THE NEW SOUTH WALES
ARBOVIRUS SURVEILLANCE &
MOSQUITO MONITORING PROGRAM

2015-2016 Annual Report


Aedes aegypti

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EXECUTIVE OVERVIEW

- **For the 2015-2016 season**, the NSW Arbovirus Surveillance Program: (i) monitored mosquito populations and undertook surveillance of arbovirus activity through virus isolation in the NSW inland, coastal regions and metropolitan Sydney, (ii) monitored flavivirus transmission through the testing of sentinel chickens across inland NSW. Most sites operated between November and April.
- **The climatic conditions** over 2015-2016 involved one of the strongest El Niño episodes to date, which contributed to the minimal rainfall over the season. For the inland rainfall was average to below average for the entire season, with both the Forbes and Nicholls hypotheses not suggestive of a potential MVEV epidemic for the season. For the coast, similar conditions prevailed.
- **For the inland**, only around 38,000 mosquitoes were trapped, around half the previous season. There were only two arboviral detections; 1BFV and 1RRV, with no seroconversions in the sentinel chickens.
- **Human notifications from the inland** of RRV and BFV totalled 264 (261RRV & 3BFV), which was below the long term average of 305. There were no human cases of flavivirus infection reported.
- **As of September 2016**, neither the Forbes nor the Nicholls hypotheses are suggestive of possible MVEV activity for the season of 2016-2017. A weak La Nińa event is forecasted for late 2016 which may result in slightly higher rainfall.
- **For the coast**, the dry conditions resulted in mosquito numbers that were less than half of the previous season. There were only two isolates, including 1BFV and 1EHV.
- **Human notifications from the coast** of RRV and BFV totalled 404 cases, including 353 RRV and 51 BFV, and this was well below average. Many of the RRV notifications occurred during the winter months and were probably related to the record outbreak during early 2015. During the summer of 2016, RRV notifications were well below average. The statistical local areas that produced the highest notifications for RRV included Maclean with 17, with Narromine and Port Macquarie-East each having 12. No SLA had more than 5 BFV notifications.
- **Sydney** also experienced a slight decrease in mosquito numbers with the drier conditions and there were no arboviral isolates from any of the monitoring sites.
- **The NSW Arbovirus Surveillance Web Site** http://medent.usyd.edu.au/arbovirus/ continued to expand and now has over 350MB, and has 2,620+ pages.
- **“*A Guide to Mosquitoes of Australia*”** is a new textbook on mosquitoes produced by staff of Pathology West and was released in March 2016.
- **In 2016, Sydney International Airport** experienced the first detections of exotic mosquitoes. There were a series of detections of the Dengue mosquito, *Aedes aegypti*, through January to March, with a more recent detection in September. Responses included regular teleconferences initiated by the NSW Ministry of Health, enhanced surveillance at the airport, and a vector survey of the Airport to examine for mosquito breeding. There was also one live male Asian Tiger Mosquito, *Aedes albopictus*, collected on 30/Apr/2016 from a flower consignment originating from China. The latter occurred in a quarantine facility and was deemed low risk.

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NSW ARBOVIRUS SURVEILLANCE AND MOSQUITO MONITORING PROGRAM 2015-2016

INTRODUCTION

The aim of the Program is to provide an early warning of the presence of Murray Valley encephalitis virus (MVEV) and Kunjin (KUNV) virus in the state, in an effort to reduce the potential for human disease. In addition, the Program compiles and analyses mosquito and alphavirus, especially Ross River (RRV) and Barmah Forest (BFV), data collected over a number of successive years. This will provide a solid base to determine the underlying causes of the seasonal fluctuations in arbovirus activity and the relative abundance of the mosquito vector species, with the potential to affect the well-being of human communities. This information can then be used as a basis for modifying existing local and regional vector control programs, and creation of new ones.

METHODS

Background

Arbovirus activity within NSW has been defined by the geography of the state, and three broad virogeographical zones are evident: the inland, the tablelands and the coastal strip (Doggett 2004, Doggett and Russell 2005). Within these zones, there are different environmental influences (e.g. irrigation provides a major source of water for mosquito breeding inland, while tidally influenced saltmarshes along the coast are highly productive), different mosquito vectors, different viral reservoir hosts and different mosquito borne viruses (e.g. MVEV and KUNV occur only in the inland, while BFV is active mainly on the coast, and RRV is active in both inland and coastal areas). As a consequence, arboviral disease epidemiology often can be vastly different between regions and thus the surveillance program is tailored around these variables.

Arbovirus surveillance can be divided into two categories: those methods that attempt to predict activity and those that demonstrate viral transmission. Predictive methods include the monitoring of weather patterns, the long-term recording of mosquito abundance, and the isolation of virus from vectors. Monitoring of rainfall patterns, be it short term with rainfall or longer term with the Southern Oscillation, is critical as rainfall is one of the major environmental factors that influences mosquito abundance; in general, with more rain come higher mosquito numbers. The long-term recording of mosquito abundance can establish baseline mosquito levels for a location (i.e. determine what are ‘normal’ populations), and this allows the rapid recognition of unusual mosquito activity. The isolation of virus from mosquito vectors can provide the first indication of which arboviruses are circulating in an area. This may lead to the early recognition of potential outbreaks and be a sign of the disease risks for the community. Virus isolation can also identify new viral incursions, lead to the recognition of new virus genotypes and identify new vectors. Information from vector monitoring can also reinforce and strengthen health warnings of potential arbovirus activity.

Methods that demonstrate arboviral transmission include the monitoring of suitable sentinel animals (such as chickens) for the presence of antibodies to particular viruses (e.g. MVEV and KUNV within NSW), and the recording of human disease notifications. Sentinel animals can be placed into potential ‘hotspots’ of virus activity and, as they are continuously exposed to mosquito bites, can indicate activity in a region before human cases are reported. Seroconversions in sentinel flocks provide evidence that the level of virus in mosquito populations is high enough for transmission to occur.

The monitoring of human cases of arboviral infection usually has little direct value for surveillance, as by the time the virus activity is detected in the human population, often not much can be done to control the viral transmission. Via the other methodologies, the aim of the surveillance program is to recognise both potential and actual virus activity before it impacts greatly on the human population, so that appropriate preventive measures can be implemented. The recording of human infections does, however, provide important epidemiological data and can indicate locations where surveillance should occur.

These methods of surveillance are listed in order; generally, with more rainfall comes more mosquito production; the higher the mosquito production, the greater the probability of enzootic virus activity in the mosquito/host population; the higher the proportion of virus infected hosts and mosquitoes, the greater the probability of transmission and thus the higher the risk to the human population. The NSW Arbovirus Surveillance and Mosquito Monitoring Program undertakes the first four methods of arbovirus surveillance and the results for the 2015-2016 season follow.

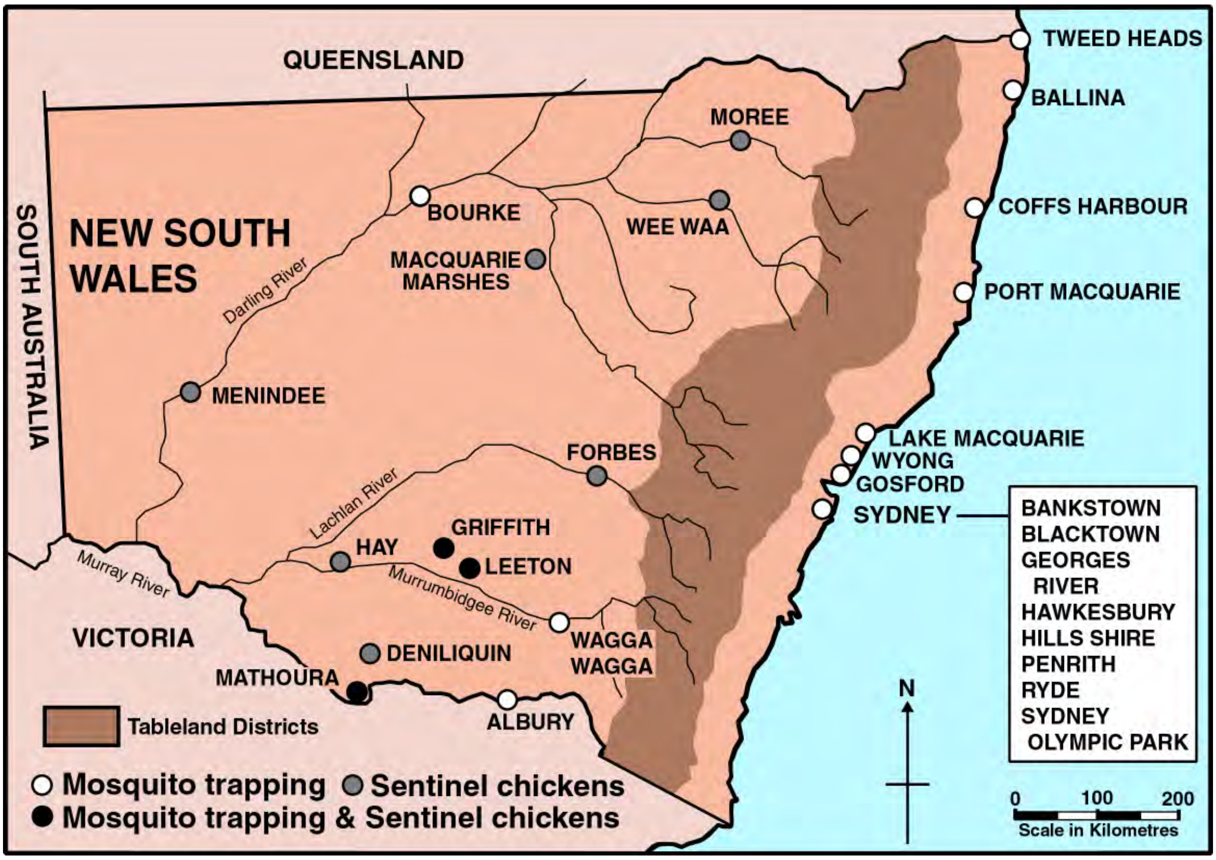


Fig 1. Mosquito trapping locations and Sentinel Chicken sites, 2015-2016.

MONITORING LOCATIONS

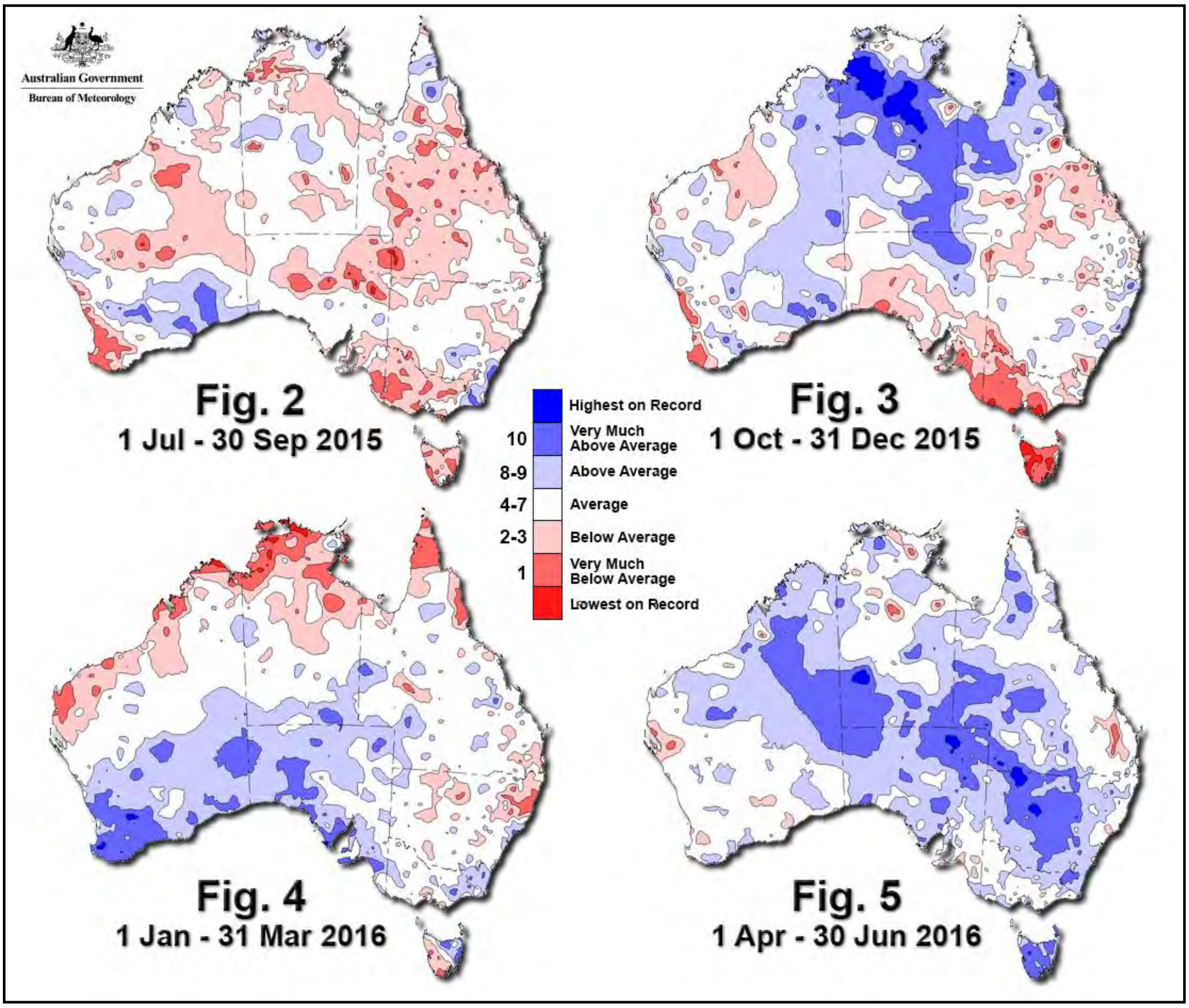
http://medent.usyd.edu.au/arbovirus/location/locations.htm

For 2015-2016, mosquito-trapping sites were operated at 6 inland, 7 coastal and 8 Sydney locations. Chicken sentinel flocks were located at 10 locations (Fig 1).

WEATHER DATA

http://medent.usyd.edu.au/arbovirus/climate/climate.htm

Mosquito abundance is dictated principally by rainfall patterns and irrigation practices in inland regions, while in coastal regions tidal inundation along with rainfall is important. Temperature and/or day-length are often critical in determining the initiation and duration of mosquito activity for species in temperate zones. Hence, the monitoring of environmental parameters, especially rainfall, is a crucial component of the Program.



Figures 2-5. Australian Rainfall deciles for the three month periods, Jul-Sep 2015, Oct-Dec 2015, Jan-Mar 2016 & Apr-Jun 2016. The stronger the red, the drier the conditions. Conversely, the stronger the blue, the wetter the conditions. *Modifed from the Australian Bureau of Meterology, 2016*.

The first quarter of 2015 (January to March) had mostly average rainfall for much of the state. The entire state had above average rainfall throughout the second quarter of 2015 (April to June). The entire state had average to pockets of below average rainfall during the third quarter of 2015 (July to September, Figure 2). The last quarter of 2015 (October to December, Figure 3) was much the same, with mostly average rainfall. Similarly, the first quarter of 2016 (January to March, Figure 4) also produced normal rainfall patterns for most of the state with dry conditions in the north coast. For the second quarter (April to June, Figure 5), rainfall was above to very much above average for the majority of the state.

The 2015-2016 season experienced one of the strongest El Niño episodes to date, which contributed to the minimal rainfall over this period. The El Niño gradually declined during early 2016 and became neutral by mid-year. As of July 2016, the prediction is for a La Niña later in the year, which is typically associated with above average rainfall.

Maximum temperatures for the last half of 2015 were above average by 2-3 degrees, with temperatures well above (4-6^{o}C) average during October and December. January 2016 experience normal temperatures, however for the following months to July, temperatures were 2-4 degrees higher than average.

MVEV Predictive Models

Two main models have been developed for the prediction of MVEV epidemic activity in southeastern Australia: the Forbes (1978) and Nicholls (1986) hypotheses.

Forbes associated rainfall patterns with the 1974 and previous MVEV epidemics, and discussed rainfall in terms of 'decile' values. A decile is a ranking based on historical values. The lowest 10% of all rainfall values constitute decile 1, the next 10% make up decile 2, and so on to the highest 10% of rainfall constituting decile 10. The higher the decile, the greater the rainfall.

The Forbes hypothesis refers to rainfall levels in the catchment basins of the main river systems of eastern Australia. These include:

- The Darling River system,
- The Lachlan, Murrumbidgee & Murray River systems,
- The Northern Rivers (that lead to the Gulf of Carpentaria), and
- The North Lake Eyre system.

The hypothesis states that if rainfall levels in these four catchment basins are equal to or greater than decile 7 for either the last quarter of the previous year (e.g. October-December 2014) or the first quarter of the current year (January-March 2015) <u>and</u> the last quarter of the current year (October-December 2015), then a MVEV outbreak is probable. By comparing the relevant quarterly rainfall amounts with historical decile 7 years, it is possible to obtain a ratio; a figure of 1 or greater indicates that rainfall was above the historical decile 7 average (Table 1). Rainfall was below decile 7 for all but one of the catchment basins for the last quarter of 2014, was above decile 7 in only one catchment basin in the first quarter of 2015, and above decile 7 in only two of the catchment basins for the last quarter of 2015, thus the Forbes hypothesis was not fulfilled for 2014-2015 (Table 1). Additionally, decile 7 or above rainfall did not occur across all the catchment basins during the first quarter of 2016, therefore according to Forbes', there should be a lower risk of an MVEV epidemic for the upcoming 2016-2017 season.

Table 1. Rainfall indices for the main catchment basins of eastern Australia as per Forbes hypothesis, relevant to the 2014-2015 and 2015-2016 seasons.

Catchment Basin	Oct-Dec 2014	Jan-Mar 2015	Oct-Dec 2015	Jan-Mar 2016
Darling River	0.80	0.65	0.72	0.67
Lachlan/Murrumbidgee/ Murray Rivers	0.97	1.05	0.70	1.14
Northern Rivers	0.94	0.67	1.35	0.57
North Lake Eyre system	1.07	0.67	1.35	0.63

The Nicholls hypothesis uses the Southern Oscillation (SO) as a tool to indicate a possible MVEV epidemic. Typically atmospheric pressures across the Pacific Ocean tend to be low on one side of the ocean and high on the other. This pattern then oscillates from year to year. Nicholls noted a correlation between past outbreaks of MVEV and the SO (as measured by atmospheric pressures at Darwin) for the autumn, winter and spring period prior to a disease outbreak. For the autumn, winter and spring periods of 2015, the SO values were respectively: 1010.83mm, 1014.37mm and 1014.57mm (indicated on Figure 6 by the yellow arrows and Table 2). The graph on the right has been modified (i.e. updated) to include those MVEV active years between 2000 and 2012 (added to the MVEV tallied black columns), and includes the values for the years 2000-2001, 2007-2008, 2010-2011 and 2011-2012. The SO values leading up to the 2003-2004 season were not included as there was only one detection of MVEV, which may have resulted from over-wintering mosquitoes.

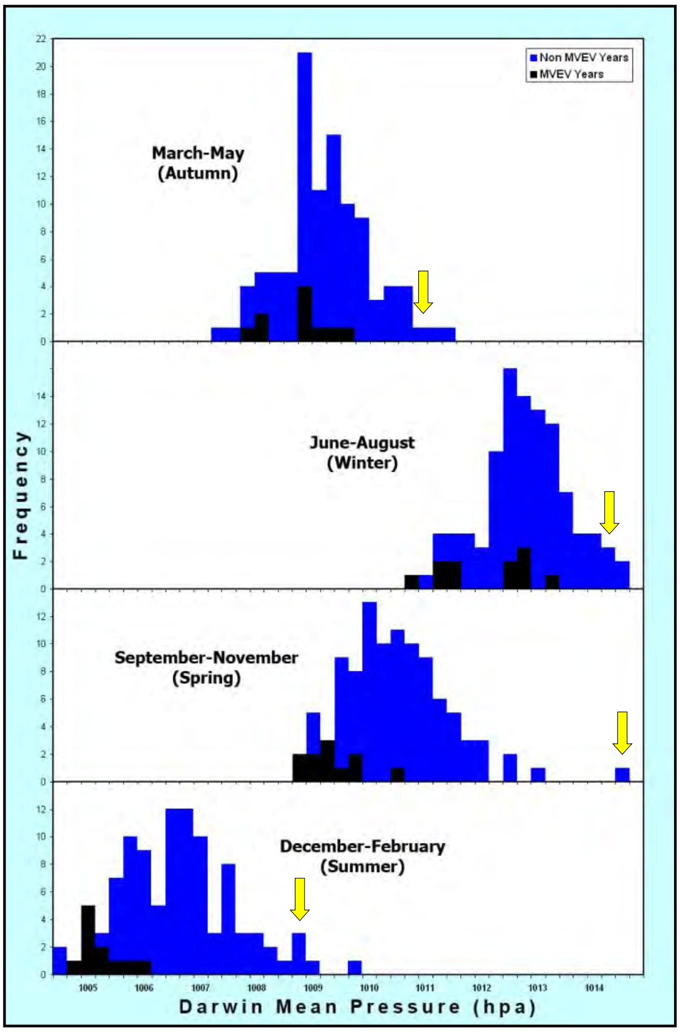


Figure 6. The SO by seasons prior to MVEV active years, according to Nicholls (1986), updated up to Spring 2015. The black bars represent the pre-MVEV active seasons. The yellow arrows indicate the respective SO values relevant to the 2015-2016 season.

As of September 2016, the autumn Nicholls' value is 1010.30mm and the winter value is 1012.57 (Table 2). Only the Winter values are within the range of values during past MVEV outbreak years, suggesting a reduced risk for 2016-2017.

Table 2. The seasonal atmospheric pressures (in mm) according to Nicholls' hypothesis, relevant to the 2016-2017 season.

	Autumn 2016	Winter 2016*	Spring 2016*
2016 Values	1010.30	1012.57	
Pre past MVEV seasons	<1009.74	<1012.99	<1009.99

*Data for Jun/16 only

It is important to note that the Forbes hypothesis was calculated on environmental conditions experienced during major MVEV epidemic seasons and the models do not propose to predict low to moderate level activity. Thus, negative MVEV models do not necessarily indicate an absence of MVEV activity. Also, these climatic based models do not take into account unusual environmental conditions such those experienced during the summer of 2008, whereby a low pressure cell that began in northern Australia moved through to the south and possibly facilitated the movement of MVEV into NSW (Finlaison *et al*., 2008). A similar phenomenon may have occurred during the 2010-11 season, whereby a low pressure cell that formed from Tropical Cyclone Yasi and moved into Victoria bringing intense rainfall, coincided with major MVEV and KUNV activity (Doggett *et al*. 2011). Nor do these models take into account virus existing in cryptic foci in south-eastern Australia.

MOSQUITO MONITORING

Methods

Mosquitoes were collected overnight in dry-ice baited Encephalitis Vector Surveillance (EVS) type traps. They were then sent live in cool, humid Eskies via overnight couriers to the Department of Medical Entomology, Institute of Clinical Pathology and Medical Research (ICPMR), Pathology West, Westmead, for identification and processing for arbovirus isolation. The mosquitoes were identified via taxonomic keys and illustrations according to Russell (1993, 1996), Dobrotworsky (1965) and Lee *et al*. (1980 – 1989). A brief description of the main mosquito species for NSW appears in Appendix 2.

Mosquito abundances are best described in relative terms, and in keeping with the terminology from previous reports, mosquito numbers are depicted as:

- 'low' (<50 per trap),
- 'moderate' (50-100 per trap),
- 'high' (101-1,000 per trap),
- 'very high' (>1,000 per trap), and
- 'extreme' (>10,000 per trap).

All mosquito monitoring results (with comments on the collections) were placed on the NSW Arbovirus Surveillance Web site, and generally were available within 1-2 days of sample receipt into the laboratory. Access to each location's result is from: **http://medent.usyd.edu.au/arbovirus/results/results.htm**.

Results

Overall, 108,663 mosquitoes representing 57 species were collected in NSW during 2015-2016, which was around half the previous season. *Culex annulirostris* was the most abundant and most important of the inland mosquito species during the summer months, whereas *Aedes vigilax*, *Culex sitiens, Aedes notoscriptus*, *Culex annulirostris, Coquillettidia linealis*, *Aedes procax*, and *Verrallina funerea* were the most numerous species on the coast. A full summary of the results on a location-by-location basis is included in Appendix 1 and the complete mosquito monitoring results are available on the NSW Arbovirus Surveillance web site. A brief description of the most important vectors is provided in Appendix 2.

Inland

The total of 37,615 mosquitoes comprising 20 species less than half the previous season total of 88,111 trapped in 2014-2015. *Culex annulirostris* was the dominant species yielded at most sites and comprised 58.1% of the total inland collections. *Anopheles annulipes* (36.0%) was the next most common species.

Coastal

In total, 30,101 mosquitoes comprising 41 species were collected from coastal NSW and this was less than half the previous season's collection. The most common species collected were *Culex sitiens* (21.9%), *Aedes multiplex* (16.7%), *Aedes notoscriptus* (12.6%), *Verrallina funerea* (12.1%), *Culex orbostiensis* (6.3%), *Culex annulirostris* (4.8%), and *Aedes vigilax* (3.9%). For most years, *Aedes vigilax* is usually by far the most predominant species and generally comprises 50-60% of the coastal collections, however in recent years collections of this species have dropped dramatically.

Metropolitan Sydney

A total of 40,947 mosquitoes, comprising 34 species, was collected from metropolitan Sydney and this was slightly down upon the previous season's total collection. *Aedes vigilax* (47.5% of the total Sydney mosquitoes trapped) was the most common species, followed by *Culex annulirostris* (13.9%), *Aedes notoscriptus* (9.6%), *Coquillettidia linealis* (5.9%), and *Culex sitiens* (5.4%).

ARBOVIRUS ISOLATIONS FROM MOSQUITOES

http://medent.usyd.edu.au/arbovirus/about/methods.htm

Methods

Viral detection now incorporates both traditional cell culture methodology and modern molecular techniques for identifying viral nucleic acid. Cell culture isolation methods were as per earlier annual reports (Doggett *et al*., 1999, 2001). ELISA assays were used to identify any suspected viral isolate and can identify the alphaviruses - BFV, RRV and Sindbis (SINV), and the flaviviruses - MVEV, KUNV, Alfuy (ALFV), Edge Hill (EHV), Kokobera (KOKV) and Stratford (STRV). Any isolate that was not identified by the assays was labelled as 'unknown'.

For viral nucleic acid detection through molecular analysis from the mosquito grinds, the homogenates were screened for alpha (BFV, RRV and SINV), and flaviviruses (MVEV, KUNV, EHV KOKV and STRV) by means of a suite of targeted multiplexed, real-time RT-PCR assays using a high saturating fluorescent dye. Viral RNA was extracted using the EZ1® Virus Mini Kit (Qiagen), reverse transcribed, and amplified on the Corbett™ Rotor-Gene 6000.

In numerous locations across the state as part of an ongoing evaluation in surveillance technologies, honey-soaked FTA® cards (Flinders Technology Associates filter paper) were placed in the EVS traps (see discussion in greater detail below). Captured mosquitoes were tested for arboviruses as above, while for the FTA cards, viral RNA was extracted from the FTA card eluates and tested by real-time RT-PCR using Pan-Flavivirus (Moureau G*, et al.* 2007, Hall-Mendelin *et al.* 2010) and Alphavirus primers. Amplified products were definitively identified by targeted multiplex RT-PCR.

A short description of the various viruses and their clinical significance is detailed in Appendix 3. Positive results were sent to Dr Jeremy McAnulty, Director, Communicable Diseases Branch, NSW Health, to the relevant Public Health Unit, and posted on the NSW Arbovirus Surveillance Web Site (under 'Mosquito/Chicken Results', and under each location's surveillance results).

Results

http://medent.usyd.edu.au/arbovirus/results/virusisolates.htm

From the mosquitoes processed, there were four arboviral detections; two each from the inland and the coast (Table 3).

Table 3. Arbovirus isolates from NSW, 2015-2016.

LOCATION - Site	Date Trapped	Mosquito Species	Virus
GRIFFITH – Hanwood	1/Feb/16	*Culex annulirostris*	BFV
PORT MACQUARIE – Stevens St	8/Feb/16	*	EHV
LEETON – Farm 347	1/Mar/16	*Culex annulirostris*	RRV
WYONG – Ourimbah	31/Mar/16	*	BFV

*Detection via Honey-Baited Cards, the mosquito species cannot be determined. BFV = Barmah Forest virus, RRV = Ross River virus, EHV = Edge Hill virus,

SENTINEL CHICKEN PROGRAM

http://medent.usyd.edu.au/arbovirus/results/chicken_results_all_sites.htm

Location of flocks

The 2015-2016 season began on 1st November 2015 with the first bleed and ended on 18th April 2016 with the last. A total of ten flocks each containing up to 15 Isa Brown pullets was deployed, with one flock each at Deniliquin, Forbes, Griffith, Hay, Leeton, Macquarie Marshes, Menindee, Moama (near Mathoura), Moree, and Wee Waa (Figure 1).

Methods

The NSW Chicken Sentinel Program was approved by the Western Sydney Local Health Network Animal Ethics committee. This approval requires that the chicken handlers undergo training to ensure the chickens are cared for appropriately and that blood sampling is conducted in a manner that minimises trauma to the chickens. The chickens are cared for and bled by local council staff and members of the public. Laboratory staff are responsible for training the chicken handlers. A veterinarian (usually the Director of Animal Care at Westmead) must inspect all new flock locations prior to deployment to ensure animal housing is adequate. Existing flocks are inspected approximately every two years. The health of each flock is reported weekly, and is independently monitored by the Animal Ethics Committee via the Director of Animal Care.

Full details of the bleeding method and laboratory testing regimen were detailed in the 2003-2004 NSW Arbovirus Surveillance Program Annual Report (Doggett *et al*. 2004).

Results are disseminated via email to the relevant government groups as determined by NSW Health and are placed on the NSW Arbovirus Surveillance website. Confirmed positives are notified by telephone to NSW Health and Communicable Diseases Network, Australia.

Results

The season began with 165 pullets and unfortunately the flock at Mathoura was attacked by fox, killing all birds, which prompted the withdrawal of the site from the program. A total of 2,353 samples was received from the ten flocks in NSW over the six-month period in 2015-2016. This represented 4,706 ELISA tests (excluding controls and quality assurance samples), with each specimen being tested for MVEV and KUNV antibodies. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

NOTIFICATIONS OF LOCALLY-ACQUIRED ARBOVIRUS INFECTIONS

All arboviral infections are notifiable under the NSW Public Health Act 2010. When a person tests positive for an arboviral infection pathology laboratories notify public health authorities who assess the notification against agreed surveillance case definitions and take appropriate actions using NSW Health disease control guidelines.

The two most common locally-acquired arbovirus infections notified in NSW are infections with Ross River virus (RRV) and Barmah Forest virus (BFV). When reviewing the historical notifications data for these two diseases it is important to note that there have been changes in the surveillance case definitions for both diseases since national surveillance case definitions were first introduced in 2004.

From 1 January 2013, the national surveillance case definitions for RRV and BFV infection were made more specific as it was noted that the cross-reactivity of the serological markers used for each disease had led to a significant numbers of dual notifications. From 1 January 2016, the case definitions were updated again so that a single IgM positive serology result would no longer meet the case definition for either infection, further reducing the likelihood of false positive notifications. There have also been changes in laboratory testing practices which may have affected the likelihood of true cases being identified and false cases being excluded, such as the withdrawal of one relatively non-specific BFV commercial testing product noted in the 2014-2015 annual report.

In the 2015-2016 financial year there were 679 notifications of RRV infection and 59 notifications of BFV infection in NSW residents, which were notable decreases compared to the 2014-2015 financial year for both RRV (1620 notifications) and BFV (189 notifications). There were no notifications of other arbovirus infections acquired in NSW during 2015-2016.

Table 4. Barmah Forest virus and Ross River virus infections in NSW residents: notifications and population notification rates* by local health district for the 2015-2016 financial year.

Local Health District	Barmah Forest virus		Ross River virus	
	Notifications	Population Rate*	Notifications	Population Rate*
Central Coast	0	0.00	18	5.35
Far West	0	0.00	12	39.14
Hunter New England	7	0.77	194	21.24
Illawarra Shoalhaven	1	0.25	13	3.24
Mid North Coast	14	6.48	71	32.85
Murrumbidgee	3	1.03	93	31.93
Nepean Blue Mountains	1	0.27	25	6.74
Northern NSW	26	8.71	97	32.49
Northern Sydney	0	0.00	11	1.22
South Eastern Sydney	1	0.11	15	1.67
South Western Sydney	0	0.00	4	0.42
Southern NSW	3	1.45	16	7.74
Sydney	1	0.16	4	0.64
Western NSW	2	0.72	99	35.61
Western Sydney	0	0.00	7	0.75
Total	**59**	**0.76**	**679**	**8.86**

* Notifications per 100,000 estimated resident population, based on ABS population estimates. Population projections by the Centre for Epidemiology and Evidence, NSW Ministry of Health, based on data from the NSW Department of Planning and Environment.

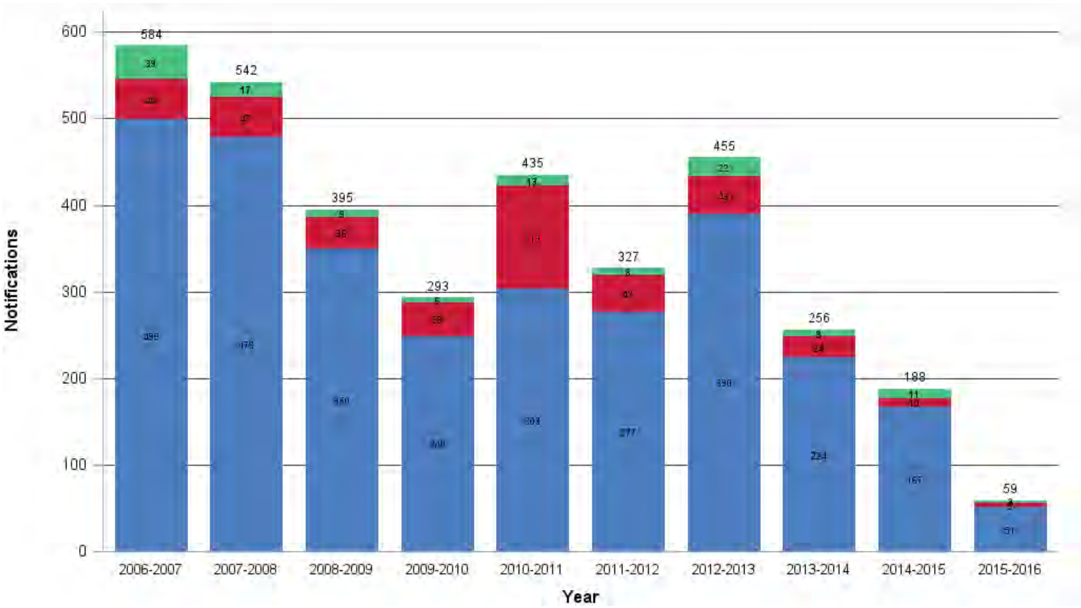
Arboviral notifications by place of residence of the case are presented by NSW local health district (LHD), by geographic region (Coastal, Inland, and Sydney metropolitan) and by Australian Bureau of Statistics (ABS) statistical area level 2 (SA2). Population rates are based on ABS estimated resident population data. It should be noted that the place of residence of a case may not be where the infection was acquired.

Notifications of BFV and RRV infection by LHD are shown in Table A. The highest number of notifications and highest population notification rates for BFV infection were in the Northern NSW and Mid North Coast LHDs, with few notifications in other LHDs.

RRV notifications were highest in the Hunter New England and Western NSW LHDs, while RRV population notification rates were highest in Far West LHD and Western NSW, and also high along the north coast (Hunter New England, Mid North Coast and Northern NSW LHDs) and in the Murrumbidgee LHD in the south.

Notifications of BFV and RRV infection by geographic region (Coastal, Inland, and Sydney metropolitan) of residence are shown in Figures 7 and 8 respectively by financial year of disease onset from 2006-2007 to 2015-2016. The Coastal region again accounted for the majority of BFV notifications (n=51, 86.4%) with only 8 notifications reported in residents of Sydney and the Inland region (Figure 7).

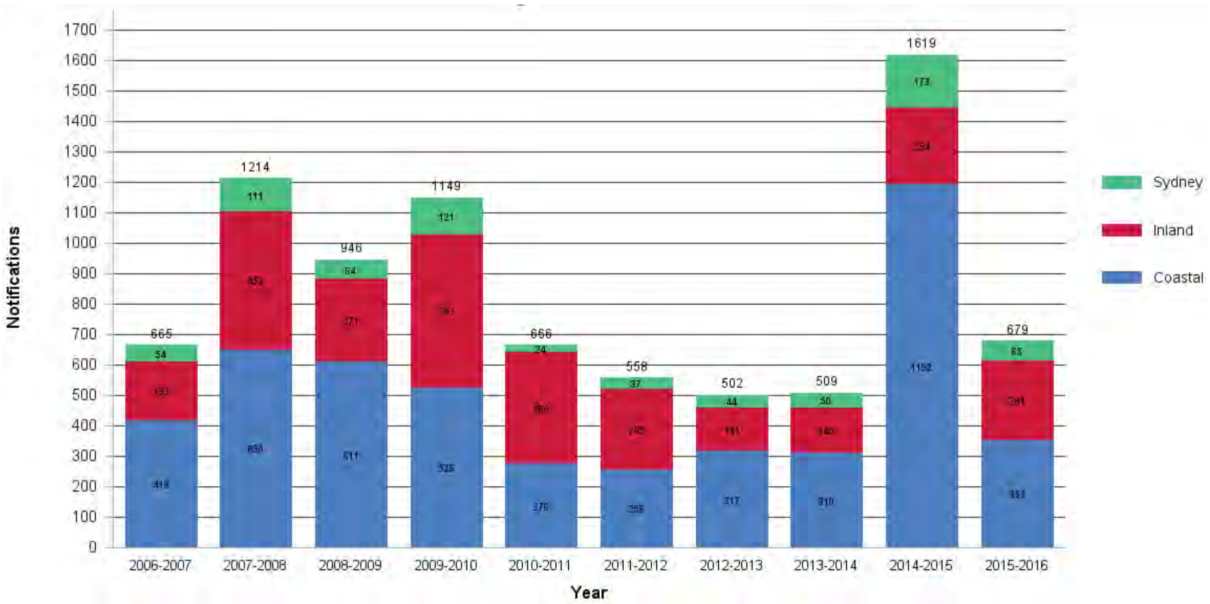
Figure 7: Barmah Forest virus infections in NSW residents: annual notifications by year of disease onset and geographical region* for the past 10 years (2006-2007 to 2015-2016).



* See Appendix 5 for definitions of the Coastal, Inland, and Sydney metropolitan regions. Due to incomplete address information, a handful of cases (approximately one per year) could not be allocated to a region.

The Coastal region also accounted for the majority of RFV notifications (n=353, 52.0%), followed by the Inland region (n=261, 38.4%) with the fewest notifications in Sydney residents (n=65, 9.6%) (Figure 8).

Figure 8: Ross River virus infections in NSW residents: annual notifications by year of disease onset and geographical region* for the past 10 years (from 2006-2007 to 2015-2016).



* See Appendix X for definitions of the Coastal, Inland, and Sydney metropolitan regions. Due to incomplete address information, a handful of cases (about one a year) could not be allocated to a region.

Notification maps of BFV and RRV infection by ABS statistical area level 2 (SA2) of residence for the 2015-2016 financial year are shown in Figures 9 and 10, together with maps of population notification rates.

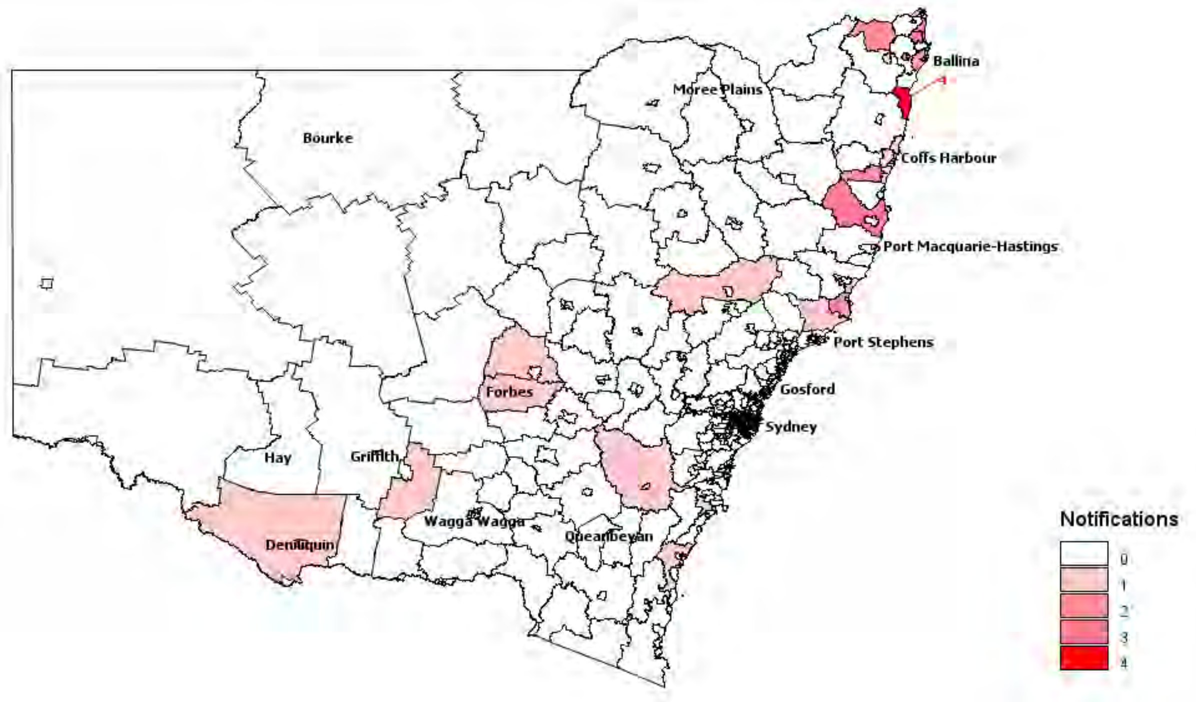
The SA2 area with the highest total number of BFV notifications was Maclean - Yamba - Iluka (n=4), with Kempsey Region, Mullumbimby, Lismore and Brunswick Heads - Ocean Shores all having 3 notifications each (Figure 9(a)). The three SA2 areas with the highest notification rates were Mullumbimby (39.6 per 100,000 population), Brunswick Heads - Ocean Shores (35.2) and Forster-Tuncurry Region (33.7) (Figure 9(b)).

The three SA2 areas with the highest total number of RRV notifications were Maclean - Yamba - Iluka (n=17), with Narromine and Port Macquarie-East each having 12 notifications (Figure 10(a)). The three SA2 areas with the highest notification rates per 100,000 population were Narromine (172.5), Forster-Tuncurry Region (151.5) and Wentworth-Balranald Region (134.2) (Figure 10(b)).

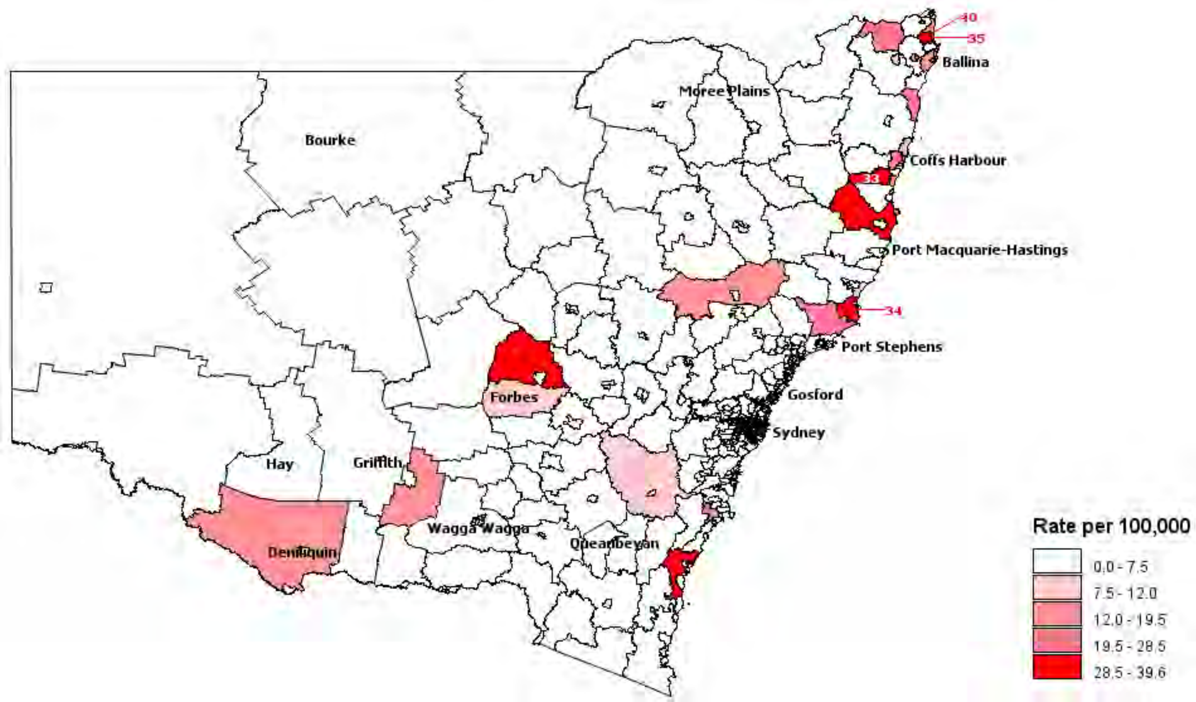
There were no human locally acquired flavivirus seroconversions reported.

Figure 9: Barmah Forest virus infections in NSW residents.

(a) Notifications by statistical area level 2 (SA2), for 2015-2016.



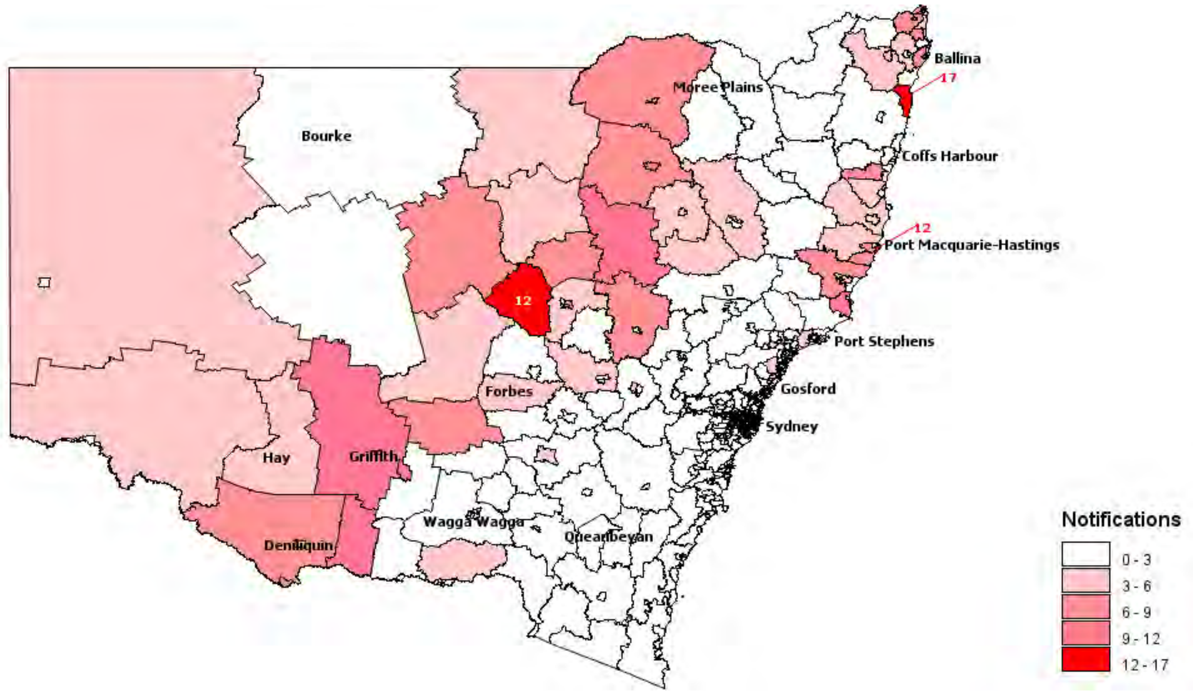
(b) Population notification rates* by statistical area level 2 (SA2), for 2015-2016.



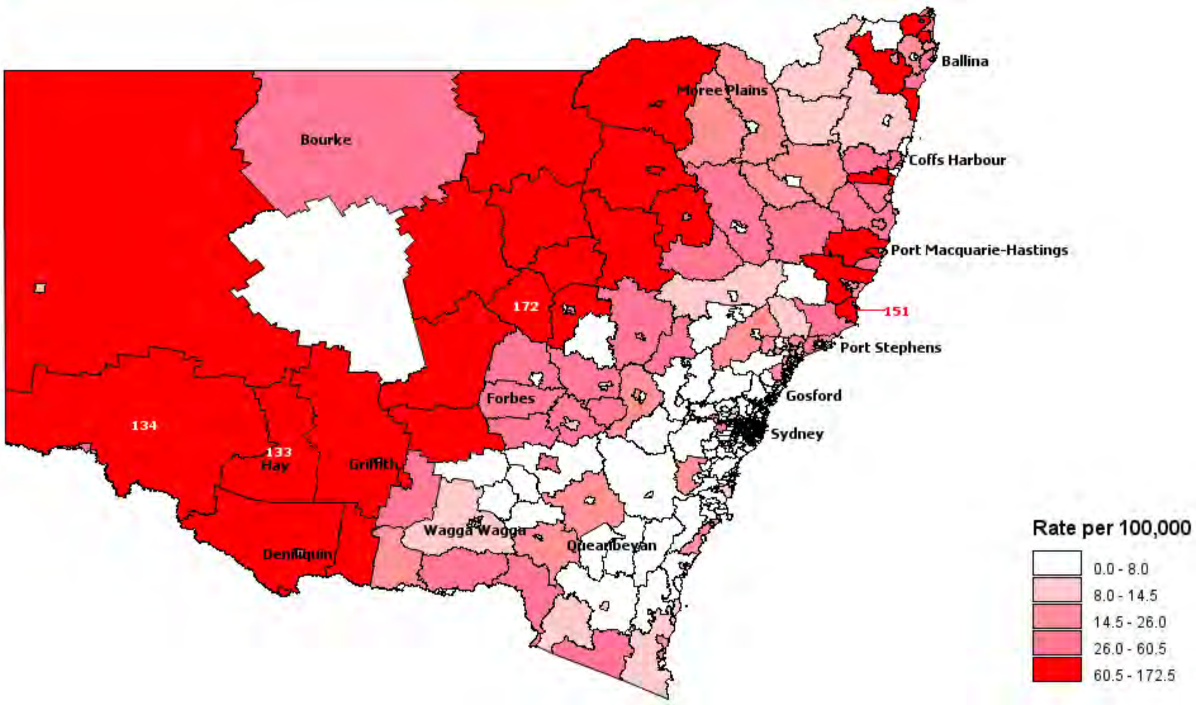
*Notifications per 100,000 estimated resident population, based on ABS population data.

Figure 10: Ross River virus infections in NSW residents.

(a) Notifications by statistical area level 2 (SA2), for 2015-2016.



(b) Population notification rates* by statistical area level 2 (SA2), for 2015-2016.



*Notifications per 100,000 estimated resident population, based on 2013 ABS population data.

DISCUSSION

The Inland. The 2015-2016 season experienced one of the strongest El Niño episodes to date, with the result that minimal rainfall occurred over the season and temperatures were well above average. As a consequence, the total numbers of mosquito trapped were one of the lowest collections to date, being around half that of the 2014-2015 season. There were only two arboviral detections (both by cell culture), including 1BFV and 1RRV, and there were no seroconversions in the sentinel chickens.

From the inland Local Health Districts, notifications of RRV and BFV totalled 264 (261RRV & 3BFV), which was below the long term average of around 300. There were no locally-acquired human cases of flavivirus infection reported. Narromine produced the highest number of RRV notifications (12) for a local statistical area, with Wentworth-Balranald Region (134.2) having the highest rate.

Currently the two main climatic models for MVEV are not suggestive of an MVEV epidemic for 2016-2017. However, as has been observed in recent years, MVEV can occur during seasons when the models have not been suggestive of an outbreak. Currently the Bureau of Meteorology is predicting a weak La Niña episode for late 2016, which may lead to enhanced rainfall, greater mosquito numbers, and increased arboviral notifications.

The Coast. Like the inland, the coastal region was significantly warmer and drier than usual with the powerful El Niño. Mosquito numbers were also well down upon average, being less than half of the previous season, and only two arboviral isolates were detected (both by FTA cards).

The number of human notifications for the coast were concomitantly also well down from the average of 742 (444RRV & 298BFV), with a total of 404 cases this season including 353 RRV and 51 BFV. However, as noted from Figure 11, which depicts total RRV notifications by month over the fiscal year of 2015-2016, there were more notifications over the first six months of the fiscal year (415 in total) compared with the last six months (384). This makes no apparent epidemiological sense as the data does not correspond to peak mosquito activity for the 2015-2016 season and it is likely that many (if not most) of the early notifications related to the massive RRV epidemic during early 2015. If the notifications during the last six months of the 2015-2016 fiscal year (a total of 387) are then compared with the long term average of 546, it is quite evident that RRV activity was down for the current season.

This was to be expected as the 2014-2015 season experienced the largest RRV outbreak since the disease became nationally notifiable in 1985. The 1,411 cases of RRV from the coast in 2015 was almost three times the average of 531. Following epidemics, 'herd immunity' effects means that activity is typically lower for a number of years, hence the minimal activity during the 2016 summer.

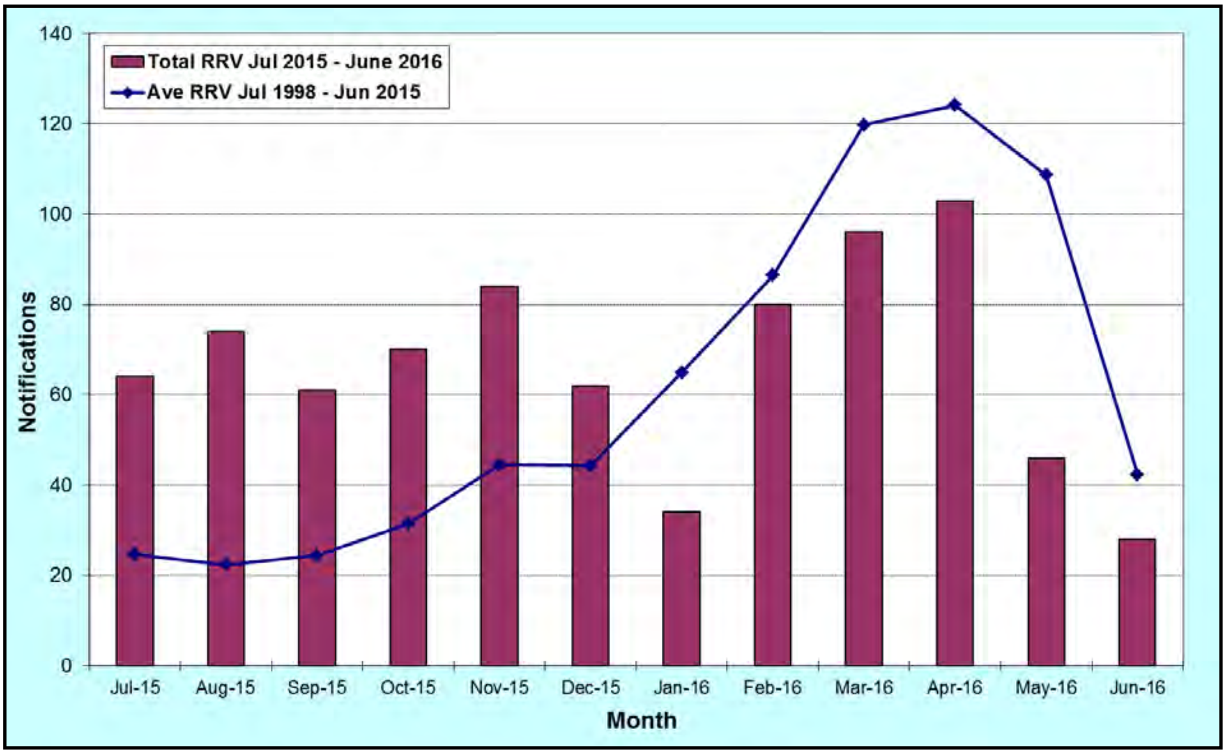


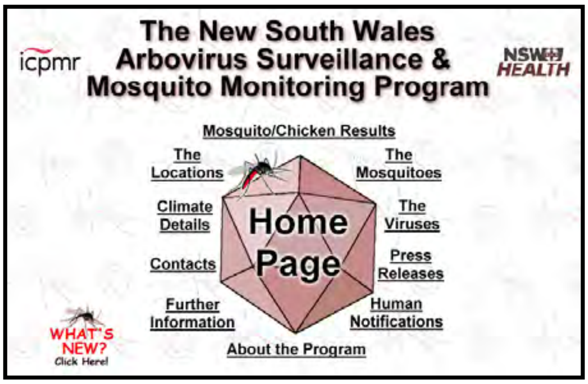
Figure 11. Notifications of RRV for NSW by month for the fiscal year 2015-2016, compared with the long term average over 1998-2015. Data from the NSW Ministry of Health, Communicable Diseases Weekly Report: http://www.health.nsw.gov.au/Infectious/reports/Pages/CDWR-2016.aspx

Sydney. Like elsewhere in the state, the hot dry conditions resulted in lower than average mosquito numbers for Sydney with no arboviral detections. The 65RRV and 5BFV notifications are below the average of 83 (71 RRV & 12 BFV). Again as above, it is likely the notifications were disproportionately towards the start of the fiscal year and related to the RRV epidemic of the previous season, with relatively minimal activity during the summer of 2016.

THE NEW SOUTH WALES ARBOVIRUS SURVEILLANCE WEB SITE

http://medent.usyd.edu.au/arbovirus/

The NSW Arbovirus Surveillance web site was established in early 1999 to facilitate the rapid dissemination of surveillance results (Doggett *et al.*, 1999b). An additional important function is to provide information on mosquitoes and the arboviruses they transmit. Over the last year, the site has continued to grow to the current size of 350MB, and has 2,620+ pages of information.



Added to the site since the last annual report includes:

- Archived data for the 2015-2016 season,
- Monthly rainfall summaries, with long-term averages,
- Monthly rainfall and temperatures maps,
- Daily high tides,
- Monthly SOI updates.

EXOTIC MOSQUITO DETECTIONS AT SYDNEY INTERNATIONAL AIRPORT

Background. Over the last six years there have been an increasing number of detections of exotic mosquitoes at major Australian ports. The main species have been the Dengue/Yellow Fever mosquito, *Aedes aegypti* (image on front cover of this report), and the Asian Tiger Mosquito, *Aedes albopictus*. Both of these pose a serious biosecurity risk to Australia being major vectors of several arboviruses including Dengue, Yellow Fever, Zika, and Chikungunya viruses.

Aedes aegypti, being a tropical species, mainly poses a threat to the more northern regions of the nation, whereas *Aedes albopictus* is more cold tolerant. This species has the potential to become established along the eastern coast of Australia including the major population centre of Sydney. As such, *Aedes albopictus* has the potential to cost the national economy hundreds of millions of dollars, through the transmission of diseases and vector control costs. Thus, it is imperative that these mosquitoes are kept out of regions of the country where they presently do not exist.

The Detections. Up until 2016, there had not been a detection of any exotic mosquito at Sydney International Airport. However, this changed when two *Aedes aegypti* larvae were detected on 14/Jan/2016, with confirmation being undertaken by the Department of Medical Entomology at Westmead Hospital. Further detections were made over the following weeks. A list of detections are in Table 6 below.

Table 6. Detections of *Aedes aegypti* at Sydney International Airport, 2016.

Date	Mosquito Stage (no)	Date	Mosquito Stage (no)
14/Jan/2016	Larvae (2)	27/Jan/2016	Female (1)
19/Jan/2016	Female (1)	15/Feb/2016	Female (1)
20/Jan/2016	Larvae (10)	18/Feb/2016	Female (1)
20/Jan/2016	Female (2)	4/Mar/2016	Female (1)
22/Jan/2016	Male (1)	15/Sep/2016	Male (1)
23/Jan/2016	Female (1)		

Furthermore, was also one live male Asian Tiger Mosquito, *Aedes albopictus*, collected on 30/Apr/2016 from a flower consignment originating from China. The latter occurred in a quarantine facility and was deemed low risk.

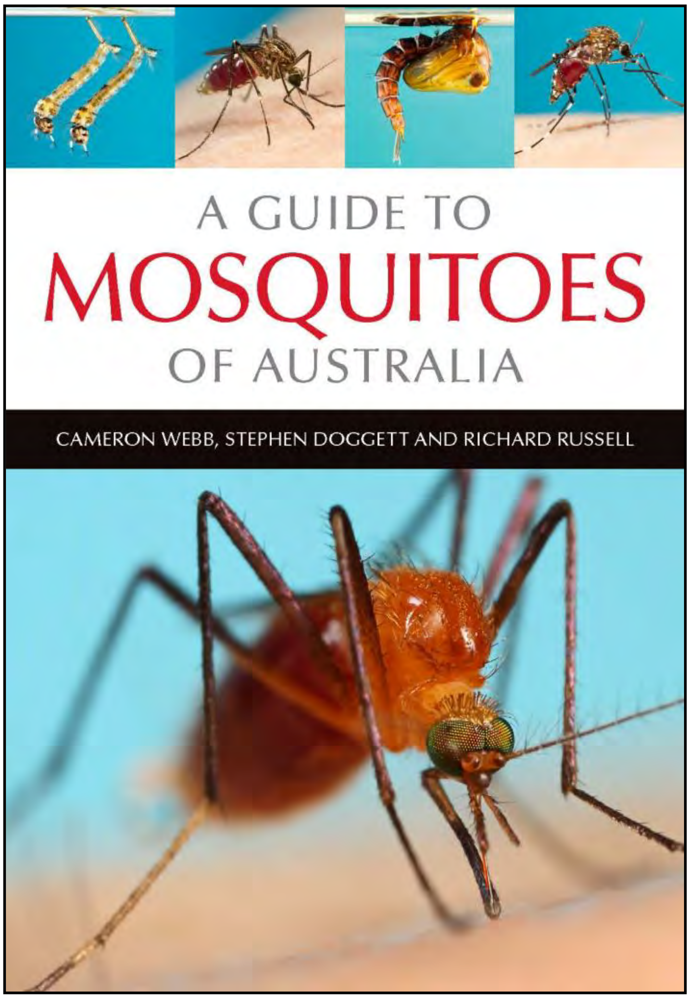
The Response. In response to the *Aedes aegypti* detections a number of actions were initiated. The NSW Ministry of Health established regular teleconferences, the Department of Agriculture and Water Resources (DAWR) undertook enhanced surveillance (both increasing the number of traps used and the frequency of trap inspections), insecticidal treatment of the detection areas were undertaken, and vector surveys were conducted both within and around the airport.

The airport survey undertaken by Medical Entomology in conjunction with DAWR, involved sampling all water sources and categorising potential vector risk. Some 107 potential sites were identified. No *Aedes aegypti* were found breeding, although

Culex quinquefasciatus and *Aedes notoscriptus* were, and recommendations to reduce the habitat of these were made. Surveys will now be undertaken annually. NSW Health are also in the process of developing contingency plans in the event that exotic mosquitoes are detected outside the port areas of DAWR responsibility.

NEW PUBLICATION & COLLABORATIVE RESEARCH

The NSW Arbovirus Surveillance Program principal aim is to act as an early warning system for arbovirus activity. However, the Program is involved in collaborative projects with a number of researchers across the country, and internationally, acts as a reference laboratory for referral of mosquito advice.



A recent key project has been the development of a new mosquito text, "***A Guide to Mosquitoes of Australia***", which was published by CSIRO Publications. The book is aimed at the secondary/tertiary level and highlights the biodiversity of mosquitoes, in particular their habitats and ecology. Around 100 mosquito species are described in detail, which includes all the major vector and pest species in Australia. All up, over 10,000 mosquito photographs were taken for the ***Guide***, with specimens derived from the NSW Arbovirus Surveillance Program. Release date was February 2016, with a price of $49.95. The Guide is available from:
http://www.publish.csiro.au/pid/6391.htm

Research collaboration over the recent season included:

- Prof. Roy Hall, University of Queensland; insect specific flavivirus detection and viral genotyping.
- Assoc. Prof. Craig Williams, University of South Australia; detection of arboviruses via FTA cards.

Additionally, the Department of Medical Entomology provided consultation services for the confirmation of exotic mosquito specimens for New Zealand Biosecurity as well as DAWR.

Appendix 1. LOCATION-BY-LOCATION SUMMARY

http://medent.usyd.edu.au/arbovirus/results/results.htm

Inland Locations

Albury: mosquito numbers were 'low' throughout the entire season with only the 'medium' collection from late February. There were no arboviral isolates from the trapped mosquitoes. Sentinel chicken flocks did not operate at Albury.

Bourke: mosquito collections were 'low' for the entire season. There were no sentinel chickens operated at Bourke this season.

Deniliquin: no mosquito collections were undertaken this season. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Forbes: no mosquito collections were undertaken this season. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Griffith: Collections at Hanwood were consistently 'very high' from mid-December until early February, while Barren Box had only the three 'very high' trap numbers in late December to early January. For the remainder of the season, both sites produced mostly 'high' mosquito numbers, which were below average for the entire season. There was one BFV from Hanwood, isolated from *Culex annulirostris* trapped on 1/Feb/2016. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Hay: no mosquito collections were undertaken this season, and there were no seroconversions to MVEV or KUNV in the sentinel chickens.

Leeton: Farm 347 produced two 'very high' traps in mid-January and numbers were maily 'high' thereafter. Almond Road had the two' high' collections in mid-January and thereafter were mostly 'low'. Both sites had below average mosquito numbers. There was one isolate of RRV from *Culex annulirostris* trapped at Farm 347 on 1/Mar/2016. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Macquarie Marshes: one mosquito collection was made in November and numbers were 'high'. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Moree: no mosquito collections were undertaken this season, and there were no seroconversions to MVEV or KUNV in the sentinel chickens.

Mathoura: only seven mosquito collections were made and this was through November and December where mosquito numbers were mostly 'low', with the one 'high' collection in the final trap. The sentinel flock was attached by foxes will all birds killed. The flock was subsequently not replaced. The one bleed in December failed to produce any seroconversion to MVEV or KUNV.

Menindee: no mosquito collections were undertaken this season, and there were no seroconversions to MVEV or KUNV in the sentinel chickens.

Wagga Wagga: trapping was undertaken at two sites and mosquito collections were 'low' for most of the season, with only three 'medium' numbers during successive weeks over late November and early December. There were no arboviral isolates this season. Sentinel chickens did not operate at Wagga Wagga.

Wee Waa: no mosquito collections were undertaken this season, and there were no seroconversions to MVEV or KUNV in the sentinel chickens.

Coastal Locations

Ballina: trapping continued at the two sites of North Creek Road and Pacific Pines. The mosquito season started off slowly at both localities, with 'medium' to 'high' through to February, and some 'very high' numbers in March. These big collections were dominated by *Culex sitiens*, *Aedes multiplex* and *Verrallina funerea*. No arboviral isolates were detected.

Coffs Harbour: trapping was undertaken at Nana Lane Depot and Christmas Bells Road. Collections were 'low' at both sites throughout the entire season. No arboviral isolates were detected.

Gosford: only the Empire Bay site was operated this year. Collections were 'high' through much of January to February, and 'medium' to 'low' thereafter. *Aedes notoscriptus* was the main species captured. No arboviral isolates were detected.

Lake Macquarie: collections were undertaken from three sites: Belmont Lagoon, Teralba and Dora Creek. Mosquito numbers were consistently 'low' from all three sites until February, where there were some 'high' collections dominated by *Aedes multiplex*. No arboviral isolates were detected.

Port Macquarie: Trapping was undertaken at three sites; North Haven, Partridge Creek, and Stevens Street. Mosquito numbers were down, with mostly 'low' collections at all sites, with the occasional 'medium' numbers from Stevens Street, with the one 'high' yield in mid-March. There was one arboviral detection via the FTA cards; EHV from Stevens Street from the mosquitoes trapped on 8/Feb/2016.

Tweed Heads: trapping was undertaken at three sites; Koala Beach, Beltana Drive and Piggabeen Road. Beltana Road yielded the greatest collections, with consistently 'high' numbers dominated by *Culex sitiens*. Piggabeen Road had 'medium' mosquito numbers until February, and then were 'high' during this month. Koala Beach had 'low' numbers throughout most of the season. No arboviral isolates were detected.

Wyong: trapping was undertaken at three sites: Ourimbah, Halekalani and North Avoca. Mosquito numbers were 'low' for the entire season. There was one arboviral detection via the FTA cards; BFV from Ourimbah from the mosquitoes trapped on 31/Mar/2016.

Sydney Locations

Bankstown: Collections this season were exclusively undertaken at Deepwater, a site known for intense local *Aedes vigilax* production. However this season, *Culex annulirostris* was the main species trapped from February until the end of the season. No arboviral isolates were detected.

Blacktown: Collections were made at two sites; Nurrangingy Reserve and Ropes Crossing. Mosquito numbers were consistently 'low' through the season, with the one 'medium' catch at Nurrangingy Reserve dominated by *Culex molestus*. No arboviral isolates were detected.

Georges River: trapping was again undertaken at the four sites of Alfords Point, Lugarno, Illawong, and Picnic Point. The biggest catch for the season for all sites was in the first for the season, which was the beginning of December, when numbers of *Aedes vigilax* were 'high'. Generally, most of the collections were 'high' in number at Alfords Point and Picnic Point, which were dominated by *Aedes vigilax*. Beyond the first week, Illawong had mostly 'medium' numbers, while collections were 'low' at Lugarno. No arboviral isolates were detected.

Hawkesbury: trapping was undertaken four sites on various weeks, including at Wheeney Creek, Yarramundi, and McGraths Hill. Wheeney Creek yielded the greatest collections when many 'high' yields through January and February, with collections dominated by *Aedes* Marks No. 51 (a relative of *Aedes procax*). McGraths Hill produced several 'high' catches over the same period, although these were dominated by *Culex quinquefasciatus*. Yarramundi produced only 'low' catches. No arboviral isolates were detected.

Penrith: trapping was undertaken at the three sites of Emu Plains, Muru Mittigar and Glenmore Park. Muru Mittigar yielded consistently 'high' numbers throughout the season, with collections dominated by *Culex annulirostris* and *Coquillettidia linealis*. Emu Plains Glenmore Park yielded mainly 'low' numbers. No arboviral isolates were detected.

Ryde: trapping was undertaken by the Medical Entomology staff from the two sites of Wharf Road and Lambert Park. For most of the season, collections were 'low', with only the one 'high' yield from Wharf Road in early March. No arboviral isolates were detected.

Sydney Olympic Park (SOP): mosquito monitoring at this location included the long-term locations of Narawang and Haslams Creek, as well as Newington. There was also an additional nearby site of Duck River at Silverwater. Mosquito numbers at the SOP locations were down in number this year, albeit 'high' from January to March at most sites. In contrast, Duck River produced some very large numbers including a 'very high' yield of 7,560 mosquitoes in mid-January, dominated by 7,335 *Aedes vigilax.* No arboviral isolates were detected.

Appendix 2. THE MOSQUITOES

The following briefly details the main mosquito species collected in NSW.

	**The Common Domestic Mosquito**, ***Aedes notoscriptus***. A common species that breed in a variety of natural and artificial containers around the home. It is the main vector of dog heartworm and laboratory studies shows it be an excellent transmitter both of RRV and BFV.
	**The Bushland Mosquito**, ***Aedes procax***. Common throughout coastal NSW. This species breeds in bushland freshwater ground. Numerous isolates of BFV have been recovered from this species and it is probably involved in the transmission of the virus.
	**The Northern Saltmarsh Mosquito**, ***Aedes vigilax***. The most important species along coastal NSW. This species breeds on the mud flats behind saltmarshes and can be extremely abundant and a series nuisance biter. It is the main vector for RRV and BFV along the coast.
	**The Common Australian Anopheline,** ***Anopheles annulipes***. A mosquito from throughout NSW, but is most common in the irrigated region of the Murrumbidgee where it can be collected in the 1000's. Despite its abundance, it is not thought to be a serious disease vector.
	**The Common Marsh Mosquito**, ***Coquillettidia linealis***. Found throughout NSW but especially in areas with freshwater marshes such as the Port Stephens area. Both BFV & RRV have been isolated from this species and is probably involved in some transmission.
	**The Common Banded Mosquito**, ***Culex annulirostris***. The species is common in the NSW inland regions that have intense irrigation. This species is highly efficient at transmitting most viruses and is responsible for the spreading of most of the arboviruses to humans inland.

Appendix 3. THE VIRUSES

Alphaviruses

Barmah Forest virus (BFV): disease from this virus is clinically similar to that of RRV disease, although BFV disease tends to be associated with a more florid rash and a shorter duration of clinical severity. This is an emerging disease and is increasingly being recognised in NSW, with around 3-400 cases annually. However, serological over diagnosis of this condition through the non-specificity of the commercial kit has been a major issue. Despite being first isolated from an inland region, cases of BFV disease tend to occur mainly in coastal regions in NSW. The main vector in NSW is *Aedes vigilax* although other species are involved, notably *Aedes procax*. In 2010-2011 there was a small epidemic (but largest to date for the inland region

Ross River virus (RRV): this virus causes RRV disease and is the most common cause of human arboviral disease in Australia. In NSW, approximately 700 cases per season are reported. A wide variety of symptoms may occur from rashes with mild fever, to arthritis that can last from months to years. The virus occurs in both inland and coastal rural regions. The main vectors are *Culex annulirostris* (inland) and *Aedes vigilax* (coast), although other mosquitoes are undoubtedly involved in the transmission of the virus as isolates have been made from many species.

Sindbis virus (SINV): this is an extremely widespread virus throughout the world and occurs in all mainland states of Australia. In contrast with Africa and Europe where outbreaks have been reported, disease from SINV is relatively uncommon in Australia; only 24 infections were notified in NSW from Jul/1995-Jun/2003 (Doggett 2004). Symptoms of disease include fever and rash. Birds are the main host, although other animals can be infected, including macropods, cattle, dogs and humans. The virus has been isolated from many mosquito species, but most notably *Culex annulirostris* in south-eastern Australia. It is also not routinely tested for any longer and it is possible that this would cross react with RRV in the commercial tests.

Flaviruses*

Alfuy virus (ALFV): no clinical disease has been associated with this virus and it has not been isolated from south-eastern Australia.

Edge Hill virus (EHV): a single case of presumptive infection with EHV has been described, with symptoms including myalgia, arthralgia and muscle fatigue. *Aedes vigilax* has yielded most of the EHV isolates in southeast Australia, although it has been isolated from several other mosquito species. The virus is quite common, with isolates from most years. The vertebrate hosts may be wallabies and bandicoots, but studies are limited.

Kokobera virus (KOKV): only three cases of illness associated with KOKV infection have been reported and all were from southeast Australia. Symptoms included mild fever, aches and pains in the joints, and severe headaches and lethargy. Symptoms were still being reported by the patients five months after onset. This virus historically was only known from inland regions of NSW until it was detected in a mosquito trapped from the coastal region in 2009-2010. *Culex annulirostris* appears to be the principal vector.

Kunjin virus (KUNV): disease from this virus is uncommon, with only two cases being notified from 1995-2003 (Doggett 2004), and one case on 2011 (Doggett *et al*. 2012). Historically, activity has been confined to the inland region of NSW where it is detected every few years; however, in the summer of 2010-2011, the virus was detected on the coast, which resulted in an outbreak amongst horses with a number of deaths resulting. *Culex annulirostris* appears to be the main vector.

Murray Valley Encephalitis (MVEV): activity of this virus is rare in south-eastern Australia and the last epidemic occurred in 1974. However, since the year 2000 there has been six seasons when MVEV activity has been detected within the state: 2000-2001, 2003-2004, 2007-2008, 2010-2011, 2011-2012, and the recent season of 2013-2014. There have been four human cases reported over 2008-2012. The virus occurs only in inland regions of the state and symptoms are variable, from mild to severe with permanent impaired neurological functions, to sometimes fatal. *Culex annulirostris* is the main vector.

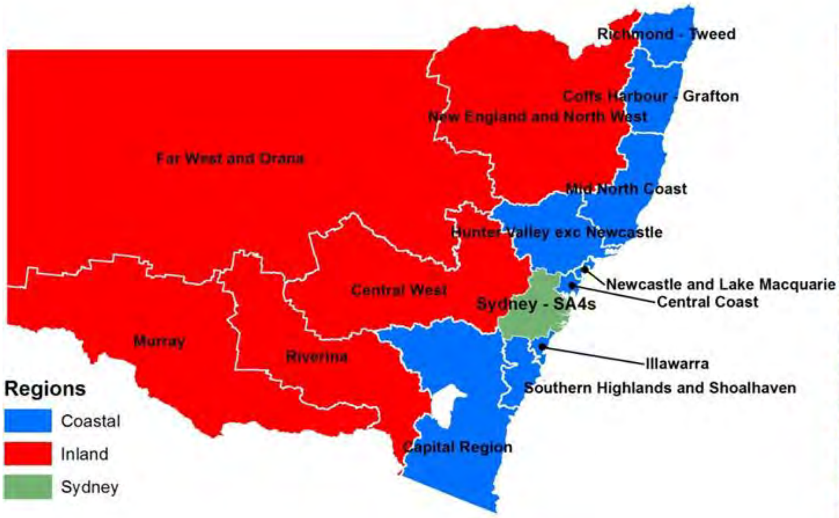
Stratford virus (STRV): there have been very few documented symptomatic patients, only three described to date and symptoms included fever, arthritis and lethargy. The virus has mostly been isolated from coastal NSW, particularly from the saltmarsh mosquito, *Aedes vigilax*, although recent isolates from the Sydney metropolitan area have been from *Aedes notoscriptus* and *Aedes procax*. This is a common virus, being isolated most years.

***Note that not all the flaviviruses above (excluding MVEV and KUNV) are tested for, and so it is not possible to determine the disease burden associated with these arboviruses. In light of some of these viruses being extremely common, it may be that disease is unrecognised (as symptoms are non-specific) and without supportive testing, is likely to remain undetected.**

Appendix 4. ABBREVIATIONS

AHS	Area Health Service
BFV	Barmah Forest virus
BOM	Bureau of Meteorology
CC	Central Coast Public Health Unit
CS	Central Sydney Public Health Unit
EHV	Edge Hill virus
FW	Far West Public Health Unit
GM	Greater Murray Public Health Unit
HUN	Hunter Public Health Unit
IgG	Immunoglobin G (a type of antibody)
IgM	Immunoglobin M (a type of antibody)
ILL	Illawarra Public Health Unit
IOD	Indian Ocean Dipole
ICPMR	Institute for Clinical Microbiology and Medical Research
MAC	Macquarie Public Health Unit
MNC	Mid North Coast Public Health Unit
MVEV	Murray Valley Encephalitis virus
MW	Mid West Public Health Unit
NE	New England Public Health Unit
NR	Northern Rivers Public Health Unit
NS	Northern Sydney Public Health Unit
KOKV	Kokobera virus
KUNV	Kunjin virus
PHU	Public Health Unit
RRV	Ross River virus
SA	Southern Area Public Health Unit
SA2	Statistical area level 2
SES	South Eastern Sydney Public Health Unit
SINV	Sindbis virus
SLA	Statistical Local Area
SO	Southern Oscillation
STRV	Stratford virus
SWS	Public Health Unit
TC	Tropical Cyclone
WEN	Public Health Unit
WS	Western Sydney Public Health Unit
VADCP	Victorian Arbovirus Disease Control Program
Virus?	Virus unknown (not BFV, RRV, SINV, EHV, KOKV, KUNV, MVEV, STRV)

Appendix 5. NSW GEOGRAPHIC REGIONS - COASTAL, INLAND, AND SYDNEY METROPOLITAN – USING ABS STATISTICAL AREA LEVEL 4 (SA4) GROUPINGS.



SA4 Name	Region
Capital Region	Coastal
Coffs Harbour - Grafton	Coastal
Newcastle and Lake Macquarie	Coastal
Southern Highlands and Shoalhaven	Coastal
Illawarra	Coastal
Hunter Valley excluding Newcastle	Coastal
Central Coast	Coastal
Richmond - Tweed	Coastal
Mid North Coast	Coastal
Central West	Inland
Far West and Orana	Inland
New England and North West	Inland
Riverina	Inland
Murray	Inland
Sydney - all 14 Sydney SA4s	Sydney

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