flocks, Victoria, 2010-11*

Site	Total number of birds that seroconverted	First Positive Date	Last Positive Date
Mildura	14	7 February 2011	7 March 2011
Mildura (new flock)	1	9 May 2011	9 May 2011
Robinvale #	12	13 February 2011	1 March 2011
Tooleybuc	6	7 February 2011	4 April 2011
Tooleybuc (new flock)	3	28 March 2011	18 April 2011
Swan Hill	1	7 March 2011	7 March 2011
Kerang	11	15 February 2011	15 March 2011
Kerang (new flock)	3	27 April 2011	9 May 2011
Barmah	11	8 February 2011	2 May 2011
Cobram	6	20 February 2011	1 May 2011
Rutherglen	Nil	n/a	n/a
Wodonga	5	23 March 2011	4 May 2011
Toolamba	8	16 February 2011	5 May 2011
Bendigo	4	2 March 2011	16 March 2011
Hamilton	Nil	n/a	n/a
Horsham	Nil	n/a	n/a
Total	85		

* 20 chickens at each site. Results include a combination of flavivirus unspecified and Murray Valley encephalitis virus.

remained very active in northern Western Australia between December and April, and the north of the state was affected by Tropical Cyclone Dianne and Tropical Cyclone Carlos. Above average rainfall was recorded across the state, with extensive flooding in many areas. Tropical Cyclone Errol brought more heavy rainfall to the Kimberley region in mid-April, and a cloud band in mid-May brought substantial rainfall to the Pilbara region. Cool, wet conditions occurred in the western Pilbara in June.

A total of 3,672 serum samples from 30 flocks were tested for antibodies to flaviviruses during 2010–11.[26] Seroconversions to flaviviruses were detected 237 (6.5%) samples compared with 16/3,941 samples (0.4%) in 2009–10.[27] Two MVEV seroconversions detected at Derby in July and one KUNV infection at Fitzroy Crossing in August and Exmouth in September were associated with continuing activity from the 2009–10 season.

The first activity associated with the 2010–11 wet season occurred in February 2011, when KUNV infections were detected in sentinel chickens at Fitzroy Crossing in the west Kimberley region and MVEV infections were detected at Wyndham (North East Kimberley), Halls Creek (South East Kimberley), Beagle Bay (West Kimberley) and Tom Price (Pilbara). Very high levels of flavivirus activity were subsequently detected throughout the Kimberley, Pilbara and Gascoyne regions in March, and the activity continued in April (Kimberley and Pilbara), May (Kimberley, Pilbara, Midwest/Wheatbelt and Goldfields) and June (Pilbara). Overall there were 226 seroconversions to MVEV and 14 KUNV infections, including seven dual MVEV/KUNV infections. The detections of MVEV activity at Leonora in the Goldfields and Dongara in the Midwest/Wheatbelt are the first in these regions since the extensive southerly activity of MVEV in 2000, and the overall level of flavivirus activity was similar to the levels seen in 2000.[28] The majority of sentinel chicken flocks required replacement with new chickens during the course of the season.

The Western Australian Department of Health issued five media statements. The first was issued on 24 September 2010 following continued detections of MVEV antibodies in sentinel chickens in the Kimberley region, and KUNV antibodies in chickens in the Pilbara and Gascoyne regions. The second was issued on 25 February 2011 after KUNV infections were detected in sentinel chickens in the Kimberley region for the first time in the 2010–11 wet season. The third media release was issued on 25 March 2011 after widespread detections of MVEV infections in sentinel chickens in the Kimberley, Pilbara and Gascoyne regions, the first evidence of MVEV activity in Western Australia for the 2010–11 season. The fourth media release was issued on 12 April 2011 after the diagnosis of a case of MVEV in Carnarvon and continued detections of antibodies to MVEV and KUNV in sentinel chickens in the Kimberley, Pilbara and Gascoyne regions. A fifth media warning was issued on the 16 May 2011 due to new detections of MVEV and KUNV infections in sentinel chickens in the Midwest/Wheatbelt and Goldfields regions, and six cases of MVEV infection including one fatality.

Tasmania

No viruses were isolated in 2010–11 in mosquitoes trapped during *ad hoc* collections undertaken in Sorrell Council region.

Arbovirus infection (NEC)

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

There were 22 notifications of arbovirus NEC in 2010–11, compared with a five-year average of 16 cases (range 4 to 33 cases). Most of these notifications relate to infections that had been acquired overseas (n=17). In 2010–11, 16 notifications were of flavivirus (unspecified), with the remainder due to the flaviviruses Kokobera (n=3) and Stratford (n=1) and unknown arboviruses (n=2).

Malaria

Malaria is a serious acute febrile illness that is normally transmitted from person to person through the bite of an infected mosquito. It is caused by a protozoan parasite in the genus *Plasmodium* that includes five species that infect humans, *Plasmodium vivax*, *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium knowlesi*.[29,30]

There were 414 notifications of malaria during the season 2010–11 (Table 1), a 27 per cent decrease compared with the mean of 570.6 notifications per year during the previous five years, consistent with the steady decline in the number of notifications since the 2004–05 season. The decline has been in both overseas acquired and locally acquired cases.

There were 7 notified locally-acquired cases associated with an outbreak of *P. falciparum* in Saibai and Duan Islands in the Torres Strait during March and April 2011.[31] The last outbreak of locally-acquired malaria on the Australian mainland occurred in North Queensland during 2002.[32]

Malaria was most frequently reported amongst people aged 25-29 years, with 57 notified cases. Similar to previous years, the majority of cases were in males (72%, n=299). Cases were from all jurisdictions. No deaths from malaria were reported during the 2010–11 season.

The infecting species was reported for 96% of notifications during the season 2010–11. *P. falciparum* and *P. vivax* were the predominant infecting species (Table 8). In 2010–11, no cases were infected with *P. knowlesi*.

Complete information about the country of acquisition was available for 341 (82%) malaria cases. Papua New Guinea was the most frequently reported place of acquisition, with 26% of cases (108/414), followed by India with 14% cases (58/414) (Figure 8).

P. vivax infections were commonly associated with travel to Asia or pacific nations (82%, 146/179). *P. falciparum* infections were frequently associated with travel to sub-Saharan, Central, West, Southern and East Africa (44%, 85/192), and only three *P. vivax* infections (2%) were associated with travel to these regions.

Table 8: Malaria cases, 2010-11, by *Plasmodium* species

Malaria species	Number of cases	%of all cases
Plasmodium falciparum	186	45%
Plasmodium vivax	175	42%
Plasmodium ovale	18	4%
Plasmodium malariae	14	1%
P. falciparum and P. vivax	4	<1%
P. falciparum and P. ovale	2	0%
Plasmodium spp.	15	4%
Total	414	100%

Other surveillance and research activities

Exotic mosquito detections at the border

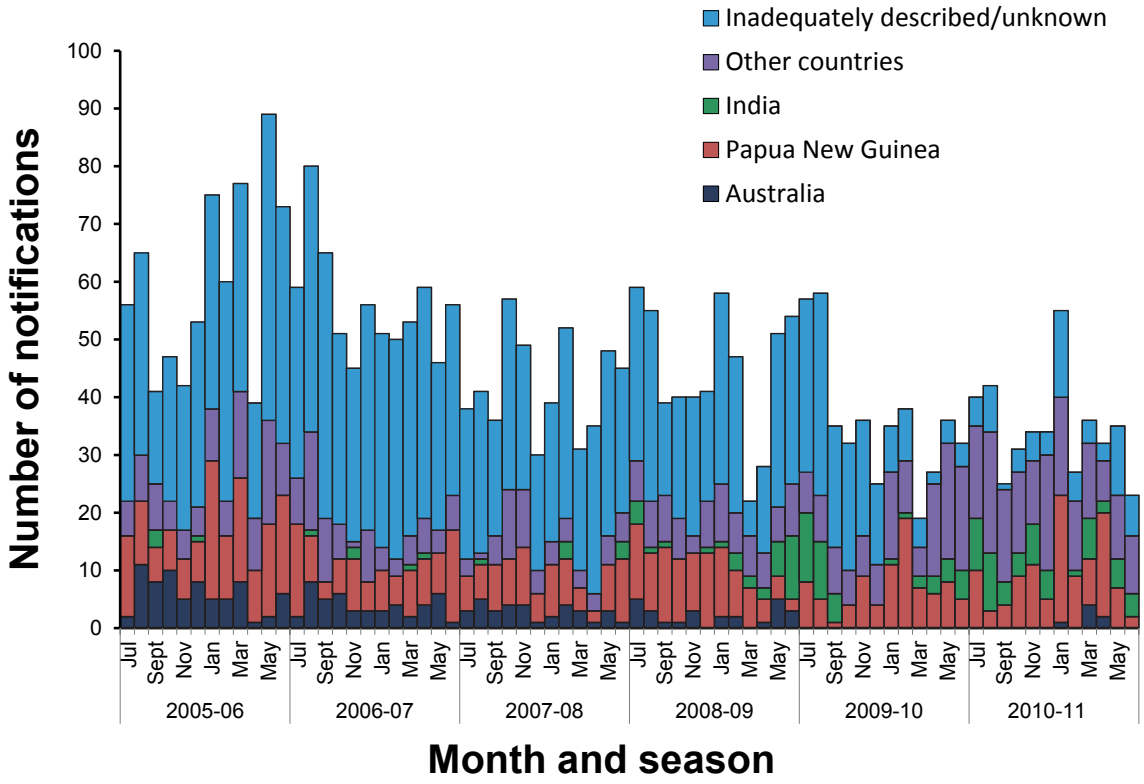
Between July 2010 and June 2011 there were five exotic mosquito detections made by the Department of Agriculture, Fisheries and Forestry (DAFF) at the Australian border compared with eight for the 2009–10 period. Two detections were made via routine quarantine inspection of imported cargo while the remaining three detections were made

Table 9: Exotic mosquito detections at the border, Australia, 2010-11

Date	Location	Species	Method of Detection	Source / Origin	Action/ Mitigation	Surveillance Results
July 2010	Port Hedland Seaport	*Ae. aegypti* (5 larvae)	Inspection	Pre-fabricated steel from China	Chlorination of goods, increased trapping	No further exotic mosquitoes detected
Dec 2010	Darwin Seaport	*Ae. albopictus* (3 larvae)	Inspection	Wooden reel of steel wire	Chlorination of goods, increased trapping	No further exotic mosquitoes detected
Jan 2011	Darwin Seaport	*Ae. aegypti* (3 adults)	CO_2 baited BG trap	Unknown/ unable to identify source	ULV fogging, receptacle treatment surveys, increased trapping	No further exotic mosquitoes detected
Jan 2011*	Thursday Island Seaport	*Ae. albopictus* (larvae)	Sentinel tyre trap	Spread from surrounding Torres Strait Islands	Port area included in control activities already being performed by QLD Health on the island.	No further exotic mosquitoes detected
Mar 2011	Darwin Seaport	*Ae. albopictus* (1 adult)	CO_2 baited BG trap	Unknown/ unable to identify source	ULV fogging, receptacle treatment surveys, increased trapping	No further exotic mosquitoes detected

* *Ae. albopictus* was collected on Thursday Island in December 2010 by QLD Health. However this detection was made on the opposite side of Thursday Island to that made by DAFF.

Figure 8: Number of notified cases of malaria, Australia, July 2005 to June 2011, by month, year and place of acquisition



through routine vector monitoring at international ports (Table 9). No further exotic mosquitoes were collected following the initial detections with the exception of *Ae. albopictus* on Thursday Island. Control activities are ongoing.

Torres Strait Ae. albopictus Elimination and Control Program

The Asian tiger mosquito, *Ae. albopictus*, which was previously exotic to Australia, was found on the outer islands of Torres Strait in April 2005.[33] This mosquito is capable of transmitting dengue and CHIKV, as well as becoming a new serious pest mosquito. Since 2005, the Australian Government has provided funding to Queensland Health towards a mosquito elimination program in the Torres Strait. The initial aim of the program was to eliminate *Ae. albopictus* from the Torres Strait islands. However, as elimination was not considered to be possible, the development and implementation of a program based on the "*cordon sanitaire*" approach (a barrier designed to prevent a disease or other undesirable condition from spreading) around Thursday and Horn Islands was initiated in May 2008 in an attempt to prevent the spread of *Ae. albopictus* further south. *Ae. albopictus* was detected on Thursday Island for the first time during a Nov-Dec 2010 field trip (one larval sample) and there were further detections on subsequent trips. On Horn Island, small populations of *Ae. albopictus* continue to occur, despite control efforts. There were no detections of *Ae. albopictus* on the mainland in 2010–11.

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 2010 to 30 June 2011, and activities undertaken by health authorities in response to human cases, as well as evidence of virus activity. Sentinel animal and vector monitoring continue to be an important part of the early warning system for arbovirus activity in Australia.

Rates and counts of RRV infection and counts of dengue fever were notably increased compared with historical totals. There were more than three times as many overseas–acquired dengue cases during the 2010–11 season as the average number during the previous five years; two thirds of these cases were in travellers returning to Australia from Indonesia.

The number and proportion of dengue cases that are overseas acquired has increased in recent years, and for cases acquired in Indonesia which comprises most of the increase, the increase in the frequency

of travel by Australians to Indonesia does not completely explain the increase.[34] Viraemic returning travellers or visitors from overseas present a risk of starting a local outbreak in North Queensland. Travellers should minimise the risk of infection by avoiding being bitten by mosquitoes through the use of personal prevention measures. Travellers are encouraged to consider the information available on the Smartraveller travel health website and to seek a doctor's advice prior to travel.[35]

The risk of dengue becoming established in North Queensland following an imported case remains a major concern. Public health authorities conduct extensive control efforts in partnership with residents in order to control the outbreaks that occur every season. There has not been a large outbreak (>100 cases) of dengue in Australia since the 2008–09 season, when there was an outbreak of DENV-3 with 915 cases in Cairns that lasted for 31 weeks.[12] In 2011, Queensland Health released the Queensland Dengue Management Plan 2010–2015 which outlines current best practice in dengue management for the four levels of dengue activity; ongoing prevention, response to sporadic cases, outbreak response and multiple outbreaks.[36]

Since 2005, *Ae. albopictus* has become established on the majority of islands in the Torres Strait. The risk of dengue transmission in central and southern Queensland and other jurisdictions would be substantially increased if this vector became established on the mainland. Control efforts through the Torres Strait *Ae. albopictus* Elimination and Control Program are vital to prevent incursions on the mainland. In mid-2011, small populations of *Ae. albopictus* continued to be maintained on Horn Island despite control efforts. Since that time, the program has been demonstrably successful at reducing *Ae. albopictus* numbers in the *cordon sanitaire* to levels where elimination is now a real possibility.

Researchers at the University of Queensland and international collaborators are trialling a novel biological control agent for mosquito-borne diseases such as dengue fever. The mosquito vectors are infected with a naturally occurring intracellular bacterium *Wolbachia pipientis* wMel strain which inhibits dengue transmission while conferring only small fitness cost to the mosquito.[37] In January 2011, researchers commenced a field trial with wMel Wolbachia-infected mosquitoes in January 2011 at Gordonvale and Yorkeys Knob in North Queensland with strong community support. Ongoing monitoring shows that Wolbachia is still present in almost 100% of all Ae. aegypti mosquitoes in these sites.[38] Based on the success of these trials, this program is being expanded to other countries (Indonesia, Vietnam and Brazil) where dengue is endemic.

Over the spring and summer of 2010–11 the southeast of Australia experienced unusually wet weather and flooding resulting in increased mosquito and wild bird populations. In South Australia and Victoria in the 2010–11 season, large increases in reported cases and rates of BFV and RRV were noted along with evidence of MVEV activity. There were two confirmed MVEV cases in South Australia. These increases occurred concurrently with outbreaks of arboviral disease in horses, particularly RRV and Kunjin. While KUNV infections were widely diagnosed in horses in southern Australia in early 2011, there were no human cases except for one case in the Northern Territory in April. The Victorian Infectious Diseases Reference Laboratory conducted real-time opportunistic serological surveillance for MVEV on referred human sera from the Murray River between February and May 2011. No individuals born after 1974 had antibodies to MVEV and the seroprevalence was comparable to background rates.[39] Differences in laboratory diagnostic practices between human and veterinary health may in part account for marked difference between case numbers in humans and animals in 2011, and there is a need to ensure the equivalence of case definitions and laboratory practices for the confirmation of zoonotic arboviruses in Australia.

In response to the MVEV outbreak between March and May 2011, the AHPPC requested that NAMAC prepare a framework for the surveillance, prevention and control of Murray Valley encephalitis virus in Australia, emphasising a One-Health approach, along with guidance for public health units as part of the CDNA Series of National Guidelines (SoNGs). This work is in progress.

While the two cases of yellow fever reported from Queensland in 2010–11 met the CDNA national surveillance case definition, both were likely to have been vaccine related. A revised CDNA case definition for yellow fever which came into effect on 1 January 2013 excludes vaccine-associated cases. Under the revised case definition, laboratory evidence provided by serology is required to be in the absence of recent vaccination (in the previous 3 weeks for seroconversion and in the previous three months for a single IgM to yellow fever in the absence of IgM to other flaviviruses).

The limitations of surveillance data used in this report are referred to in detailed notes on the interpretation of NNDSS which is available in the 2010 NNDSS annual report.[40] A specific limitation of the data used in this report relates to the virological testing which is required to distinguish alphavirus disease from other causes of arthritis. The alphavirus infections notified to NNDSS each season are based on laboratory definitive evidence only and assume a clinically compatible illness. A case can still be notified when clinical illness may not be consistent with

the diagnosis of alphavirus infection. Cross-reacting IgM between RRV and BFV is a known issue, and from 1 January 2013, revised case definitions for RRV and BFV were implemented to address this. Under the revised case definition, a diagnosis for BFV based on IgM with requires the absence of IgM to RRV, and vice versa for the diagnosis of RRV. Alternatively, diagnosis can be based on IgM in the presence of IgG to that same virus. Another limitation on the findings of this report relates to place of acquisition of infection for infections that are commonly acquired overseas, in terms of completeness and consistency of coding. The National Surveillance Committee is currently undertaking a project to standardise coding of place of acquisition between jurisdictions.

Continued vigilance and the involvement of all relevant sectors enable the rapid detection of and early response to the threat of arboviral disease and malaria in Australia. The expert advice provided by NAMAC to AHPPC, CDNA and health departments has a vital role in mitigating mosquito-borne disease threats.

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