Arboviral diseases and malaria in Australia, 2009–10: Annual report of the National Arbovirus and Malaria Advisory Committee

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Abstract

The National Notifiable Diseases Surveillance System received 7,609 notified cases of disease transmitted by mosquitoes for the season 1 July 2009 to 30 June 2010. The alphaviruses Barmah Forest virus and Ross River virus, accounted for 6,546 (79%) of these notifications during the 2009–10 season. There were 37 notifications of dengue virus infection locally-acquired from North Queensland and 581 notified cases in Australia that resulted from overseas travel. This number of overseas acquired cases continues to rise each year due to increasing disease activity in the Asia–Pacific region and increased air travel. Detection of flavivirus seroconversions in sentinel chicken flocks across Australia provides an early warning of increased levels of Murray Valley encephalitis virus and Kunjin virus activity. Flavivirus activity was detected in western and northern Australia in 2009–10, which prompted public health action. No human cases of Murray Valley encephalitis virus infection were notified, while there were 2 cases of Kunjin virus infection notified. There were no notifications of locally-acquired malaria in Australia and 429 notifications of overseas-acquired malaria during the 2009–10 season. This annual report presents information of diseases transmitted by mosquitoes in Australia and notified to the National Notifiable Diseases Surveillance System. *Commun Dis Intell* 2012;36(1):70–81.

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 surveillance of mosquito-borne diseases of public health importance in Australia for the season 1 July 2009 to 30 June 2010. It includes locally and overseas acquired notified cases of disease caused by the alphaviruses (Barmah Forest virus, chikungunya virus and Ross River virus), flaviviruses (dengue virus, Murray Valley encephalitis virus, Kunjin virus, Japanese encephalitis virus and yellow fever virus) and malaria.

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

Methods

Human cases of arbovirus infection and malaria are monitored using the National Notifiable Diseases Surveillance System (NNDSS). All Australian states and territories require doctors and/or pathology laboratories to notify cases of infectious diseases that are important to public health including several arboviruses and malaria. The *National Health Security Act 2007* provides the legislative basis for communicable disease notifications in Australia and authorises the exchange of health information between jurisdictions and the Commonwealth. The Act provides for the establishment of the National Notifiable Diseases List, which specifies the diseases about which personal information can be provided. State and territory health departments transfer these notifications regularly to the NNDSS. 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 March 2011 and analysed by date of diagnosis. This is a derived field and represents the earliest of the reported fields of notification date and notification received date. The dataset represents a 'snap shot', and numbers

in this report may vary slightly from those reported from other NNDSS sources. Detailed notes on the interpretation of NNDSS are available in the 2009 NNDSS annual report.[1] Case definitions for the diseases included in this report are available from http://www.health.gov.au/casedefinitions The report includes information on the following pathogens transmitted by mosquitoes:

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

To compare notifications in 2009–10 to historical totals, counts and crude rates of notification were compared either with the mean of the previous 5 years or with data from the previous year. The Australian Bureau of Statistics estimated resident population for Australia and each state or territory at June 2009 was used to calculate notification rates.

Additional information was available from a survey conducted with some state and territory public health surveillance managers. The survey sought to confirm cases reported to NNDSS and determine the place of acquisition for locally-acquired cases of dengue virus infections. States and territories may conduct follow-up of arbovirus and malaria cases to determine the likely place of acquisition of infection.

Results

During the 2009–10 season, there were 7,609 notifications of diseases transmitted by mosquitoes. This represented a 6% increase from the mean of 7,207 notifications for the previous 5 years. A summary of the counts and crude rates of these mosquito-borne diseases is shown in Table 1. There were no reported cases of yellow fever during the season.

Alphavirus

The most frequently reported alphaviruses in Australia, Ross River virus (RRV) and Barmah Forest virus (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).[2] No specific treatment or vaccine is available for these diseases. The viruses are maintained in a primary mosquito–mammal cycle involving macropods (kangaroos and wallabies), possibly other marsupials (e.g. possums), flying fox and native rodents. Horses, which may act as amplifier hosts, appear to develop joint and nervous system disease after infection with RRV. During the 2009–10 season, there were 6,546 notifications of alphaviruses (BFV and RRV) of which RRV infections accounted for 79% (5,148).

Barmah Forest virus infections

There were 1,398 notifications of BFV infections during the 2009–10 season, representing a rate of 6.4 per 100,000 population, which has decreased from the mean of 8.3 per 100,000 population for the previous 5 years (Table 1). Queensland reported the largest number of notifications of BFV (845) while the highest rate was reported in the Northern Territory (42 per 100,000 population).

Cases were reported in all jurisdictions. Approximately half of cases were male (52%). The median age for cases was 47 years.

As in previous years, there was a marked seasonal trend with the highest number of cases being diagnosed in the months of March (181) and April (180).

Ross River virus infections

There were 5,148 notifications of RRV infection during 2009–10 representing a rate of 23 per 100,000 population (Table 1). This was a 2.7% increase over the mean of the previous 5 years. Queensland reported the largest number of cases of RRV (2,540) while the highest rate was reported in the Northern Territory (143 per 100,000 population).

Cases were reported in all jurisdictions. Just under half of all notifications were male (44%). The median age for cases was 42 years.

As in previous years, there was a marked seasonal trend with the highest number of notifications being diagnosed in the months of March (928) and April (1,020).

South Australia reported a significant increase in RRV notifications when compared with the mean of the previous 5-year period. For the 2009–10 reporting period there were 391 RRV notifications (232 in 2008-09); 49 of which were along the Murray River; with the rest dispersed throughout both regional and metropolitan areas. RRV notifications in 2009–10 alone indicate a high level of virus activity and susceptibility in human populations. Heavy rainfall in South Australia since March 2010 has no doubt played a role in this.[3]

Chikungunya virus infection

Chikungunya virus (CHIKV) is a member of the alphavirus genus in the family *Togaviridae* and is closely related to RRV and BFV. Illness is charac-

Table 1: Number of notified cases, rate and 5-year mean rate per 100,000 population of mosquito-borne diseases, Australia, 2004–05 to 2009–10, by disease and state or territory

Disease		State or territory								
		ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Aust
Arbovirus Infection (NEC*)	Notified cases 2009/10	0	0	3	9	0	0	2	0	14
	Rate, 09/10	0.0	0.0	1.3	0.2	0.0	0.0	0.0	0.0	0.1
	Mean rate, 2004/05 – 08/09	0.0	0.0	0.3	0.5	0.0	0.0	0.1	0.0	0.1
Barmah Forest virus infection	Notified cases 2009/10	5	297	94	845	38	1	32	86	1,398
	Rate, 09/10	1.4	4.2	41.6	19.1	2.3	0.2	0.6	3.8	6.4
	Mean rate, 2004/05 – 08/09	1.4	7.5	41.6	21.5	4.4	0.2	0.5	6.8	8.3
Dengue virus infection†	Notified cases 2009/10	19	117	30	160	11	4	51	226	618
	Rate, 09/10	5.4	1.6	13.3	3.6	0.7	0.8	0.9	10.1	2.8
	Mean rate, 2004/05 – 08/09	1.6	1.3	9.2	7.5	1.1	0.4	0.3	2.7	2.4
Japanese encephalitis virus infection – infection acquired overseas	Notified cases 2009/10	0	0	0	0	0	0	0	0	0
	Rate, 09/10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Mean rate, 2004/05 – 08/09	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Kunjin virus infection	Notified cases 2009/10	0	0	1	1	0	0	0	0	2
	Rate, 09/10	0.0	0.0	0.4	0.0	0.0	0.0	0.00	0.0	0.01
	Mean rate, 2004/05 – 08/09	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Malaria	Notified cases 2009/10	3	84	13	134	23	3	94	75	429
	Rate, 09/10	0.9	1.2	5.7	3.0	1.4	0.6	1.7	3.3	2.0
	Mean rate, 2004/05 – 08/09	3.5	2.0	18.8	5.5	1.8	3.4	2.1	4.2	3.1
Murray Valley encephalitis virus infection	Notified cases 2009/10	0	0	0	0	0	0	0	0	0
	Rate, 09/10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean rate, 2004/05 – 08/09	0.00	0.00	0.19	0.01	0.00	0.00	0.00	0.04	0.01
Ross River virus infection	Notified cases 2009/10	20	1139	323	2540	391	41	351	343	5148
	Rate, 09/10	5.7	16.0	142.8	57.4	24.1	8.1	6.4	15.3	23.4
	Mean rate, 2004/05 – 08/09	3.0	13.3	131.3	50.2	13.1	5.2	2.7	32.4	20.7

Does not include 33 chikungunya virus infections reported to the National Notifiable Diseases Surveillance System during the 2009–10 season as chikungunya is not reported by all jurisdictions.

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

† Locally acquired and overseas acquired; See Table 2.

NEC Not elsewhere classified.

terised by a sudden onset of fever, rash and severe joint pain. The acute disease lasts 1–10 days, but convalescence may include prolonged joint swelling and pain lasting months. It has clinical similarities to dengue, including occasional cases with haemorrhagic manifestations.[4] CHIKV is of concern given that the virus is transmitted from human to human by infected mosquitoes. Other vertebrates are not required for high levels of transmission to occur. In Australia, the confirmed mosquito vectors for CHIKV include *Aedes aegypti,* which occurs in northern Queensland and *Aedes albopictus,* which is found on Cocos, Christmas and the Torres Strait Islands.[5] Effective surveillance is required as there is the potential for the virus to become established in humans and spread in areas in Australia where the vectors exist. Other Australian mosquitoes that have been shown to be competent laboratory vectors of CHIKV include *Ae. vigilax, Ae. procax, Ae. notoscriptus* and *Coquillettidia linealis.*[6]

CHIKV infection is a notifiable disease in all jurisdictions other than the Australian Capital Territory. There were 33 notifications of overseas-acquired CHIKV infection reported to NNDSS during the 2009–10 season compared with 21 cases in 2008–09 and 3 cases in 2007–08. Twelve of the cases were reported to have acquired their infection during travel to India.

Flaviviruses

This section provides information on several flaviviruses notified to NNDSS including dengue virus (DENV), Murray Valley encephalitis virus (MVEV), Kunjin virus (KUNV) and Japanese encephalitis virus (JEV). Other flaviviruses may be notified under the arbovirus (NEC) category. Dengue is characterised by flu like symptoms (fever, headache, muscle/joint pain) and has 4 distinct serotypes. Infection with MVEV, KUNV and JEV can, in a small percentage of cases, result in illness involving the DENV nervous system including encephalitis of variable severity. *Ae. aegypti* is the major vector of dengue in Australia and *Culex annulirostris* is the major vector of MVEV, JEV and KUNV. No specific treatment is available for these diseases and care is largely supportive. A vaccine is not available for prevention of DENV, MVEV or KUNV infection but a vaccination to prevent JEV infection is available.[7] There were 620 notified flavivirus cases in 2009–10, which included 618 notified cases of DENV and 2 notified cases of KUNV disease (Table 1). There were no notified cases of JEV or MVEV.

Dengue virus infection

There were 618 notified cases of DENV infection during the season of 2009–10. Of these, 37 notified cases were locally-acquired in north Queensland and 581 notified cases acquired their DENV infection while overseas (Table 2).

Locally-acquired dengue virus infection

Local transmission of DENV is restricted to areas of northern Queensland where the key mosquito vector, *Ae. aegypti* is present.[8] Dengue is not endemic in north Queensland, however local transmission can occur upon introduction of the

Table 2: Place of reporting of notified cases of dengue virus infection, Australia, 1 July 2005 to 30 June 2010, by state or territory

Dengue	Year of diagnosis	State or territory								
		ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Aust
Locally-acquired*	2005/06	0	0	0	42	0	0	1	0	43
	2006/07	0	0	1	46	0	0	0	0	47
	2007/08	0	0	0	26	0	0	0	0	26
	2008/09	0	5	0	1,008	0	0	3	1	1,017
	2009/10	0	3	0	33	0	0	1	0	37
Total locally-acquired		0	8	1	1,155	0	0	5	1	1,170
Overseas-acquired	2005/06	7	56	16	33	10	0	12	22	156
	2006/07	2	71	14	67	12	0	9	27	202
	2007/08	4	105	26	84	35	4	15	94	367
	2008/09	13	168	24	121	26	6	18	120	496
	2009/10	19	114	30	127	11	4	50	226	581
Total overseas-acquired		45	514	110	432	94	14	104	489	1,802

* Cases acquired their infection while living in or visiting north Queensland.

virus to the mosquito vector by a viraemic tourist or a resident returning from a dengue-affected area overseas.[9] There were 37 notified cases of locally-acquired DENV infection during 2009–10. All cases of infection were acquired in north Queensland. Locally-acquired cases were notified between September 2009 and May 2010 and were associated with a number of outbreaks identified in north Queensland, dominated by 16 cases of DENV-2 from Tully.

Overseas-acquired dengue virus infection

There were 581 notifications of DENV infection acquired overseas during the 2009–10 season (Table 1), which was an increase when compared with the average of 257 over the last 5 years. All jurisdictions reported increased numbers of notifications of overseas-acquired DENV infection since 2005–06 (Figure). Most notably, Western Australia reported 226 cases compared with 22 cases in 2005–06.

Country of acquisition was available for 416 (72%) of the 581 cases of overseas-acquired DENV reported to NNDSS (Table 3). Indonesia (notably Bali) was the country of acquisition for 274 (47%) cases and involved all 4 dengue serotypes. Nineteen other destinations were identified by patients. The infecting DENV serotype was determined for 216 (37%) of the 581 overseas-acquired dengue cases. DENV serotype 2 (n = 98) was the most frequently reported serotype.

Figure: Notified cases of overseas-acquired dengue virus infection, Australia, 1 July 2004 to 30 June 2010, by state or territory

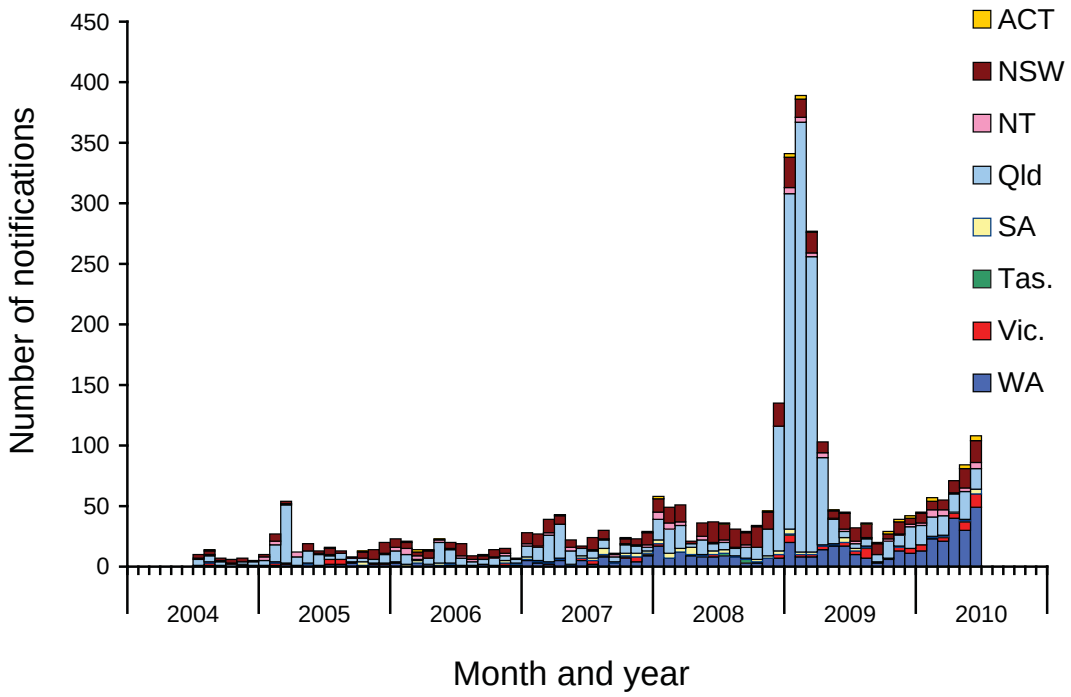


Table 3: Notified cases of overseas-acquired dengue virus infection, Australia, 1 July 2009 to 30 June 2010, by serotype and country of acquisition

Country of acquisition	Dengue serotype					Total cases
	Dengue 1	Dengue 2	Dengue 3	Dengue 4	Untyped	
Indonesia	34	66	22	10	142	274
Thailand	3	6	5	2	20	36
East Timor	5	0	0	2	13	20
Fiji	0	6	3	0	7	16
Vietnam	3	1	0	0	10	14
Other country	11	11	3	2	29	56
Country not listed	6	8	5	2	144	165
Total	62	98	38	18	365	581

Japanese encephalitis virus infections

The last JEV notification in Australia was reported by New South Wales in September 2008 and was acquired overseas. There were no cases of locally-acquired JEV infection notified to NNDSS in Australia during 2009–10. The last case of locally-acquired JEV infection was reported in 1998.[10]

Kunjin virus disease

There were 2 human cases of KUNV disease reported in Australia during 2009–10. One case each was reported by Queensland and the Northern Territory. The Northern Territory case exhibited encephalitic symptoms that are unusual for this disease.

Murray Valley encephalitis virus infection

There were no human cases of MVEV infections reported in Australia during 2009–10. Previous MVEV cases were reported in March and May 2009 with 2 cases each reported from Western Australia and the Northern Territory. Both cases from the Northern Territory were fatal.

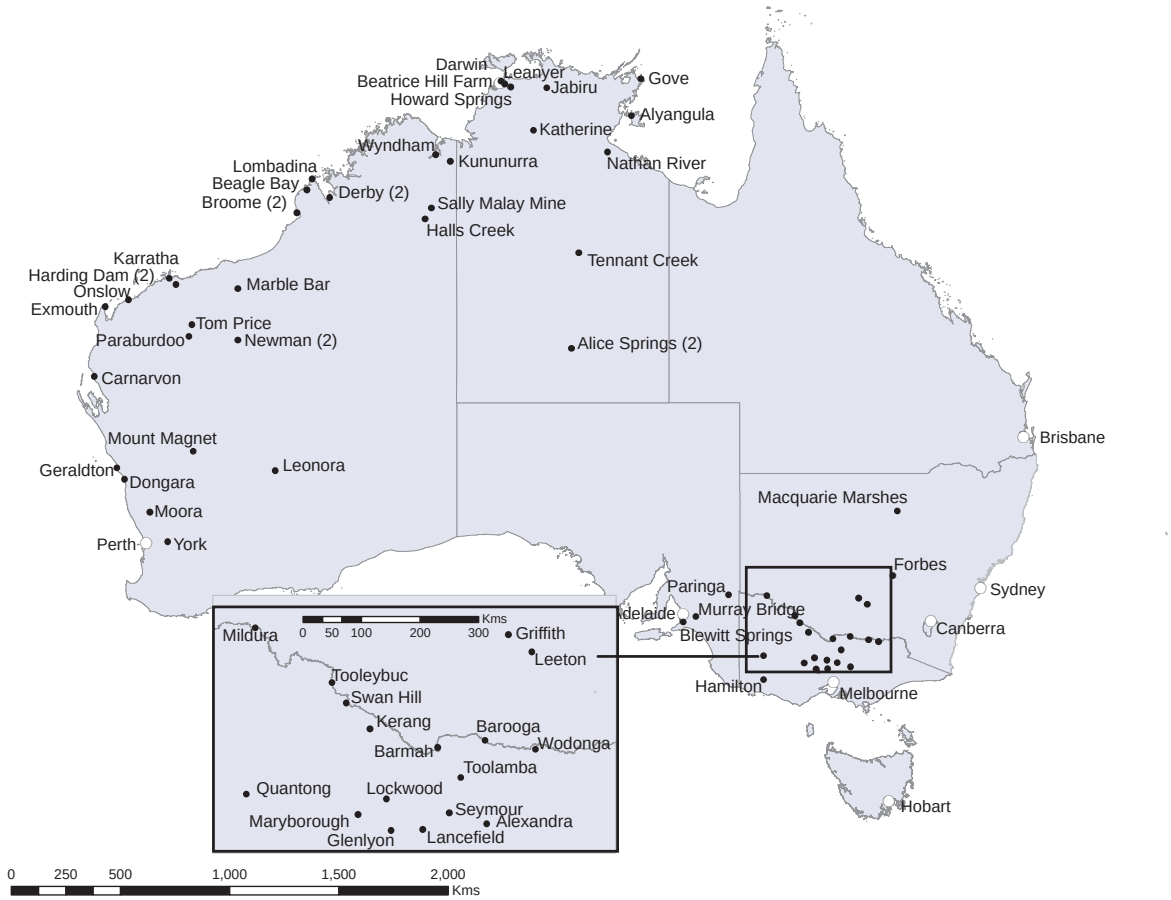
Sentinel chicken flavivirus surveillance programs

The sentinel chicken program is designed to detect flavivirus activity in Western Australia, New South Wales, Victoria, South Australia and the Northern Territory. The program aims to provide early warning of the endemic arboviruses MVEV and KUNV, as well as exotic arboviruses such as JEV.[11] A public health response or warning can be implemented when chickens from a flock develop new antibodies to a flavivirus of interest. These warnings advise residents of the need to take added precautions to avoid mosquito bites and may be used to direct mosquito management programs. Chickens are replaced at least annually and more frequently if birds die or large proportions seroconvert. The flocks are well positioned to detect flavivirus activity and provide a timely and accurate indication of risk to people.[12] The location of sentinel chicken sites during 2009–10 is shown in the Map.

Northern Territory

Sentinel chicken flocks in the Northern Territory are maintained, bled and analysed for flavivirus antibodies in a combined program between the Northern Territory Department of Health, Centre for Disease

Map: Sentinel chicken testing sites, Australia, 2009–10



Control Medical Entomology section, the Northern Territory Department of Resources (DoR) Berrimah Veterinary Laboratories, and volunteers.

DoR officers or volunteers usually bleed flocks once a month and the samples are tested by DoR for antibodies to MVEV and KUNV.

In the 2009–10 season, MVEV activity was detected in the flocks at Jabiru in April, and at Tennant Creek in August 2009 and May 2010. The three chickens that seroconverted to MVEV in Tennant Creek in August, outside the main MVE season, are possibly a carry over of MVEV activity from the previous season as the chickens were not bled in July 2009. The results in 2009–10 indicated low MVE virus activity in the Northern Territory, despite above average rainfall in the Top End. There have been no seroconversions to MVEV in the Alice Springs flocks since 2001–02, when the nearby Ilparpa swamp was drained, despite high levels of summer rain and large volumes of effluent released into the swamp this year. The high summer rain indicated an expected seroconversion to MVEV from one of the predictive models[13] and was the impetus for mosquito control precautions and warnings. The absence of any MVEV activity may have been partially due to an extensive aerial larval control of the swamp with methoprene pellets in March, but may also indicate that the local MVE ecology near Alice Springs has changed with the draining of the swamp and now may not be as suitable for MVEV transmission.

The results further indicate that MVEV is endemic as far south as Tennant Creek, and that high levels of activity in the Top End are not necessarily a prerequisite for activity in the semi-arid areas south to Tennant Creek.

KUNV activity occurred in the Top End, with seroconversions to KUNV being detected in the Howard Springs flock in January, and a flavivirus only indication in the Howard Springs flock, and the Coastal Plains flock in June 2010. The sentinel chicken flavivirus only seroconversion in Howard Springs in June 2010 later seroconverted to KUNV in 2010–11. There was a case of KUN encephalitis in the Darwin rural area in June 2010. Health warnings were issued in March and April and after the KUN encephalitis case. This is one of the rare instances of KUN encephalitis, and was reported in the *Northern Territory Disease Control Bulletin*.[14]

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, Mid West 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 enzyme-linked immunosorbent assay.[15]

Rainfall prior to commencement of the 2009–10 wet season was generally below average in northern Western Australia. Thunderstorms and tropical cyclones (Tropical Cyclone Laurence and Tropical Cyclone Magna) caused above average rainfall in the north from November to January, and temperatures were warmer than usual. Warm dry conditions prevailed in February and March. Heavy rainfall returned to the north in April, and the wet, warm conditions continued into May.

A total of 3,941 serum samples from 30 flocks (including one new flock at One Arm Point near Lombadina) were tested for antibodies to flaviviruses during 2009–10.[16] Seroconversions to flaviviruses were detected in just 16 (0.4%) samples. One KUNV seroconversion was detected at Lombadina in July, 1 MVEV seroconversion at the Harding Dam flock in August, and 1 MVEV seroconversion at Tom Price in August was associated with activity extending from the 2008–09 wet season.

The first activity associated with the 2009–10 wet season occurred in February 2010, when KUNV was detected at Halls Creek in the south-east Kimberley region. Flavivirus activity was subsequently detected in the north-east Kimberley region (1 MVEV and 1 KUNV infection) and Lombadina in the West Kimberley region (5 MVEV infections) in May 2010. Overall, 13 seroconversions were detected through to July 2010. The level of MVEV and KUNV activity in sentinel chickens was substantially lower than the previous season, which was one of the highest on record for flavivirus activity. No flavivirus cases were reported in Western Australia during 2009–10.

The Western Australian Department of Health issued three media statements. The first was released on 24 August 2009, following continuing detections of MVEV and KUNV in sentinel chickens in the Pilbara region (associated with continued activity from the 2008–09 season). The second media statement was issued on 8 April 2010 after KUNV was detected in sentinel chickens in the Kimberley region for the first time in the 2009–10 wet season. The third media release was released on 9 June 2010

after MVEV was detected in sentinel chickens in the Kimberley region, representing the first evidence of MVEV activity in Western Australia for the 2009–10 season.[15,16]

New South Wales

The New South Wales Arbovirus Surveillance and Mosquito Monitoring program at the Institute of Clinical Pathology and Medical Research undertakes the New South Wales sentinel chicken program. The 2009–10 season began on 1 November 2009 with the first bleed and ended on 14 April 2010 with the last. A total of 2,133 samples were received from 7 sentinel chicken flocks in New South Wales during this period in 2009–10. The sentinel chicken flocks were located at Bourke, Deniliquin, Forbes, Griffith, Leeton, Macquarie Marshes and Menindee (Map). There were no seroconversions to MVEV or KUNV (personal communication: Stephen Doggett, New South Wales Health). A description of the bleeding method of the chickens and the testing regime is outlined in the 2003–04 New South Wales Arbovirus Surveillance Program annual report.[17]

Victoria

The Victorian sentinel chicken program is undertaken by the Department of Primary Industries on behalf of the Department of Health. For the period 1 July 2009 to 30 June 2010 sentinel chickens were placed at 10 locations along the Murray River and monitored from November 2009 to April 2010. Blood samples were collected weekly and tested for the presence of flavivirus antibodies. A total of 3,521 individual sentinel chicken samples were received and no samples were confirmed positive for flavivirus antibodies (personal communication: Rod Moran, Victorian Government Department of Health).

South Australia

Sentinel chicken flocks at Blewitt Springs, Murray Bridge and Paringa were screened twice for MVE and KUNV by the Department of Primary Industries South Australia in conjunction with the Department of Health and pathology services. No seroconversions to either virus were detected.[3]

Malaria

Malaria is a serious acute febrile illness that is normally transmitted from person to person through the bite of an infected mosquito. It is caused by a protozoan parasite called *Plasmodium* that includes 4 species that infect humans – *vivax, falciparum*, *malariae* and *ovale*.[18] A 5th species, *Plasmodium knowlesi* has been recently identified as a cause of human malaria occurring predominantly in South East Asia. Infection with this primate malaria has the potential of being fatal if treatment is not given early in the course of an infection.[19]

There were 429 notifications of overseas-acquired malaria during the season 2009–10, representing a rate of 2.0 per 100,000 population (Table 1). This was a decrease when compared with the mean rate of the previous 5 years of 3.1 per 100,000 population. There were no reports of locally-acquired malaria. The last Australian outbreak of locally-acquired malaria occurred in the Torres Strait (Saibai Island) in May 2004 where 3 cases of *P. falciparum* infection were reported.[20] The last outbreak of locally-acquired malaria on the Australian mainland occurred in north Queensland during 2002.[21]

The age group most affected was the 25–29 year age group with 65 notified cases. Approximately two-thirds of the 429 notified cases were male (70%), which was consistent with previous years. Cases were reported in all jurisdictions. No deaths from malaria were reported during the 2009–10 season.

The infecting *Plasmodium* species was reported for 98% of malaria notifications during the 2009–10 season (Table 4). *P. falciparum* and *P. vivax* were the predominant species. New South Wales notified 1 overseas-acquired case of *P. knowlesi* during the 2009–10 season. The infection was acquired in Indonesian Borneo. A man in his 30s attended a suburban hospital in Sydney, New South Wales, with a 2-week history of morning fevers and mild headaches. His symptoms started 13 days after he left Indonesian Borneo (Kalimantan). He had spent an average of 10 days per month for the past 18 months working adjacent to a forest area in South Kalimantan Province, Indonesian Borneo. The most recent visit was toward the end of the rainy season. He did not use any personal protection measures (mosquito nets, long clothing, insect repellent) or malaria chemoprophylaxis. He did not travel to any other malaria-endemic areas during this 18-month period. He was treated with atovaquone/proguanil for 3 days and the fever resolved and his platelet count returned to the reference level within 48 hours. He did not show any complications.

The country of acquisition of infection was available for 240 (56%) cases of malaria reported to NNDSS (Table 5). Papua New Guinea was identified as the place of acquisition for 84 (20%) cases and included both *P. falciparum* and *P. vivax* species. Thirty six other destinations were identified as a place of acquisition, including India (42), Ghana (12) and Uganda (12).

Table 4: Overseas-acquired malaria cases, Australia, 1 July 2009 to 30 June 2010, *Plasmodium* species, by state or territory

Plasmodium species	State or territory									Type (%)
	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Aust	
Plasmodium falciparum	2	45	2	56	10	3	28	40	186	43
Plasmodium vivax	1	30	10	71	10	0	59	24	205	48
Other *Plasmodium* species	0	6	0	4	1	0	6	5	22	5
Mixed *Plasmodium* species	0	2	1	0	0	0	1	5	9	2
Plasmodium species	0	1	0	3	2	0	0	1	7	2
Total	3	84	13	134	23	3	94	75	429	100

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

Table 5: Overseas-acquired malaria cases, Australia, 1 July 2009 to 30 June 2010, by country of acquisition and *Plasmodium* species

Country of acquisition	Total cases	*Plasmodium* species				
		Not specified	falciparum	vivax	Mixed *Plasmodium* species	Other species
Papua New Guinea	84	3	24	56	1	0
India	42	0	1	41	0	0
Ghana	12	0	9	1	0	2
Uganda	12	0	9	0	0	3
Other country	90	0	51	32	3	4
Country not listed	189	4	92	75	5	13
Total	429	7	186	205	9	22

Arbovirus infection (NEC)

The category includes notifications of arbovirus infections not elsewhere classified (NEC). There were 14 notifications in this category during the 2009–10 season, which was similar when compared with the previous 5 years. Queensland (9) the Northern Territory (3) and Victoria (2) accounted for all notified cases.

Other surveillance and research activities

National Arbovirus Monitoring Program

The National Arbovirus Monitoring Program (NAMP) monitors the distribution of economically important arboviruses of livestock and their vectors in Australia. Important arboviruses include blue-tongue virus, Akabane virus and bovine ephemeral fever virus (BEFV) and are further described in the NAMP 2009–2010 annual report.[22]

Northern Australia Quarantine Strategy

The Australian Quarantine and Inspection Service (AQIS) Northern Australia Quarantine Strategy (NAQS) continues to undertake limited surveillance for the presence of JEV in the Torres Strait and mainland Australia. A sentinel pig herd at Injinoo airport near Bamaga in Cape York, Queensland has not shown any serological evidence of mainland presence since early 2004.[23]

Torres Strait Aedes 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.[24] If this mosquito establishes in mainland Australia, it will increase the number and extent of mosquitoes capable of transmitting dengue and chikungunya, as well as becoming a new serious pest mosquito. Since 2005, the Australian Government provided funding to Queensland Health towards a mosquito elimination program in the Torres Strait. The initial aim of the program was to eliminate *Ae. albopictus* from the Torres Strait islands. The development and implementation of a program based on the 'cordon sanitaire' approach (a barrier designed to prevent a disease or other undesirable condition from spreading) around Thursday and Horn islands

was initiated in May 2008 in an attempt to prevent the spread of *Ae. albopictus* further south, following unsuccessful attempts to eliminate *Ae. albopictus* from the outer islands of the Torres Strait.[25] Multiple incursions of *Ae. albopictus* into the Torres Strait had likely occurred and resulted from human activity or traffic moving these mosquitoes around the Torres Strait. In May 2009, the Australian Government agreed to provide further funding to Queensland Health over 4 years to continue support towards the Torres Strait Health Protection Strategy mosquito program.[26] The focus of the program is surveillance and control of *Ae. albopictus* in the Torres Strait and prevention of the spread of *Ae. albopictus* from the Torres Strait to mainland Australia.

Discussion

This report summarises the surveillance of nationally notifiable mosquito-borne disease in Australia for the season 1 July 2009 to 30 June 2010.

Australia recorded its first overseas-acquired case of *Plasmodium knowlesi* this year. *P. knowlesi* is now established as the fifth *Plasmodium* species to cause malaria in humans. Given the case history, clinicians should now consider the possibility of infection with *P. knowlesi* in patients who have acquired malaria in forest areas of South East Asia.[27]

The 2009–10 dengue fever season, when there were 37 locally-acquired notified cases, was comparatively mild compared with the 2008–09 season. In 2008–09, outbreaks of all 4 serotypes affected several locations with over 1,000 dengue cases in a short period and represented the largest reported annual number of cases in recent times.[28,29]

Much of the increase in overseas-acquired DENV infections over the past few years can be attributed to an increase in disease activity in the Asia/Pacific region as well as increased travel by Australians to some destinations in South East Asia. Dengue is the most rapidly increasing mosquito-borne viral disease in the world. The *Dengue Strategic Plan for the Asia Pacific Region (2008–2015)*[30] (The Strategic Plan) has been prepared by the WHO Regional Offices for South East Asia and the Western Pacific to respond to the increasing threat from dengue, which is spreading to new geographical areas in Member countries of the South-East Asia and the Western Pacific regions. The Strategic Plan provides a framework for national plans and is used to mobilise resources where they are needed. The NAMAC reviewed and endorsed this plan.

The Strategic Plan provides generic recommendations to allow its local adaptation. Effective dengue control is not possible if control efforts are limited to one country or a few countries. It requires the adoption of a regional approach through collaboration among countries and sustained partnerships to enable countries to implement evidence-based interventions and the use of best practices.[30]

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

MVEV and KUNV activity was detected in the sentinel chicken flocks in northern Western Australia and the Northern Territory. This led to public health media releases in both jurisdictions, which warned the public of potential infection and other prevention strategies.

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 2009 NNDSS annual report.[1] A specific limitation of the data used in this report relates to the virological testing, which is required to distinguish alphavirus disease from other causes of arthritis. The alphavirus infections notified to NNDSS each season are based on laboratory definitive evidence only and assumes a clinically compatible arthritic infection. A case can still be notified when clinical illness may not be consistent with the diagnosis of alphavirus infection. Furthermore, false positive reactions are an issue in the serological diagnosis of some arboviral infections and cross-reacting IgM can occur, particularly with flavivirus infections.[31] Human surveillance for alphavirus infection enables local authorities to implement public health action and manage local disease outbreaks, but does not necessarily provide a reliable indication of the true incidence of a disease.

Another limitation of surveillance data of this report relates to place or country of acquisition of infection. This information is currently not available for South Australian notifications to NNDSS.

NAMAC provides advice on the strategic approaches to the management of arbovirus diseases and malaria, which continue to pose significant challenges to Australia and the region. This report describes the activities resulting from notified cases of human infections to health authorities and sentinel animal activities for the early detection of serious disease threats. Public Health authorities recognise the importance of vigilance in the surveillance of these diseases, which enables the rapid detection and response to the threat of arborviral disease and malaria.

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References

1. Office of Health Protection. Australia's notifiable disease status, 2009: annual report of the National Notifiable Diseases Surveillance System. *Commun Dis Intell* 2009;33(2):89–154.
2. Russell RC, Dwyer DE. Arboviruses associated with human disease in Australia. *Microbes Infect* 2000;2(14):1693–1704.
3. Williams C. 2009–10: a season of enhanced surveillance, virus detection in mosquitoes and formal intelligence reports to the Health Department. Adelaide: Sansom Institute, University of South Australia; 2011.
4. Parida MM, Santhosh SR, Dash PK, Lakshmana Rao PV. Rapid and real-time assays for detection and quantification of chikungunya virus. *Future Virol* 2008;3(2):179–192.
5. Harrington S, Lindsay MD, Douglas A. Christmas Island and Cocos (Keeling) Islands, Indian Ocean: Mosquito fauna and mosquito-borne disease risk assessment and management recommendations. FINAL REPORT of investigations undertaken in 2007–08: Public Health Division, Western Australian Department of Health; 2009.
6. van den Hurk AF, Hall-Mendelin S, Pyke AT, Smith GA, Mackenzie JS. Vector competence of Australian mosquitoes for chikungunya virus. *Vector Borne Zoonotic Dis* 2010;10(5):489–495.
7. Australian Technical Advisory Group on Immunisation. *The Australian Immunisation Handbook* 9th edn. Canberra, Australia: National Health and Medical Research Council; 2008.
8. Hanna JN, Ritchie SA, Richards AR, Humphreys JL, Montgomery BL, Ehlers GJ, et al. Dengue in north Queensland, 2005–2008. *Commun Dis Intell* 2009;33(2):198–203.
9. Queensland Health. Dengue Fever Management Plan for North Queensland 2005–2010 Cairns, Queensland: Tropical Public Health Unit Network, Queensland Health; 2005.
10. Hanna JN, Ritchie SA, Phillips DA, Lee JM, Hills SL, van den Hurk AF, et al. Japanese encephalitis in north Queensland, Australia, 1998. *Med J Aust* 1999;170(11):533–536.
11. Broom AK, Azuolas J, Hueston L, Mackenzie JS, Melville L, Smith DW, et al. Australian encephalitis: Sentinel Chicken Surveillance Programme. *Commun Dis Intell* 2001;25(3):157–160.
12. Broom AK. Sentinel Chicken Surveillance Program in Australia, July 2002 to June 2003. *Commun Dis Intell* 2003;27(3):367–369.
13. Kurucz N, Whelan PI, Jacups SP, AK B, Melville LF. Rainfall, mosquito vector numbers and seroconversions in sentinel chickens to Murray Valley encephalitis virus in the Northern Territory. In: *Arbovirus Research in Australia:* 2005. pp. 188–192.
14. Kurucz N, Gray TJ, Burrow J, Whelan P. A confirmed case of Kunjin virus disease encephalitis acquired in rural Darwin, NT--The mosquito story. *The Northern Territory Disease Control Bulletin* 2010;17(4):5–10.
15. Hall RA, Broom AK, Harnett AC, Howard MJ, Mackenzie JS. Immunodominant epitopes on the NS1 protein of MVE and KUN viruses serve as targets for a blocking ELISA to detect virus-specific antibodies in sentinel animal serum. *J Virol Methods* 1995;51(2–3):201–210.
16. Johansen C, McFall S, Wong S, Avery V, Cashen C, Wallace M, et al. The University of Western Australia Arbovirus Surveillance and Research Laboratory Annual Report: 2009–2010: Discipline of Microbiology and Immunology, The University of Western Australia; 2010.
17. Doggett S, Clancy J, Haniotis J, Russell R, Hueston L, Marchetti M, et al. The New South Wales Arbovirus Surveillance and Mosquito Monitoring Program 2003–2004 Annual Report: Medical Entomology Department, Institute of Clinical Pathology and Medical Research, University of Sydney and Westmead Hospital; 2004.
18. Heymann D, ed. *Control of Communicable Diseases Manual.* 18th edn. Washington: American Public Health Association; 2004.
19. Cox-Singh J, Davis TM, Lee KS, Shamsul SS, Matusop A, Ratnam S, et al. *Plasmodium knowlesi* malaria in humans is widely distributed and potentially life threatening. *Clin Infect Dis* 2008;46(2):165–171.
20. Sweeny A, Beard F. Queensland Health Notifiable Diseases Report 2002–2006. Brisbane: Communicable Diseases Branch, Brisbane: Queensland Health; 2009
21. Hanna JN, Ritchie SA, Eisen DP, Cooper RD, Brookes DL, Montgomery BL. An outbreak of *Plasmodium vivax* malaria in Far North Queensland, 2002. *Med J Aust* 2004;180(1):24–28.

22. Animal Health Australia. National Arbovirus Monitoring Program Annual Report 2008–2009. Canberra: Animal Health Australia; 2010.

23. Animal Health Australia. Animal Health in Australia 2008. Canberra, Australia; 2009.

24. Ritchie SA, Moore P, Carruthers M, Williams C, Montgomery B, Foley P, et al. Discovery of a widespread infestation of *Aedes albopictus* in the Torres Strait, Australia. *J Am Mosq Control Assoc* 2006;22(3):358–365.

25. Queensland Health. *Aedes albopictus* elimination program in the Torres Strait: Report for the period 1 July 2007–30 June 2008; 2009.

26. Australian Government Department of Health and Ageing. Portfolio budget statements 2009–10: Budget related paper No. 1.10; 2009.

27. Figtree M, Lee R, Bain L, Kennedy T, Mackertich S, Urban M, et al. *Plasmodium knowlesi* in Human, Indonesian Borneo. *Emerg Infect Dis* 2010;16(4):672–674.

28. Hanna JN, Ritchie SA. Outbreaks of dengue in north Queensland, 1990–2008. *Commun Dis Intell* 2009;33(1):32–33.

29. Hanna JN, Ritchie SA, Hills SL, Pyke AT, Montgomery BL, Richards AR, et al. Dengue in north Queensland, 2002. *Commun Dis Intell* 2003;27(3):384–389.

30. Regional Office for South-East Asia and the Western Pacific WHO. The Dengue Strategic Plan for the Asia Pacific Region, 2008–2015. New Delhi; 2008.

31. Public Health Laboratory Network laboratory case definition for arbovirus and flavivirus. Accessed on March 2012. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/cda-phlncd-flavivirus.htm