THE NEW SOUTH WALES
ARBOVIRUS SURVEILLANCE &
MOSQUITO MONITORING PROGRAM

icpmr

2010-2011 Annual Report

Aedes vittiger

S. DOGGETT, J. CLANCY, J. HANIOTIS, C. WEBB & R.C. RUSSELL
Mosquito & Arbovirus Surveillance Laboratory,
Medical Entomology Department, CIDMLS,
Institute for Clinical Pathology & Medical Research
University of Sydney and Westmead Hospital, NSW 2145.

L. HUESTON & D.E. DWYER
Arbovirus Laboratory, Clinical Virology, CIDMLS,
Institute for Clinical Pathology & Medical Research,
Westmead Hospital, Westmead, NSW 2145.

ISBN 1-74080-133-4

EXECUTIVE OVERVIEW

- **For the 2010-2011 season**, the NSW Arbovirus Surveillance Program: (i) monitored mosquito vector 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** leading up to the 2010-2011 season for the inland were of above to well above average rainfall for the entire second half of 2010, plus above average rainfall along the Murray for the first quarter of 2011. Both the Forbes' and Nichols' hypotheses were indicating probable MVEV activity for the 2010-2011 season. For the coast, conditions were mostly similar although the north coast had average rainfall through the late summer and temperatures became cool from March onwards, which resulted in reduced mosquito numbers.
- **For the inland**, the wet conditions meant that mosquito numbers were extremely high; over 200,000 mosquitoes were trapped, being over six times that of the previous season. Two collections from Griffith yielded over 10,000 mosquitoes per trap. There was considerable arboviral activity, with 105 isolates (7 BFV, 13 RRV, 2 EHV, 2 KOKV. 7 KUNV and 3 unknowns), and 21 seroconversions in the sentinel chickens (10 MVEV and 11 KUNV). Arboviral activity occurred over two peaks; the alphaviruses BFV and SINV were active from early November to mid-January, while the flaviruses were active later in the season from late January to late March.
- **Human notifications from the inland** totalled 461, which was around 50% greater than the long term average of 313, and included 249 RRV and 112 BFV. The number of BFV cases represented the largest epidemic of BFV disease for inland NSW, with case numbers of around four times greater than normal. There was one human case of MVEV disease. There was also a widespread outbreak of equine disease across eastern Australia involving RRV, KUNV and MVEV.
- **As of September 2011,** the Forbes' theory is indicating a possible MVEV epidemic for the season of 2011-2012, although the Nichols' theory is less suggestive.
- **For the coast**, mosquito numbers were well below previous years, due largely to very small collections of *Aedes vigilax* this season. As a result, arboviral activity was lower than previous years. There was a total of nine isolates, including 4 BFV, 3 RRV, and 2 unknowns. Three isolates each were from *Aedes vigilax* and *Culex annulirostris*.
- **Coastal disease notifications** totalled 563 cases including 299 BFV and 264 RRV, and this was well below the average of 749. Notifications of BFV notifications were close to normal, but RRV cases were almost half. The statistical local area that produced the highest case load was Byron, with 49 notifications (14 RRV & 35 BFV).
- **For the Sydney locations,** six sites operated and mosquito numbers were similar to last season despite the extra sites. This was largely due to smaller collections of *Aedes vigilax*. There was one isolate of KUNV from Lower Portland in Baulkham Hills, which was the first ever isolate of KUNV from coastal NSW. Human notifications were well below the average of 86, with a total of 63 cases including 25 RRV and 38 BFV.
- **The NSW Arbovirus Surveillance Web Site** http://www.arbovirus.health.nsw.gov.au/ continued to expand and now has over 266MB of information with 2,000+ pages.

TABLE OF CONTENTS

NSW ARBOVIRUS SURVEILLANCE AND MOSQUITO MONITORING PROGRAM 2010-2011

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 2010-2011 season follow.

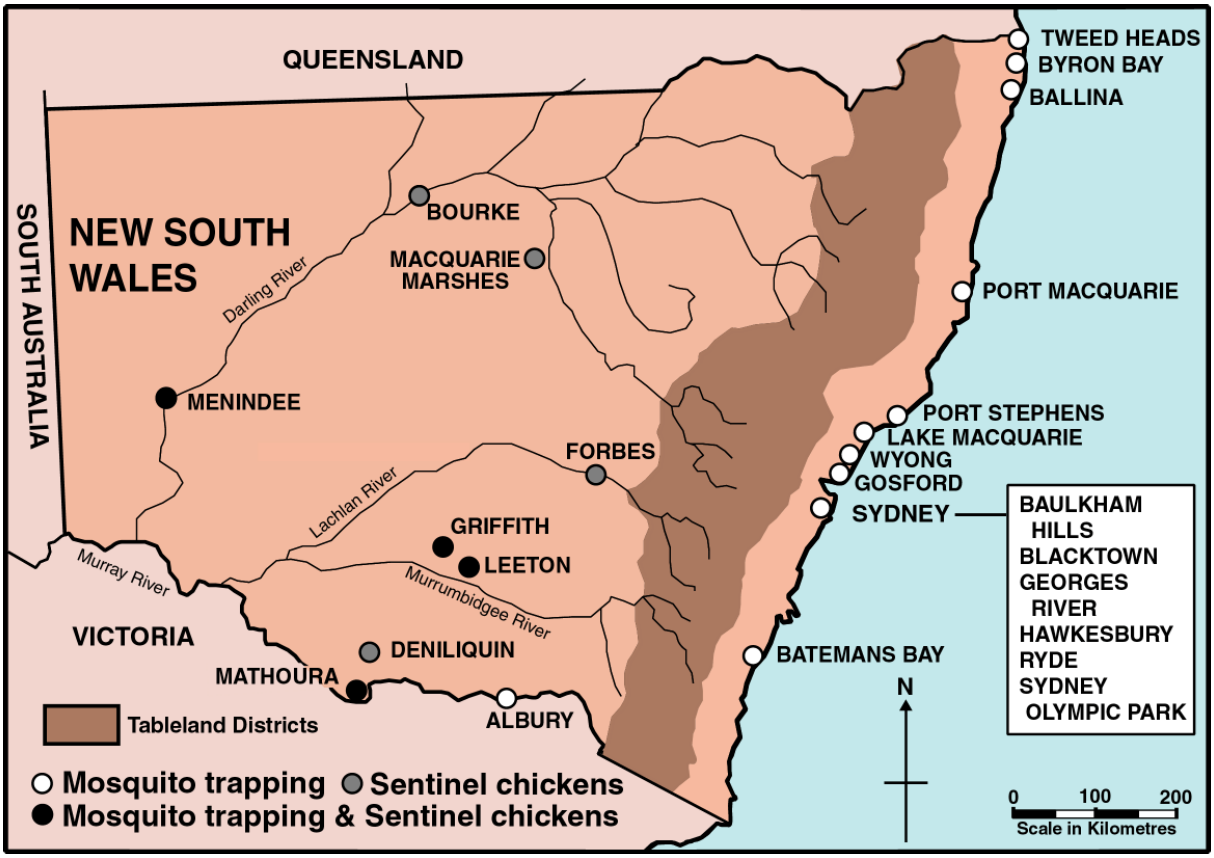


Fig 1. Mosquito trapping locations and Sentinel Chicken sites, 2010-2011.

MONITORING LOCATIONS

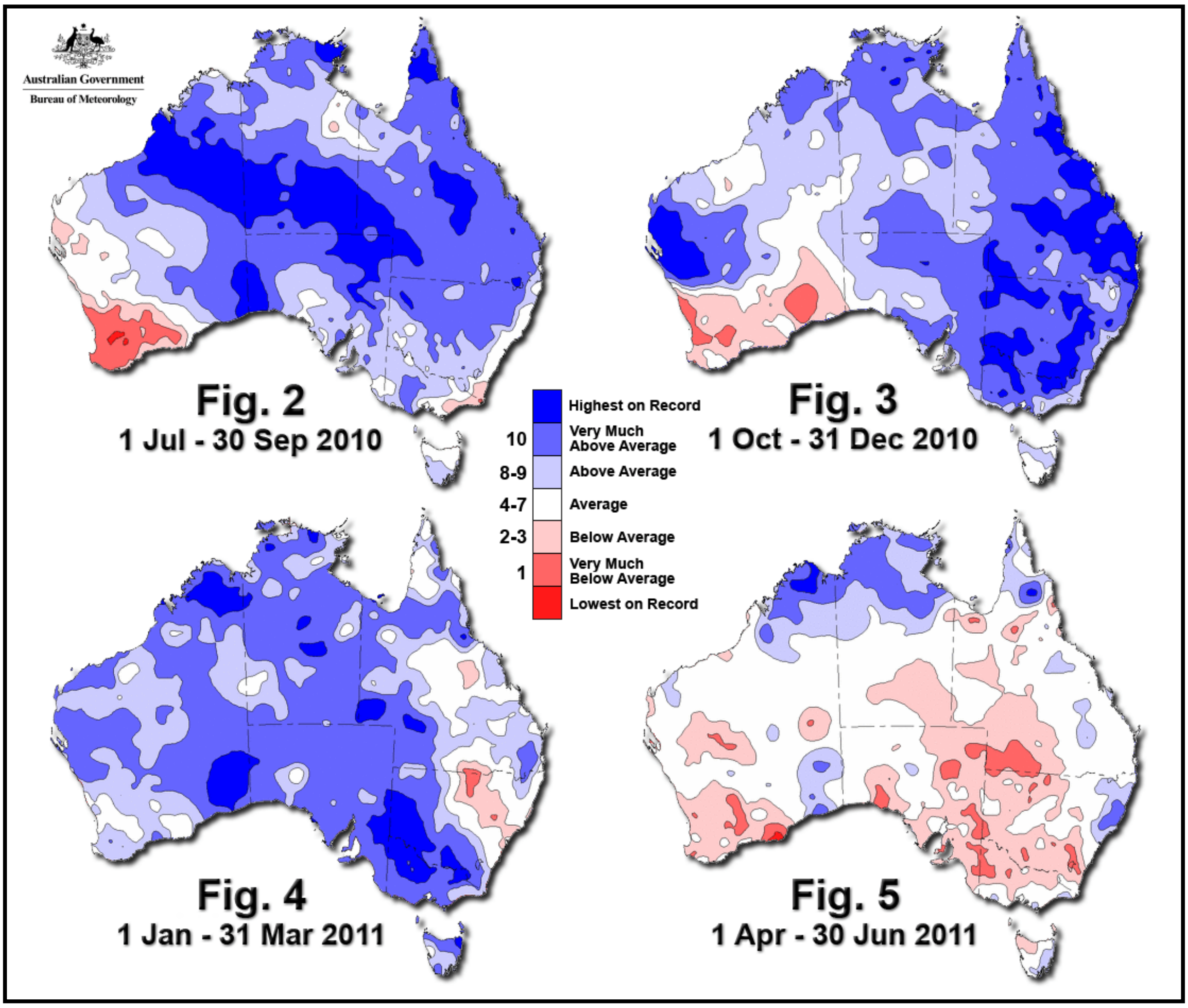
http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/location/locations.htm

For 2010-2011, mosquito-trapping sites were operated at 5 inland, 9 coastal and 6 Sydney locations (Fig 1). Chicken sentinel flocks were located at 8 locations. Short term mosquito trapping was also conducted at Wagga and Bellingen.

WEATHER DATA

http://www.arbovirus.health.nsw.gov.au/areas/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 2010, Oct-Dec 2010, Jan-Mar 2011 & Apr-Jun 2011. The stronger the red, the drier the conditions. Conversely, the stronger the blue, the wetter the conditions. *Modifed from the Australian Bureau of Meterology, 2011*.

The first quarter of 2010 saw rainfall that was above to very much above average across southeastern and central Australia. For the three months of April to June 2010, precipitation levels were around average. The third quarter of 2010 was again extremely wet for much of Australia, with the entire inland of NSW having above to very much above average rainfall (Figure 2). This rainfall pattern continued into the last quarter of 2010 for eastern Australia, with many areas of NSW having record rainfall (Figure 3). During this time the coastal strip also experienced higher than average rainfall patterns. For southern and western NSW, the above average rainfall continued into the first quarter of 2011 with many average along the Murray having very much above average rainfall (Figure 4). The second quarter of 2010 experienced drier rainfall patterns and the inland had mostly below average precipitation (Figure 5).

Temperatures for the last half of 2010 were continually below average due to the increased cloud cover with the greater rainfall. In January 2011, temperatures were slightly above average across the state, however for the remainder of the season both maximum and minimum temperatures were around two degrees below average.

MVEV Predictive Models

Three models have been developed for the prediction of MVEV epidemic activity in southeastern Australia: the Forbes' (1978), Nicholls' (1986) and Bennett (Bennett *et al*. 2009) 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.

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 (eg. October-December 2009) or the first quarter of the current year (January-March 2010) <u>and</u> the last quarter of the current year (October-December 2010), 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 not above decile 7 for any of the catchment basins for the last quarter of 2009, however it was for first and last quarters of 2010, and the thus the Forbes hypothesis was fulfilled for the season of 2010-2011 (Table 1). At the time of writing this report in September 2011, all the catchment basins have received rainfall greater than decile 7 for both the last quarter of 2010 and the first quarter of 2011, indicating a possible risk of an MVEV epidemic for the upcoming 2011-2012 season.

Table 1. Rainfall indices for the main catchment basins of eastern Australia as per Forbes' hypothesis, relevant to the 2010-2011 and 2011-2012 seasons.

Catchment Basin	Oct-Dec 2009	Jan-Mar 2010	Oct-Dec 2010	Jan-Mar 2011
Darling River	0.88	1.31	1.72	1.01
Lachlan/Murrumbidgee/ Murray Rivers	0.78	1.45	1.99	2.02
Northern Rivers	0.83	1.00	1.80	1.38
North Lake Eyre system	0.84	1.19	2.28	1.39

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 2010, the SO values were respectively: 1009.57mm, 1012.60mm and 1009.53mm (indicated on Figure 6 by the yellow arrows). Only the autumn period was not within the range of values for the same period of past MVEV outbreak years. The summer 2010–2011 SO value of 1005.00mm was well within the range of that experienced during MVEV years. As of September 2011, the autumn Nicholls' value for 2011 is 1009.07mm and within the range of values during past MVEV outbreak years, however the winter value of 1013.43 is outside the range.

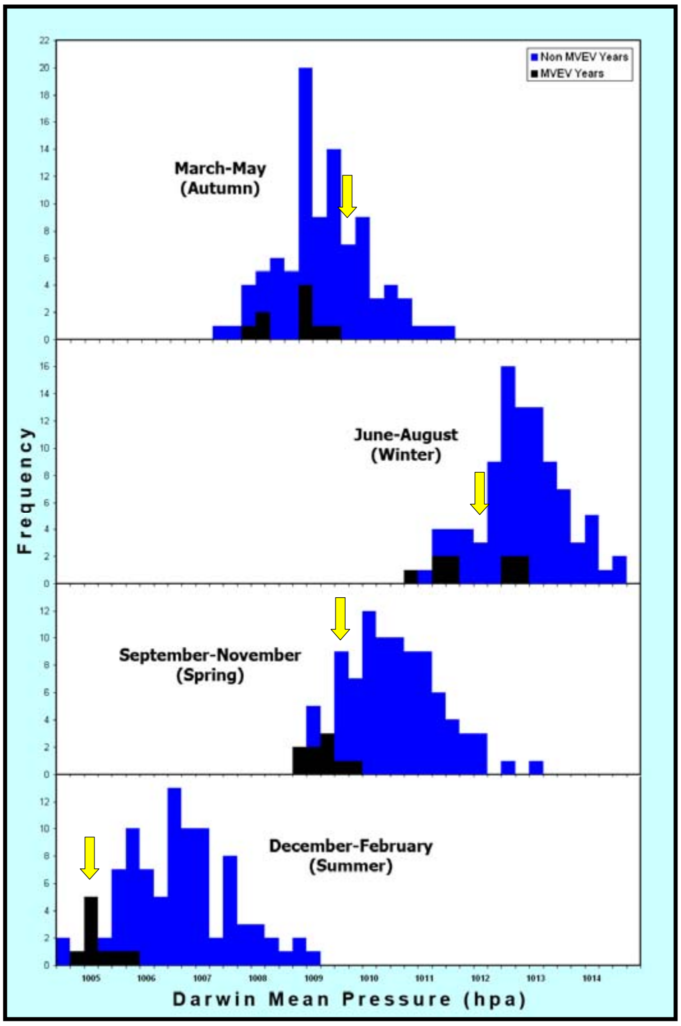


Figure 6. The SO by seasons prior to MVEV active years, according to Nicholls (1986), updated up to Autumn 2011. The black bars represent the pre-MVEV active seasons. The yellow arrows indicate the respective SO values relevant to the 2010-2011 season.

The Indian Ocean Dipole (IOD) is almost the Indian Ocean equivalence of the SO in the Pacific and involves a similar oscillation in climatic events. The IOD is calculated through the differences in sea surface temperatures between eastern and western Indian Ocean. Bennett and colleagues noted that the IOD tends to be negative in years prior to MVEV epidemics. However, arguably this hypothesis is not a model but more of a vague association as the paper fails to indicate over what period the IOD value must be in the negative region prior to MVEV active years. For example, in November 2010 the value of the IOD was +0.1 and it was suggested that as this value was in the positive range there was a reduced potential of MVEV activity in 2011 for southeastern Australia (Victoria Health Department, 2010). Despite this, there was subsequently extensive activity along the Murray and through inland NSW. Similarly, there have been many years when the IOD has been negative without ensuing MVEV activity (JAMSTEC, 2011). In its current form, the Bennett hypothesis appears to have little to no value in MVEV prediction and clearly the hypothesis requires further refinement in order to become a useful predictive tool.

It is important to note that all the hypotheses have been calculated on environmental conditions experienced during major MVEV epidemic seasons and the models do not propose to predict low to moderate level activity, such as occurred during the 2000-2001, 2003-2004 and the 2007-2008 seasons. Thus, negative MVEV models do not necessarily indicate no MVEV activity. Also, these models do not take into account unusual environmental conditions such that 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). Nor do these models take into account the possibility that the virus exists in cryptic foci in southeastern Australia, which may be the case.

MOSQUITO MONITORING

Methods

Mosquitoes were collected overnight in dry-ice baited Encephalitis Vector Surveillance 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), 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 receiving the sample into the laboratory. Access to each location's result is from:
http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/results/results.htm.

Results

Overall, 267,977 mosquitoes representing 56 species were collected in NSW during the 2010-2011 season, which was approximately 2.5 times the previous season's collection. *Culex annulirostris* was the most abundant and most important of the inland mosquito species during the summer months, whereas *Aedes vigilax*, *Aedes notoscriptus*, *Coquillettidia linealis*, *Culex sitiens, Culex annulirostris* 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.

Inland

The total of 207,992 mosquitoes trapped, comprising 23 species, was six times larger than that of the previous season's collection, and over 18 times that of the 2008-2009 season total. *Culex annulirostris* was the dominant species yielded at most sites and comprised 77.0% of the total inland collections. *Anopheles annulipes* (12.9%) was the next most common species, with *Culex australicus* (4.4%) and *Aedes theobaldi* (3.0%).

Coastal

In total, 43,239 mosquitoes comprising 48 species were collected from coastal NSW and this was around half the previous season's total collection of approximately 83,000. The most common species collected were *Aedes vigilax* (22.1% of the total coastal mosquitoes trapped), *Aedes notoscriptus* (14.0%), *Coquillettidia linealis* (13.3%), *Culex annulirostris* (8.4%), *Verrallina funerea* (8.1%), *Culex sitiens* (6.1%), *Culex orbostiensis* (5.4%)*, Coquillettidia xanthogaster* (4.5%), *Mansonia uniformis* (4.6%), *Aedes multiplex* (3.1%), and *Aedes procax* (1.8%).

Metropolitan Sydney

A total of 16,746 mosquitoes, comprising 23 species, was collected from metropolitan Sydney and this was slightly up upon the previous season's total collection, although there were a number of extra trapping sites this year. *Aedes vigilax* (30.1% of the total Sydney mosquitoes trapped) was the most common species, followed by *Coquillettidia linealis* (13.1%), *Aedes notoscriptus* (10.7%), *Culex annulirostris* (8.4%), *Culex sitiens* (7.7%) and *Culex orbostiensis* (4.9%).

ARBOVIRUS ISOLATIONS FROM MOSQUITOES

http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/about/methods.htm

Methods

Viral isolation methods were as per earlier annual reports (Doggett *et al*., 1999a, 2001). 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'. 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).

Table 2. Arbovirus isolates from Inland NSW, 2010-2011.

LOCATION	Date Trapped	Mosquito Species	Virus							
			BFV	RRV	SINV	EHV	KOKV	KUNV	Virus?	Tot
GRIFFITH	16-Nov-10	*Culex annulirostris*	1		1					**2**
GRIFFITH	23-Nov-10	*Culex annulirostris*			1					**1**
ALBURY	23-Nov-10	*Culex annulirostris*			1					**1**
GRIFFITH	30-Nov-10	*Culex annulirostris*			1					**1**
LEETON	7-Dec-10	*Aedes theobaldi*	1							**1**
LEETON	7-Dec-10	*Culex annulirostris*	1							**1**
MURRAY	7-Dec-10	*Anopheles annulipes*			1					**1**
MURRAY	7-Dec-10	*Culex annulirostris*			14					**14**
MURRAY	7-Dec-10	*Culex australicus*			1					**1**
ALBURY	13-Dec-10	*Culex annulirostris*			1					**1**
GRIFFITH	13-Dec-10	*Culex annulirostris*	1		11					**12**
LEETON	14-Dec-10	*Culex annulirostris*	1		2					**3**
MURRAY	14-Dec-10	*Culex annulirostris*			8					**8**
MURRAY	21-Dec-10	*Culex annulirostris*			2					**2**
ALBURY	22-Dec-10	*Culex annulirostris*			4					**4**
GRIFFITH	21-Dec-10	*Culex annulirostris*			8					**8**
WAGGA	21-Dec-10	*Culex annulirostris*			4					**4**
LEETON	23-Dec-10	*Aedes theobaldi*	1							**1**
LEETON	23-Dec-10	*Culex annulirostris*			2					**2**
GRIFFITH	31-Dec-10	*Culex annulirostris*			4					**4**
MURRAY	4-Jan-11	*Culex annulirostris*							1	**1**
LEETON	5-Jan-11	*Aedes theobaldi*	1							**1**
LEETON	5-Jan-11	*Culex annulirostris*			1					**1**
ALBURY	11-Jan-11	*Aedes mallochi*				1				**1**
ALBURY	11-Jan-11	*Culex annulirostris*			1					**1**
MURRAY	11-Jan-11	*Aedes sagax*							1	**1**
BOURKE	17-Jan-11	*Culex annulirostris*			2					**2**
MURRAY	18-Jan-11	*Culex annulirostris*							1	**1**
MENINDEE	31-Jan-11	*Culex annulirostris*		1						**1**
LEETON	1-Feb-11	*Aedes theobaldi*		1						**1**
MURRAY	2-Feb-11	*Aedes vittiger*				1				**1**
MURRAY	2-Feb-11	*Culex annulirostris*						1		**1**
GRIFFITH	8-Feb-11	*Culex annulirostris*						1		**1**
LEETON	9-Feb-11	*Culex annulirostris*			1					**1**
GRIFFITH	22-Feb-11	*Culex annulirostris*						1		**1**
LEETON	23-Feb-11	*Culex annulirostris*		1						**1**
GRIFFITH	8-Mar-11	*Culex annulirostris*		8			1	1		**10**
MURRAY	8-Mar-11	*Culex annulirostris*						1		**1**
GRIFFITH	8-Mar-11	*Anopheles annulipes*		1						**1**
LEETON	9-Mar-11	*Aedes theobaldi*		1						**1**
GRIFFITH	15-Mar-11	*Culex annulirostris*						2		**2**
LEETON	22-Mar-11	*Culex annulirostris*					1			**1**
		TOTAL	**7**	**13**	**71**	**2**	**2**	**7**	**3**	**105**

BFV = Barmah Forest virus, RRV = Ross River virus, SINV = Sindbis virus, EHV = Edge Hill virus, KOKV = Kokobera virus, KUNV = Kunjin virus, Virus? = unknown (not BFV, RRV, SINV, EHV, KOKV, KUNV, MVEV, STRV).

Results

http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/results/virusisolates.htm

From the mosquitoes processed, there were 111 viral isolates; 102 from the inland and nine from coastal locations. These are listed in Tables 2 and 3.

Table 3. Arbovirus isolates from Coastal NSW, 2010-2011.

Location	Date Trapped	Mosquito Species	Virus				Tot
			BFV	RRV	KUNV	Virus?	
PORT STEPHENS	12-Jan-11	*Aedes vigilax*	2				2
PORT STEPHENS	18-Jan-11	*Aedes vigilax*	1				1
GOSFORD	20-Jan-11	*Aedes notoscriptus*	1				1
PORT STEPHENS	25-Jan-11	*Aedes vigilax*	1				1
PORT STEPHENS	8-Mar-11	*Coquillettida linealis*		1			1
PORT MACQUARIE	15-Mar-11	*Culex annulirostris*		1			1
PORT MACQUARIE	15-Mar-11	*Culex australicus*		1			1
BALLINA	22-Mar-11	*Culex halifaxii*				1	1
BAULKHAM HIILS	25-Mar-11	*Culex annulirostris*			1		1
BALLINA	30-Mar-11	*Verrallina funerea*				1	1
Total			**5**	**3**	**1**	**2**	**11**

BFV = Barmah Forest virus, RRV = Ross River virus, KUNV = Kunjin virus, Virus? = unknown (not BFV, RRV, SINV, EHV, KOKV, KUNV, MVEV, STRV).

SENTINEL CHICKEN PROGRAM

http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/about/chickenmethods.htm

Location of flocks

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

Methods

The NSW Chicken Sentinel Program was approved by the SWAHS 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 118 pullets and five deaths were recorded during the program. A total of 2,300 samples was received from the eight flocks in NSW over the six-month period in 2010-2011. This represented 4,600 ELISA tests (excluding controls and quality assurance samples), with each specimen being tested for MVEV and KUNV antibodies.

There were a number of seroconversions to MVEV and KUNV; these are listed in Table 4 below.

Table 4. Seroconversions to MVEV and KUNV in the sentinel chicken flocks, 2010-2011.

LOCATION	Date Bled	MVEV	KUNV	Total
Bourke	21-Feb-11	5		**5**
	7-Mar-11		1	**1**
	21-Mar-11	1		**1**
Forbes	17-Mar-11		1	**1**
	23-Mar-11	1	1	**2**
Leeton	13-Mar-11		1	**1**
	19-Mar-11	1		**1**
	3-Apr-11		1	**1**
	11-Apr-11		1	**1**
	17-Apr-11		1	**1**
Macquarie Marshes	21-Feb-11	2		**2**
	6-Mar-11		3	**3**
Moama	6-Apr-11		1	**1**
	Total	**10**	**11**	**21**

HUMAN NOTIFICATIONS

http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/human/human.htm

The notification of human arboviral infections is based on laboratory notifications, which define cases as being '*confirmed*', '*presumptive*', '*inconclusive*' or '*negative*' (Mackenzie *et al*. 1993). A '*confirmed*' infection is where there is at least a fourfold rise or fall in antibodies between paired sera, with the first blood sample begin taken early in the disease phase (the 'acute' sample) and the second sample taken during convalescence of the illness (the 'convalescent' sample). The detection of the virus by isolation or through molecular techniques also constitutes a '*confirmed*' infection. A '*presumptive'* infection is where there is IgM antibody in the acute sera, or moderate or high antibody (such as IgG) with IgM antibodies. An '*inconclusive*' infection has little to no IgM antibody in the acute sample or stable antibody levels in two convalescent samples without IgM antibodies. A '*negative'* infection has no specific arbovirus antibody.

Table 5. Arbovirus notifications according to former Area Health Service, July 2010 - June 2011*.

Month	CS	NS	WS	WE	SW	CC	HU	IL	SE	NR	MN	NE	MA	MW	FW	GM	SA	Total
RRV	4	6	2	7	4	11	83	3	2	102	53	51	45	40	58	155	12	638
BFV	0	5	2	2	2	6	42	23	2	135	74	17	13	10	21	51	19	424
Total	**4**	**11**	**4**	**9**	**6**	**17**	**125**	**26**	**4**	**237**	**127**	**68**	**58**	**50**	**79**	**206**	**31**	**1062**

CS = Central Sydney, NS = Northern Sydney, WS = Western Sydney, WE = Wentworth, SW = South Western Sydney, CC = Central Coast, HU = Hunter, IL = Illawarra, SE = South Eastern Sydney, NR = Northern Rivers, MN = Mid North Coast, NE = New England, MA = Macquarie, MW = Mid Western, FW = Far Western, GM = Greater Murray, SA = Southern Area. *Data from 'GODSEND'.

Table 5 contains the number of laboratory notifications of human RRV and BFV infection by former Area Health Service (AHS) for NSW. The former AHSs data were used, rather than the current, to allow for a comparison of notification trends over time. Also note that the majority of notifications are *'presumptive'* infections. As a result there are likely to be significant errors in the data given the high false positive rate of commercial kits (20% false positives), the degree of cross-reactivity of closely related arboviruses, the persistence of IgM for long periods (18 to 48 months) in genuine infections, and the fact that antibody is produced regardless of clinical disease (L. Hueston, *pers. comm*.). In an investigation of serologically diagnosed BFV cases from the mid-north coast of NSW, it was found that there was a significant amount of over diagnoses (Cashman *et al*. 2008).

The total number of RRV and BFV notifications for the period July 2010 to June 2011 was 1,062 and included 424 BFV and 638 RRV. This season had one of lowest totals of notifications since that of 2004/05, yet slightly below the long term average of 1,143. The coastal region accounted for 563 (53.0% of the state total) of the BFV and RRV notifications, which was well below the seasonal average of 749. The 461 notifications (43.4% of the state total) from the inland were well above previous seasonal average of 313. Within the Sydney region there were 63 cases reported, around 25% below the seasonal average of 83.

From the coast, the Northern Rivers and Mid North Coast Health Services received the highest number of notifications (237 and 127 respectively) with the Hunter having 125. Combined, these three areas accounted for 46.0% of all the arbovirus notifications for the state. From the inland, the Greater Murray AHS had the highest number of notifications (206), with the Far West having 79.

Figure 7 depicts the notifications and notification rates of RRV and BFV by Statistical

Local Area (SLA) for NSW during the 2010-2011 mosquito season.

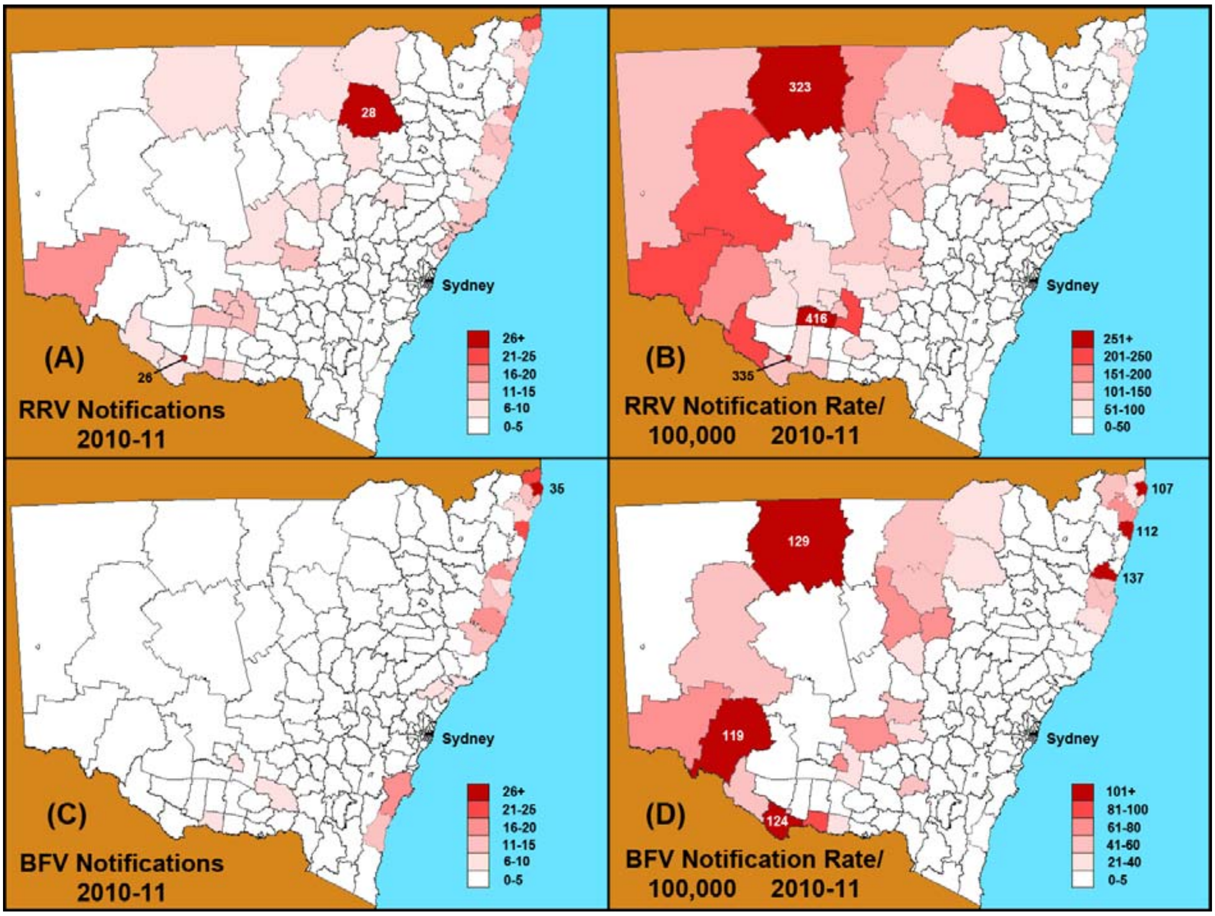


Figure 7. Notifications and notification rates of RRV and BFV by Statistical Local Areas for NSW for Jul 2010 to Jun 2011. (A) RRV notifications. (B) RRV notification rate/100,000 population. (C) BFV notifications. (D) BFV notification rate/100,000 population. Note that different scales are used on each graph. Data from 'GODSEND'.

There was one MVEV notification from northern inland NSW. This patient is making a full recovery.

DISCUSSION

The Inland. The extremely heavy rainfall throughout inland NSW during the second half of 2010, along with the above average precipitation in the south and west of the state during the first quarter of 2011 resulted in a massive explosion in mosquito populations along with major arbovirus activity. With the heavy rainfall, the climatic models of Forbes' and Nichols' were both suggestive of probable MVEV activity, which did lead to an increased level of surveillance. Over 200,000 mosquitoes were trapped during the season and this was six times larger than the collection made in 2009-2010 and over 18 times that in the season of 2008-2009. There were 105 isolates from the mosquitoes. with a diversity of viral types including seven BFV, 13 RRV, 71 SINV, two

EHV, two KOKB, seven KUNV and three unidentified. There were 21 seroconversions in the sentinel chicken flock including 10 MVEV and 11 KUNV.

As can be seen in Figure 8, the arboviral activity across the inland occurred in two phases this season. The first phase began in mid-November consisted largely of the alphaviruses SINV and BFV, and faded to mid-January, although some isolates of SINV were obtained after this period. The second phase of activity mainly involved the flaviviruses KUNV and MVEV, beginning in late January and ending in late March. Interestingly the RRV activity occurred during the second phase.

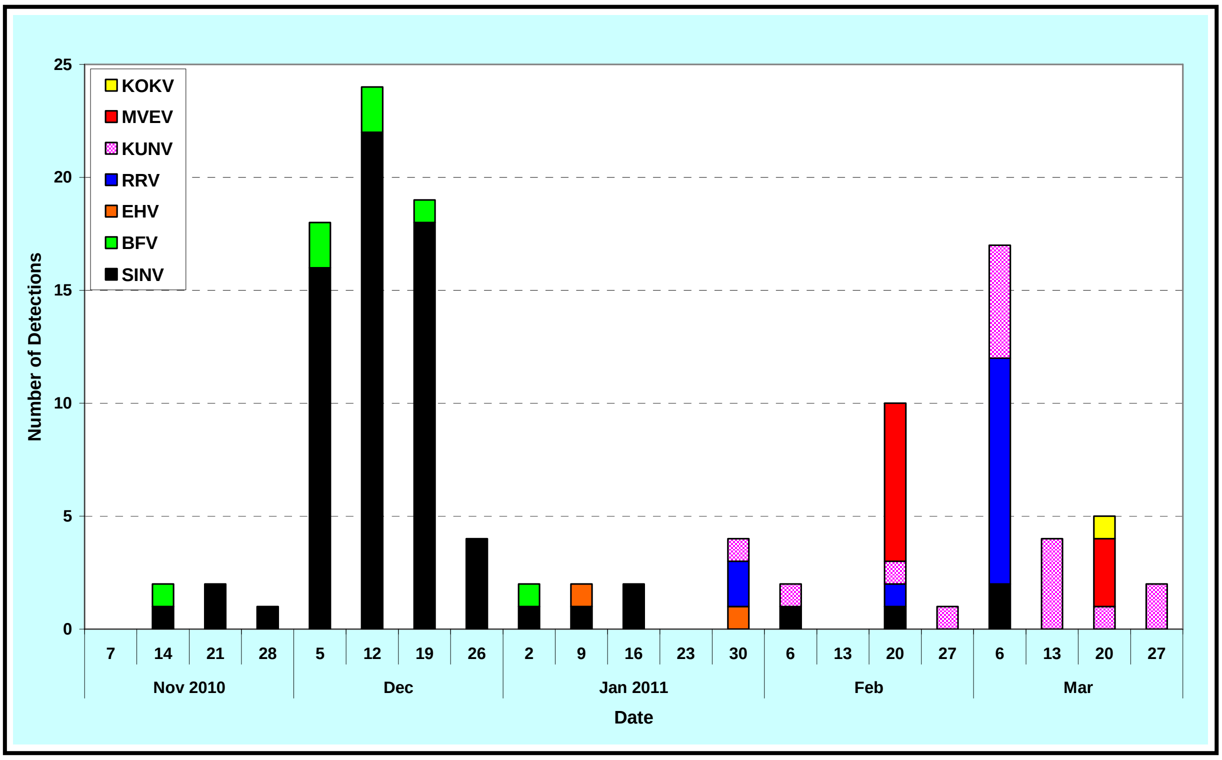


Figure 8. Weekly timeline of arboviral detections as per isolations from mosquitoes and sentinel chicken seroconversions, from inland NSW 2010-2011.

The MVEV in NSW was detected over two periods; firstly on 21/Feb/2011 at Bourke and Macquarie Marshes and then around one month later at Leeton on 19/Mar/11, Bourke on 21/Mar/2011, and Forbes on 23/March/2011. Whereas KUNV was more active being detected almost every week over a nine week period from late January to late March, from most inland surveillance sites (Figure 9). In comparison, the MVEV activity along the Murray as detected by the Victorian Arbovirus Disease Control Program detected the virus over a much longer period; with seroconversions from almost every week from 7/Feb/2011 to the week beginning 24/Apr/2011, thus over 12 weeks (Andrews *et al*. 2011). The Victorian program did not routinely test for KUNV and a number (23) of non-typed flavivirus seroconversions were detected in the sentinel chickens, with three dual MVEV/KUNV infections identified. Seroconversions to MVEV along the Murray occurred in all sentinel chicken flocks barring the most easterly two of Rutherglen and Wodonga (Figure 9); similarly the NSW program also detected no KUNV or MVEV this far east although there was one flavivirus isolate of EHV from the nearby site to Wodonga of Albury. In total, the Victorian program detected 46 MVEV seroconversions with positive chickens from west to east at, Mildura, Robinvale, Tooleybuc, Swan Hill, Kerang, Barmah, Toolamba and Cobram. There where also two MVEV seroconversions from additional flocks located at Bendigo. A total of 69 chickens were detected with flavivirus antibodies, presumably a number of these may have been infections with KUNV in light of the activity of this virus across NSW. However, isolates of the flaviviruses EHV and KOKV were also yielded from the NSW program, with EHV being isolated from sites along the Murray (Albury and Mathoura), and thus some of the seroconversions could have been to these viruses.

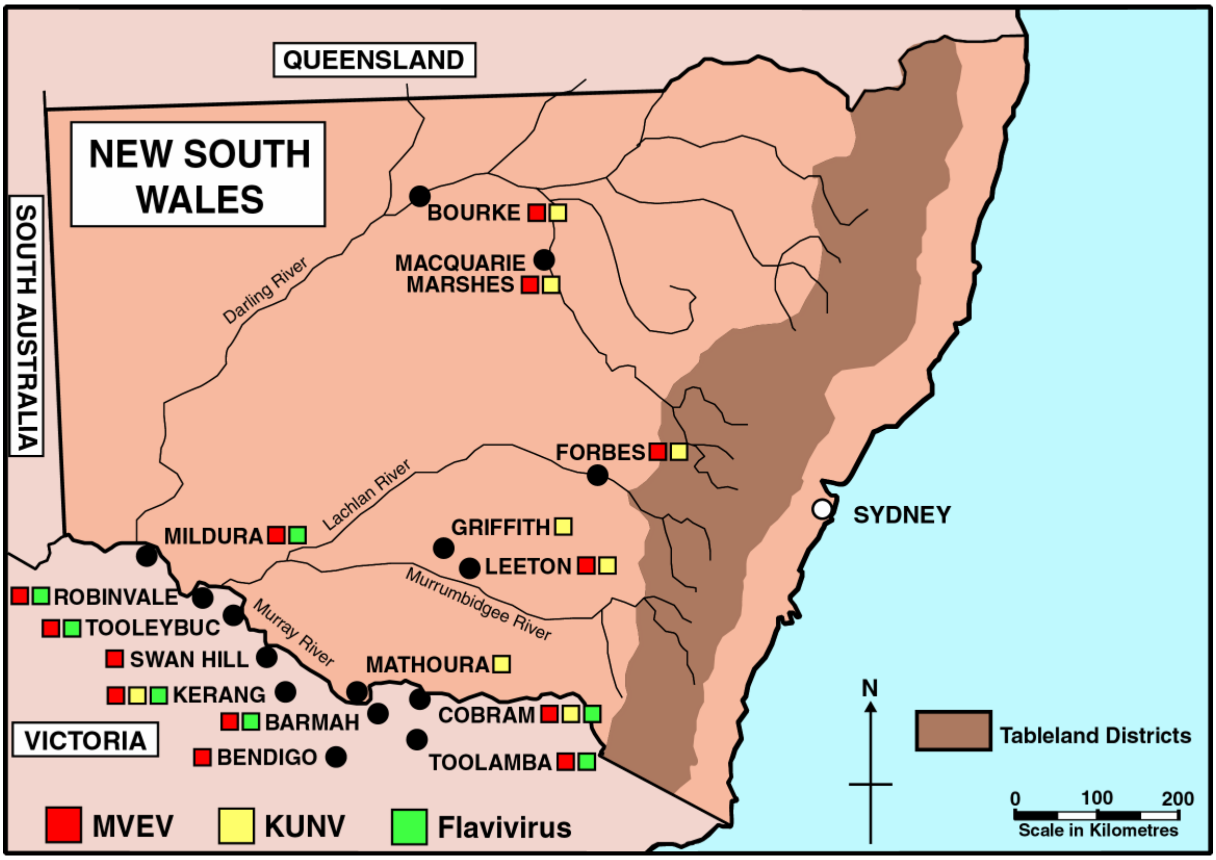


Figure 9. Locations across south eastern Australia where flavivirus activity (MVEV & KUNV) were recorded for 2010-2011. This represents data from mosquito isolations and chicken seroconversions from the NSW Arbovirus Surveillance Program and the Victorian Arbovirus Disease Control Program (Andrews *et al*., 2011). The Victorian program did not test for seroconversions to KUNV, rather general flavivirus antibodies, which are indicated in the green. There was also widespread activity of KUNV and MVEV in horses, these sites are not depicted.

As already noted there was one non-fatal human case of MVEV disease from northern NSW, there were also two cases from South Australia (one fatal), yet no cases from Victoria (Moran, 2011). A serosurvey along the Murray revealed infections in seven humans with MVEV and two with KUNV (Moran, 2011). There was also a major outbreak of disease in horses involving two syndromes; muscle and joint soreness, and a neurological syndrome. Equine cases occurred across eastern Australia (including NSW, Vic, Qld and SA) and were suspected to have involved MVEV and KUNV for the neurological cases, and RRV for the muscle/joint syndrome. As of 24/May/2011, some 876 horses were affected with 79 deaths, yielding an overall fatality rate of around 9% (Muscatello, 2011). Most of the deaths related to the neurological syndrome and if the muscle/joint cases are excluded, then the fatality rate was just over 11%. In early June, three cases of neurological illness were subsequently diagnosed from WA. In Victoria, the RRV cases were mostly from central Victoria, while the neurological cases were mainly from the north of the state, along the Murray. While in NSW, the equine cases were all neurological and occurred throughout the length of the slope districts as well as along the entire coastal strip, albeit mainly close to the base of the mountains. Cases in this state first appeared in late January and were still being reported in early June. In SA, most equine cases were reported from around the mouth of the Murray River. There have been considerable discrepancies in the serological testings of the horses by different agencies (and consequently in the reporting of results) and this is yet to be rectified.

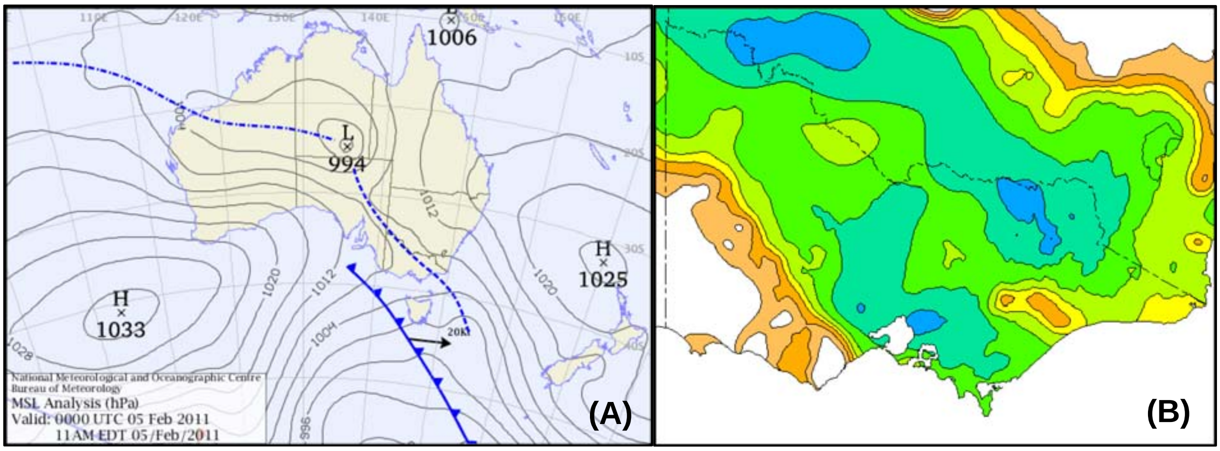


Figure 10. Meteorological maps from 5/Feb/2011. Figure A shows the low pressure cell being the remanent of TC Yasi and the low depression trough which formed that ran south east through the Murray Valley. Figure B shows the intensive rainfall in Victoria associated with the trough from the same day, which was particularly heavy along the Murray River; the colour progression to blue indicates greater rainfall amounts.

Currently there are various debates about the status of MVEV endemicity in southeastern Australia. Various suggestions have been made including that MVEV is brought south through opportunistic movements of water birds in intensively wet seasons, or that the virus may occur in enzootic foci and only appears during protracted periods of high precipitation that initiates major vector breeding. More recently a third proposal was suggested. Following an outbreak of Bovine Ephemeral Fever virus (BEFV) in 2008, which was concomitant with MVEV activity through central inland NSW, it was suggested that virus infected vectors may be blown south from endemic regions in the north through unusual meteorological events. In this case, a low pressure cell that began in northern Australia moved through central Qld and thence through central NSW and out through Victoria. This low pressure cell preceded the first cases of BEFV in NSW by 1-2 days. A similar scenario may have occurred this season. Tropical cyclone Yasi, which crossed the coast in far north Qld, moved westward and into central Australia where it finally dissipated. In the process, a low depression trough was formed that ran from the northwest to the southeast passing through large tracts of the Murray Valley (Figure 10A). This brought heavy rainfall to southern NSW and Victoria, but particularly along the Murray (Figure 10B). The first seroconversions to MVEV in southeastern Australia for the 2010-2011 season occurred along the Murray at three sites (Barmah, Mildura and Tooleybuc) during the week beginning 7/Feb/11 (Andrews *et al*. 2011), which was the very week after the rainfall event associated with TC Yasi. The time to the seroconversions were comparable to that observed with the first BEFV seroconversions in 2008. As noted above the first MVEV detections in NSW occurred two weeks later on 21/Feb/2011. The TC Yasi possible link may also explain why the activity seemed to be more intense along the Murray Valley then in other parts of NSW.

Unfortunately concurrent surveillance methodologies (i.e. both mosquito collections and sentinel chicken flocks) were not operated at many of the inland sites when the MVEV activity was detected. There were no mosquito collections at the times of the seroconversions from Bourke or Forbes. Retrospective analysis of flavivirus detection technologies when both mosquito surveillance with virus isolation and sentinel chicken flocks have operated concurrently, revealed that both systems will detect a flavivirus on 50% of occasions. By only having one system in place, the surveillance program is thus substantially weakened and the flavivirus activity will not be detected around half the time. In light of the continuing MVEV risk for the upcoming season (discussed below), multiple surveillance systems should be operated at inland sites.

One unusual aspect to the mosquito collections for this season was the high number and proportion of floodwater *Aedes* collected, notably *Aedes theobaldi*, *Aedes vittiger*, *Aedes eidsvoldensis* and *Aedes sagax*. Also unusual was that a number of isolates were recovered from these species including BFV, RRV and EHV. Viruses such as MVEV are known to survive in the eggs of floodwater *Aedes* species, which is a mechanism by which the virus can be maintained from one mosquito season to the next (Broom *et al*. 1995). In late 2003, there was one seroconversion in the sentinel chicken flock to MVEV at Menindee despite two seasons of dry weather. There was extensive flavivirus activity along the Darling River in early 2001 with MVEV seroconversions at Menindee. The seroconversion in 2003 occurred shortly after a period of local rainfall, and it was postulated that the activity may have resulted through survival of MVEV in floodwater *Aedes* eggs (Doggett *et al*. 2004). In light of the extensive MVEV activity this season and the high number of *Aedes* in the collection, there must be a considerable risk of MVEV recurring in 2011-2012.

For the MVEV climatic based models, the Forbes' hypothesis is indicating probable activity for the 2011-2012 season, however the Nichol's theory is more circumspect as only the Autumn period is in line with past pre-MVEV active years. It is also important to note that during various recent MVEV active seasons, namely 2000-2001, 2003-2004 and 2007-2008, that both the hypotheses were not suggesting potential activity.

Along with the flaviviruses, there was considerable alphavirus activity involving SINV, RRV and BFV. There were 71 SINV isolates the majority occurring during the first wave of arbovirus activity between mid-November and mid-January (Figure 8). The virus was widespread being detected at almost all inland monitoring sites including Albury, Bourke, Griffith, Leeton, Mathoura and Wagga. SINV is a bird related virus and activity of this virus has on occasion in the past shown to precede that of MVEV and KUNV (Doggett *et al*. 2001), thus perhaps this virus could an early warning indicator for MVEV. No human cases of SINV disease were notified. The Victorian program also yielded several SINV isolates from mid-December (Andrews *et al*. 2011).

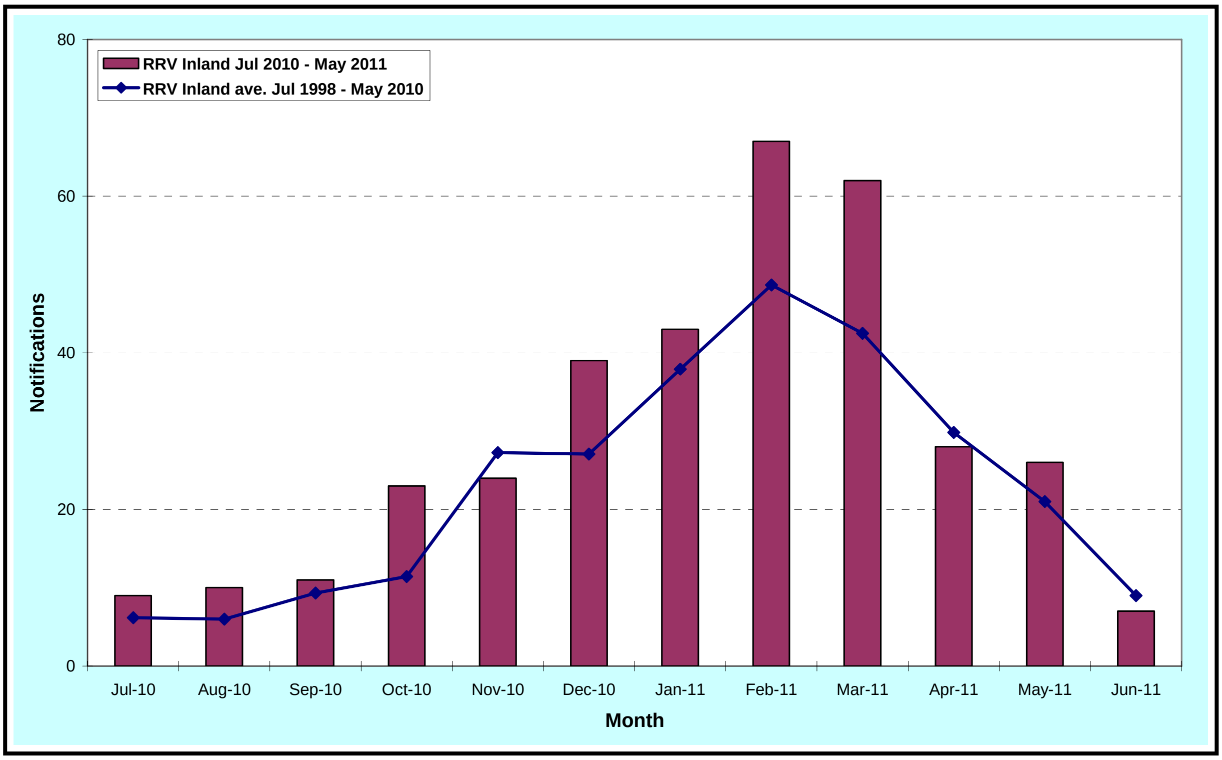


Figure 11. Notifications of RRV per month from inland NSW. The bars are for 2010-2011 season and the line represents the long term average. Data from 'GODSEND'.

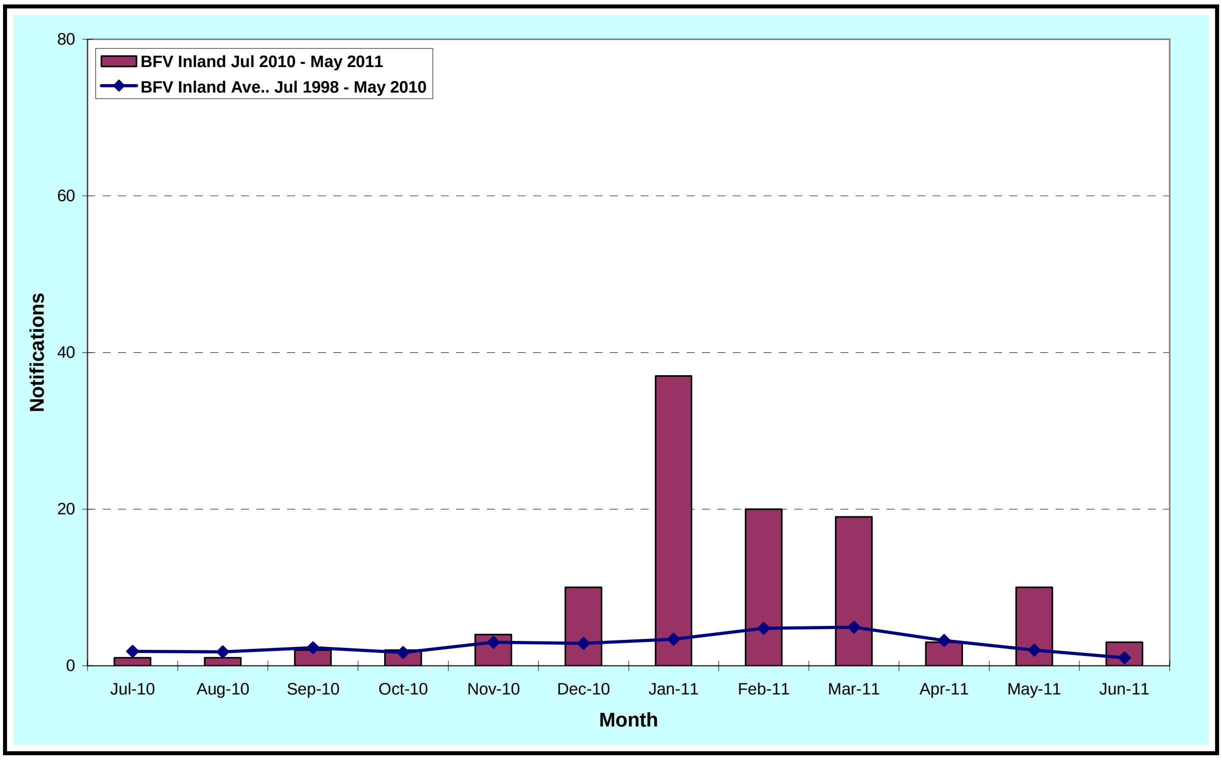


Figure 12. Notifications of BFV per month from inland NSW. The bars are for 2010-2011 season and the line represents the long term average. Data from 'GODSEND'.

Thirteen RRV isolates were made during the course of the season, all during the second wave of arboviral activity, which was also when the peak in notifications occurred (Figure 11). The RRV isolates occurred from several sites including Griffith, Leeton and Menindee, with ten isolates coming from *Culex annulirostris*, two from *Aedes theobaldi* and one from *Anopheles annulipes*. Human notifications were again greater than average (349 this season compared to the average of 285), although not as high as the last (493) despite the much greater mosquito abundances this season (Table 6). This could relate to the 'herd immunity' effect, namely when there is recent activity of an infectious agent within a community a number of individuals will become immune; this can reduce the potential and size of subsequent outbreaks. The SLAs that produced most cases (Figure 7A) included Narrabri (28 notifications), Deniliquin (26), Wentworth (16), Griffith (15), Leeton (15) and Forbes (14). The highest rates (Figure 7B) were from the SLAs of Murrumbidgee (416/00,000), Deniliquin (335), Bourke (323), Wentworth (226), Wakool (223), Narrandera (214), Central Darling (213) and Narrabri (210). Interestingly the top 25 highest notification rates this season for RRV were all from the inland, indicating the greater risk of arboviral disease for communities from inland regions of NSW.

Despite BFV being first isolated from an inland region (from the Barmah State Forest along the Murray River in Victoria in 1974) isolates of the virus from inland NSW are rare; prior to this season the virus had only been isolated on two occasions, once in Menindee during the 1992-1993 season and once in Leeton during the 2007-2008 season. For the 2010-2011 season, BFV was isolated on seven occasions, twice from Griffith and five times from Leeton. Four of the isolates were yielded from *Culex annulirostris* and three from *Aedes theobaldi*. As noted above, the isolates were made during the first wave of arboviral activity between mid-November and early January. Like the arboviral isolates, human cases have been uncommon from inland regions with an historical average of 28 notifications (Table 6). The 2010-2011 season resulted in 112 notifications, an epidemic that was four times the average and almost double the previous inland region high of 58 recorded during the 2005-2006 season. Most of the cases this season occurred through December to March (Figure 12), before the peak in RRV notifications. Thus there was a strong correlation between the timing of the alphavirus isolations and the human disease notifications. The SLAs that produced most cases included Leeton (eight notifications), Berrigan (seven) and Wagga (six), while the highest rates were from Bourke (129/100,000), Murray (124) and Balranald (119).

The Coast. Arbovirus activity along the coast was relatively low for the season of 2010-2011. There were only eight identified isolates: five BFV, three RRV, plus three unknowns. Human notifications were also well down, the 563 reported cases (299 BFV and 264 RRV) was around 20% lower that the long term average of 749 (Table 6). The difference this season was due to the much lower reports of RRV disease (264 notifications compared with the average of 439), with much fewer cases reported during normal peak incidence (Figure 13). The BFV isolates occurred early in the season and this coincided with a peak in notifications (Figure 14), which prompted a number of PHU's to release mosquito warnings.

Despite the lower activity, rainfall on the coast was generally well above average for the 2010-2011 season, and the last quarter of 2010 being especially wet. For many regions, more rainfall results in greater mosquito number, which in turn leads to greater arbovirus activity and more human cases. In contrast, mosquito numbers were well down, especially that of *Aedes vigilax*, the saltmarsh mosquito. This season, *Aedes vigilax*, which is the main arboviral vector, only comprised 22.1% of all mosquitoes trapped from the coast when normally this figure is around 50-60%. Early seasonal rainfall can prevent the saltmarsh habitat from undergoing the usual tidal inundation and drying cycle which is so important for egg maturation in the species. The continual wetting of the habitat may have allowed predators to access the marshes thereby preventing the populations of the species from building up as per normal years. The other species that has produced numerous arboviral isolates over recent years, especially BFV, is *Aedes procax* and this season its numbers were also down. Most years this species accounts for around 3-5% of the collections, but this season it was down to 1.8%. The fewer numbers of the two major coastal vectors must have been a major contributing factor for the lower than usual arboviral activity.

Table 6. Notifications of BFV & RRV infection* per virogeographic regions of NSW, per season from 1994-1995 to 2010-2011 (*after Doggett 2004, Doggett & Russell 2005*).

Season	BFV				RRV			
	Coastal Cases[1]	Inland Cases[2]	Sydney[3]	Total	Coastal Cases[1]	Inland Cases[2]	Sydney[3]	Total
94/95	233	8	7	**248**	163	45	14	**222**
95/96	141	9	3	**153**	399	511	32	**942**
96/97	155	19	16	**190**	731	566	250	**1,547**
97/98	103	14	2	**119**	162	129	41	**332**
98/99	208	26	8	**242**	575	522	117	**1,214**
99/00	158	22	6	**186**	359	341	43	**743**
00/01	367	18	3	**388**	432	218	115	**765**
01/02	371	14	11	**396**	135	73	6	**214**
02/03	407	21	6	**434**	395	57	10	**462**
03/04	303	26	6	**335**	417	176	41	**634**
04/05	394	33	9	**436**	327	87	23	**437**
05/06	536	58	20	**614**	730	419	119	**1,268**
06/07	504	47	38	**589**	428	196	52	**676**
07/08	471	49	17	**537**	638	453	105	**1,196**
08/09	355	38	10	**403**	614	275	63	**952**
09/10	246	41	6	**293**	511	493	119	**1,123**
10/11	299	112	38	**424**	264	349	25	**638**
Total	**4,952**	**443**	**168**	**5,563**	**7,016**	**4,561**	**1,150**	**12,727**
Ave[4]	310	28	11	348	439	285	72	795

[1]Represents the former Area Health Services of CC, HUN, ILL, MNC, NR and SA. [2]Represents the former Area Health Services of FW, GM, MAC, MW and NE. [3]Represents the former Area Health Services of CS, NS, SES, SWS, WEN and WS. [4]This is the fourteen season average from 1994-1995 to 2009-2010. *Data from 'GODSEND'.

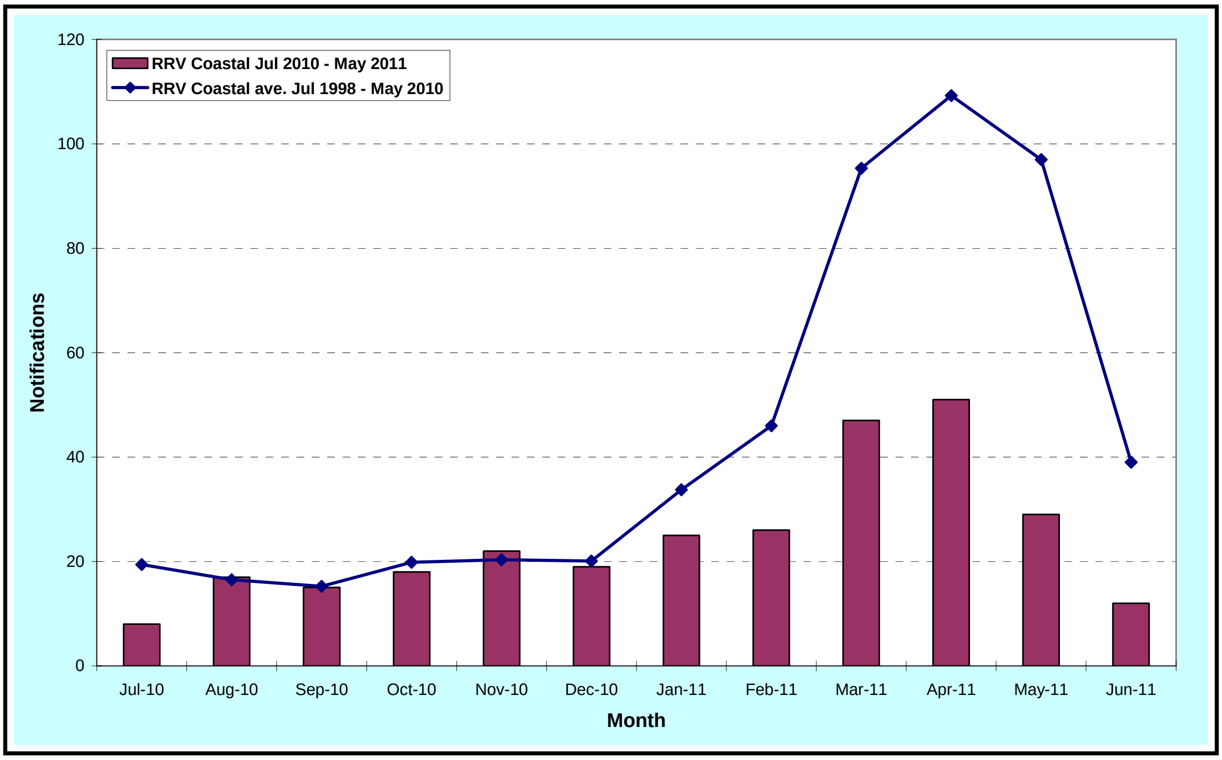


Figure 13. Notifications of RRV per month from coastal NSW. The bars are for 2010-2011 season and the line represents the long term average. Data from 'GODSEND'.

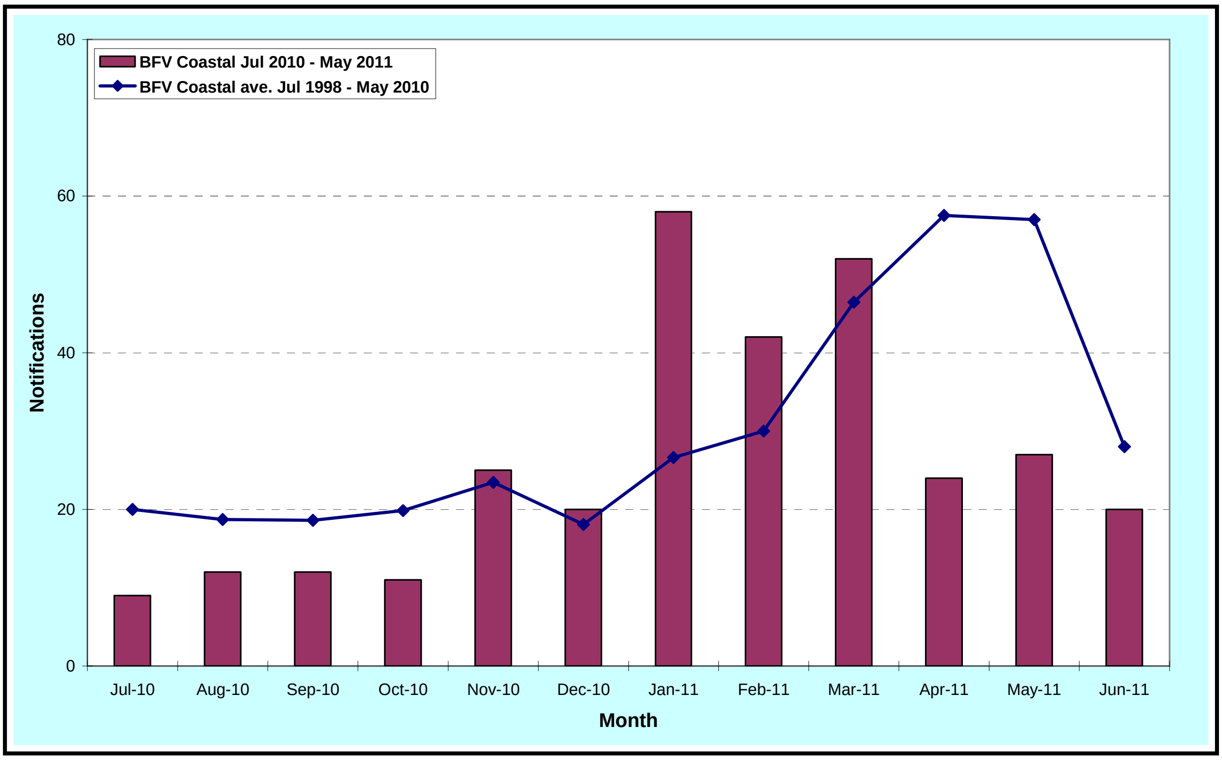


Figure 14. Notifications of BFV per month from coastal NSW. The bars are for 2010-2011 season and the line represents the long term average. Data from 'GODSEND'.

Additionally, mosquito activity declined much more quickly this season compared to the past. From March onwards temperatures were below average and mosquito numbers fell away quite quickly, albeit bar the most northern sites. The shorter season (combined with lower vector numbers) is reflected in the human notifications, which were well below average from April onwards (Figures 13 & 14).

In terms of overall notifications for SLAs across the state, Byron had the greatest number with 49 (35 BFV & 14 RRV), followed by Tweed (24 BFV & 22 RRV) and Maclean (24 BFV & 14 RRV, Figures 7a&c). In relation to notification rates (Figures 7b&d), Maclean was the highest for the coast with 177/100,000, followed by Byron (149), Richmond River (135) and Nambucca (99).

For the south coast, monitoring was confined to Batemans Bay, where two traps were operated. Mosquito numbers were well down this year, in fact *Aedes notoscriptus* was regularly the most common species trapped each week, where normally *Aedes vigilax* is the most common. There were no arboviral isolates from the mosquitoes. From the Eurobodalla shire, there were 18 human notifications (14 RRV and 4 BFV), which was well down upon previous years and the average of 28.

Sydney. For the Sydney region, six trapping sites operated over 2010-2011. Total mosquitoes trapped were only slightly greater than last season despite the extra two trapping locations. Mosquito numbers were mostly down due to the lower number of *Aedes vigilax* trapped this season. There were 63 human disease notifications (38 BFV and 25 RRV) and this was well down upon the long term average of 83 (11 BFV and 72 RRV), largely due to the notifications of RRV being about one third that of normal (Table 6). This season was one of the few times that there were more BFV notifications (38) than RRV (25). No particular SLA dominated in terms of notifications and there were none with more than four reported cases.

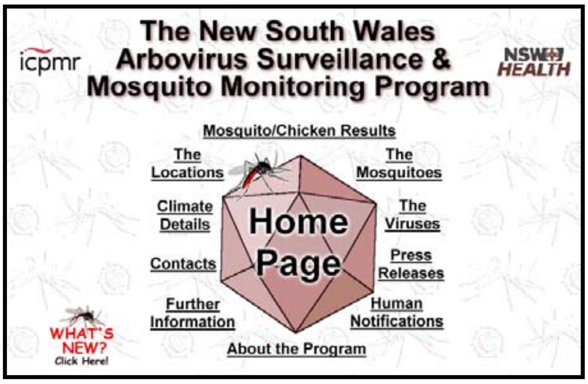
There was one isolate of KUNV virus from the Lower Portland site within Baulkham Hills. This was from *Culex annulirostris* trapped on 25/Mar/11. This is the first ever isolate of KUNV from coastal NSW and the isolate coincided with an outbreak of KUNV disease as discussed above. It is unknown if the virus will continue to persist on the coast and if it will present a human health risk. A number of horse handlers were tested for antibodies to KUNV and no positive individuals were found (L. Hueston, unpublished data).

The KUNV isolate follows the isolation of KOKV for the first time from coastal NSW in 2009-2010. The mechanism of virus transferral to the coast is presently unknown, although in both years there was extensive activity of the each virus across the inland. In light of this, the possibility of MVEV occurring along the coast in the future can not be readily dismissed, which highlights the need for ongoing virus surveillance in regions considered otherwise non-endemic.

THE NEW SOUTH WALES ARBOVIRUS SURVEILLANCE WEB SITE

http://www.arbovirus.health.nsw.gov.au/

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 266MB, and has 2,000+ pages of information.



Added to the site since the last annual report includes:

- Archived data for the 2010-2011 season,
- Weekly rainfall summaries,
- Monthly rainfall summaries, with long-term averages,
- Monthly rainfall and temperatures maps,
- Daily high tides,
- Monthly SOI updates.

Appendix 1. LOCATION-BY-LOCATION SUMMARY

http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/results/results.htm

Inland Locations

Albury: mosquito numbers were notably greater this season compared to the last two previous, with two collections of over two thousand mosquitoes per trap night from Kremur St in mid-December. Collections from early November through to mid-March this season were consistently 'high' and above average from Kremur St, and 'high' from Waterworks Rd through early November to early January. There were seven arboviral isolates from the trapped mosquitoes; these are listed in Table 7 below. No sentinel chicken flocks operated at Albury.

Table 7. Arbovirus isolates from Albury, 2010-2011.

Site	Date Trapped	Mosquito Species	Virus		
			EHV	SINV	Total
Waterworks Rd	23-Nov-10	*Culex annulirostris*		1	**1**
Kremur	13-Dec-10	*Culex annulirostris*		1	**1**
Kremur	22-Dec-10	*Culex annulirostris*		4	**4**
Kremur	11-Jan-11	*Aedes mallochi*	1		**1**
Kremur	11-Jan-11	*Culex annulirostris*		1	**1**
		Virus	**1**	**7**	**8**

Bourke: there were only two mosquito collections undertaken: one each in mid-November and mid-January. The second collection during the week of the 16/Jan/2011, yielded 'high' mosquito numbers with two Sindbis isolates both from *Culex annulirostris*. There were a number of seroconversions in the sentinel chickens; five MVEV from the bleed from the 23/Feb/11, one KUNV in the following week, and a further MVEV seroconversion from the bleed taken on 21/Mar/11.

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

Forbes: no mosquito collections were undertaken this season. There were three seroconversions in the sentinel flocks: one MVEV from the bleed taken on 23/Mar/11 and two KUNV, one each from the bleeds on 17/Mar/11 and 23/Mar/11.

Griffith: the overall collection of mosquitoes for this season was one of the greatest for many years, with over 100,000 mosquitoes trapped for the season. Collections at Hanwood were consistently 'very high' from early November until late March, with 'extreme' numbers of over 11,000 trapped on two occasions, once in mid-December and again in late February. Barren Box had lower mosquito numbers, although numbers were mostly 'very high' from November to early March. There were a total of 42 isolates, which was one of the highest numbers of isolates to date and included BFV for the first time; these are listed in Table 8 below. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Table 8. Arbovirus isolates from Griffith, 2010-2011.

Site	Date Trapped	Mosquito Species	Virus					
			BFV	RRV	SINV	KOKV	KUNV	Total
Hanwood	15-Mar-11	*Culex annulirostris*					2	**2**
Hanwood	8-Mar-11	*Culex annulirostris*		3				**3**
Hanwood	8-Mar-11	*Anopheles annulipes*		1				**1**
Hanwood	8-Mar-11	*Culex annulirostris*		1				**1**
Barren Box	8-Mar-11	*Culex annulirostris*					1	**1**
Barren Box	8-Mar-11	*Culex annulirostris*		1				**1**
Barren Box	8-Mar-11	*Culex annulirostris*				1		**1**
Barren Box	8-Mar-11	*Culex annulirostris*		2				**2**
Hanwood	22-Feb-11	*Culex annulirostris*					1	**1**
Hanwood	8-Feb-11	*Culex annulirostris*					1	**1**
Hanwood	31-Dec-10	*Culex annulirostris*			4			**4**
Barren Box	21-Dec-10	*Culex annulirostris*			1			**1**
Hanwood	21-Dec-10	*Culex annulirostris*			6			**6**
Barren Box	13-Dec-10	*Culex annulirostris*			4			**4**
Hanwood	13-Dec-10	*Culex annulirostris*	1					**1**
Hanwood	13-Dec-10	*Culex annulirostris*			8			**8**
Hanwood	30-Nov-10	*Culex annulirostris*			1			**1**
Hanwood	23-Nov-10	*Culex annulirostris*			1			**1**
Barren Box	16-Nov-10	*Culex annulirostris*			1			**1**
Hanwood	16-Nov-10	*Culex annulirostris*	1					**1**
		Total	**2**	**8**	**26**	**1**	**5**	**42**

BFV = Barmah Forest virus, RRV = Ross River virus, SINV = Sindbis virus, KOKV = Kokobera virus, KUNV = Kunjin virus.

Table 9. Arbovirus isolates from Leeton, 2010-2011.

Site	Date Trapped	Mosquito Species	Virus				
			BFV	RRV	SINV	KOKV	Total
Farm 347	7-Dec-10	*Aedes theobaldi*	1				**1**
Farm 347	7-Dec-10	*Culex annulirostris*	1				**1**
Farm 347	14-Dec-10	*Culex annulirostris*	1		2		**3**
Farm 347	23-Dec-10	*Aedes theobaldi*	1				**1**
Farm 347	23-Dec-10	*Culex annulirostris*			1		**1**
Farm 347	23-Dec-10	*Culex annulirostris*			1		**1**
Farm 347	5-Jan-11	*Culex annulirostris*			1		**1**
Farm 347	5-Jan-11	*Aedes theobaldi*	1				**1**
Farm 347	1-Feb-11	*Aedes theobaldi*		1			**1**
Farm 347	9-Feb-11	*Culex annulirostris*			1		**1**
Farm 347	23-Feb-11	*Culex annulirostris*		1			**1**
Farm 347	9-Mar-11	*Aedes theobaldi*		1			**1**
Farm 347	22-Mar-11	*Culex annulirostris*				1	**1**
		Total	**5**	**3**	**6**	**1**	**15**

BFV = Barmah Forest virus, RRV = Ross River virus, SINV = Sindbis virus, KOKV = Kokobera virus.

Leeton: mosquito numbers from Farm 347 were well above average for the entire season and mostly 'very high' even with the first collection in November. Mosquito numbers from Almond Rd were lower, although there were a number of 'very high' collections early in the season. There were 15 arboviral isolates, all were from Farm 347 and included the BFV for the second time only at Leeton; all isolates are listed in Table 9. There were several seroconversions; one to MVEV from the bleed taken on 19/Mar/11, and four KUNV seroconversions, one each from the bleeds taken on 13/Mar/11, 3/Apr/11, 11/Apr/11 and 17/Apr/11.

Macquarie Marshes: only very limited mosquito trapping was undertaken and this mostly occurred after mid-February when numbers were mostly 'low'. There were two MVEV seroconversions from the bleed taken on 21/Feb/2011 and three KUNV seroconversions from the bleed taken on 6/Mar/11.

Mathoura: surveillance was conducted for the first time at this site. Trapping was undertaken at Picnic Point and at Moama from where the sentinel chicken flock was located. Mosquito collections early at the season at Picnic Point were 'very high' through December and thereafter mostly 'high'. Moama tended to collect higher mosquito numbers with mostly 'very high' collections from mid-January through to early March. There were a total of 32 isolates and these are listed in Table 10 below. There was one KUNV seroconversion in the sentinel chicken flock from the bleed taken on 6/Apr/11.

Table 10. Arbovirus isolates from Mathoura, 2010-2011.

Site	Date Trapped	Mosquito Species	Virus				
			SINV	EHV	KUNV	Virus?	Total
Mathoura	7-Dec-10	*Anopheles annulipes*	1				**1**
Mathoura	7-Dec-10	*Culex annulirostris*	14				**14**
Mathoura	7-Dec-10	*Culex australicus*	1				**1**
Mathoura	14-Dec-10	*Culex annulirostris*	8				**8**
Mathoura	21-Dec-10	*Culex annulirostris*	2				**2**
Mathoura	4-Jan-11	*Culex annulirostris*				1	**1**
Mathoura	11-Jan-11	*Aedes sagax*				1	**1**
Moama	18-Jan-11	*Culex annulirostris*				1	**1**
Moama	2-Feb-11	*Aedes vittiger*		1			**1**
Mathoura	2-Feb-11	*Culex annulirostris*			1		**1**
Moama	8-Mar-11	*Culex annulirostris*			1		**1**
		Total	**26**	**1**	**2**	**3**	**32**

SINV = Sindbis virus, EHV = Edge Hill virus, KOKV = Kokobera virus, KUNV = Kunjin virus, Virus? = unknown (not MVEV, KUNV, EHV, STRV, KOKV, RRV, BFV or SINV).

Menindee: Mosquito collections were undertaken at one site producing 'high' mosquito numbers for most of the season. There was one RRV isolate from *Culex annulirostris* trapped on 31/Jan/11. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Wagga Wagga: trapping was undertaken at two sites on eight occasions. Collections were mostly 'high' in number with some 'very high' collections in mid-December. There were four isolates of SINV from *Culex annulirostris* trapped on 21/Dec/10. No sentinel chicken flocks operated from Wagga Wagga.

Coastal Locations

Ballina: trapping was again undertaken at two sites this year: North Creek Road and Pacific Pines. North Creek Road consistently produced greater mosquito numbers and were 'high' for all but two weeks early in the season during late October and early November. Despite this, the highest collections were from Pacific Pines and 'very high' collections were yielded in late February and early April. The collections at this time were strongly dominated by *Verrallina funerea*, and this was the most common species trapped from both sites. Compared to previous years, *Coquillettidia linealis* was particularly abundant this season. There were two unidentifiable isolates (not BFV, RRV, MVEV, EHV, KOKV, KUNV, MVEV, STRV); one from *Culex halifaxii* trapped at Pacific Pines on 22/Mar/11 and one from *Verrallina funerea* trapped at North Creek Rd on 30/Mar/11.

Batemans Bay: mosquito trapping was again conducted at two sites over the season: the Council Deport and Watergardens. The former site produced mostly yielded 'high' numbers, with *Aedes vigilax* dominating the collections. Collections from Watergardens were consistently 'low' with one 'medium' trap in late February. No arboviral isolates were yielded.

Bellingen: trapping was conducted on three occasions only and 'low' mosquito numbers were trapped. No arboviral isolates were yielded.

Byron Bay: traps operated at Luan Court and Wirree Drive. Mosquito numbers at Luan Court were rarely greater than 'low' for the entire season. Wirree Drive yielded slightly greater collections but tended to be 'medium' in number. No arboviral isolates were yielded.

Gosford: two sites at Gosford were again monitored this year: Empire Bay and Killcare Heights. Mosquito numbers tended to be lower this year, although the start of the season yielded a number of 'high' collections, which tended to be dominated by *Aedes notoscriptus*. *Aedes vigilax* was only occasionally the dominant species trapped. There was one isolate of BFV from *Aedes notoscriptus* trapped at Empire Bay on 20/Jan/11.

Lake Macquarie: collections were undertaken from three sites: Belmont Lagoon, Dora Creek and Teralba, and only 'low' numbers were trapped for the entire season. No viruses were isolated from the mosquitoes.

Port Macquarie: Trapping began in late February and continued until mid-May from two sites: Lord St and Partridge Ck. Collections at Lord St tended to be 'low' to 'medium', with *Coquillettidia linealis* being the main species collected. Partridge Ck consistently yielded 'high' collections, with the main species being trapped being *Culex annulirostris*, *Coquillettidia linealis*, *Verrallina funerea* and *Mansonia uniformis*. There were two RRV isolates, both from *Culex annulirostris* trapped at Partridge Ck on 15/Mar/11.

Port Stephens: monitoring of mosquitoes was undertaken at the usual five sites up until mid-April, although trapping was mostly fortnightly from February onwards. The collections, as per the norm, varied substantially in mosquito abundance and species composition between the sites, which reflects the diverse mosquito breeding habitats within the region. Some trapping sites for example, are near freshwater habitats, while others are near saltmarsh environments. For the 2010-2011 season, mosquito numbers were down upon previous years largely due to the small than usual collections of *Aedes vigilax*. Gan Gan had 'low' to 'medium' collections up until mid-January, when collections were 'high' for the remainder of the month. Thereafter mosquito numbers varied from through 'low' to 'high'. *Coquillettidia linealis* was the main species collected. Saltash collections were down upon usual for this site and tended to be 'low' to 'medium', although several 'high' catches were made in January. *Coquillettidia linealis* was again generally the predominant species; normally there is a much higher proportion of *Aedes vigilax* at this site. Medowie collected mostly 'high' mosquito densities. *Aedes vigilax* was the dominant mosquito species in most of the collections. Karuah produced similar collections to Medowie, albeit slightly higher and *Aedes vigilax* was predominant. Thus mosquito numbers were 'high' throughout the season. As per usual, Heatherbrae yielded the most mosquitoes for any site along coastal NSW. There were three weeks of 'very high' collections; one each in mid-January, mid-March and early April. These largest collections tended to be predominantly *Aedes vigilax* and *Coquillettidia linealis.* Generally however, collections were down upon previous seasons. There were five arboviral isolates: four were BFV isolated from *Aedes vigilax* with one each trapped from Karuah on 12/Jan/11, Heatherbrae on 12/Jan/11, Gan Gan on 18/Jan/11 and Medowie on 25/Jan/11, plus there was one RRV from *Coquillettidia linealis* trapped at Gan Gan on 8/Mar/11.

Tweed Heads: mosquito collections were mostly 'low' up to February with a number of 'high' collections thereafter through to April. The collections were dominated by *Culex sitiens*. In contrast, *Aedes vigilax* collections were well down; the most caught in one week was only 22. No virus isolation was undertaken.

Wyong: trapping was undertaken at two sites: Ourimbah and Halekalani. Collections were consistently 'low' and dominated by *Aedes notoscriptus*, with occasional 'medium' to 'high' numbers of *Culex annulirostris* trapped from the latter site from January until early March. No arboviral isolates were yielded.

Sydney Locations

Baulkham Hills: trapping began in late January at three sites: Lower Portland, South Maroota and Cattai. Mosquito numbers were mostly 'medium' with the occasional 'high' collection, with freshwater species dominating at all sites. There was one isolate of KUNV from *Culex annulirostris* trapped at Lower Portland on 25/Mar/11, this is the first ever isolation of KUNV from the coastal strip of NSW.

Blacktown: Mosquito trapping was undertaken on eight occasions from two locations, Nurragingy Reserve and Ropes crossing, and 'low' to 'medium' mosquito numbers were mainly yielded. No arboviral isolates were yielded.

Georges River: trapping was again undertaken at the same three sites of Alfords Point, Lugarno and Illawong, on four occasions only. Mosquito numbers were much lower this year, with collections mostly 'low' to 'medium' and the occasional 'high' trap. No arboviral isolates were yielded.

Hawkesbury: trapping was undertaken four sites on various weeks, including at Wheeney Creek, Yarramundi, Sackville and McGraths Hill. The collections were generally ‘low’ for most of the season (and lower than previous years), although Wheeney Creek occasionally had ‘high’ mosquito numbers early in the season. No arboviral isolates were yielded.

Ryde: as per every season Wharf Road trapped the most mosquitoes for any of the sites at Ryde as it is closer to the *Aedes vigilax* breeding ground in Homebush Bay. Numbers at this site were consistently high from mid-January to March. Overall collections were down this year, with most other sites trapping ‘low’ numbers. Maze Park had the occasional ‘high’ yield, dominated by *Culex annulirostris*. Virus isolation was undertaken mainly from Lambert Park and no isolates were yielded.

Sydney Olympic Park: mosquito monitoring at this location has been occurring for a number of years and just one site was again included in the processing for arbovirus surveillance. Mosquito collections were mostly ‘low’ to ‘medium’ collections for the entire season. No arboviral isolates were yielded.

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. 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 from BFV across inland NSW.

Ross River virus (RRV): this virus causes RRV disease and is the most common arbovirus affecting humans in NSW and Australia. For the state, there are around 700 cases per season. A wide variety of symptoms may occur from rashes with mild fever, to arthritis that can last from months to occasionally 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 southeastern Australia.

Flaviruses

Alfuy virus (ALFV): no clinical disease has been associated with this virus and it has not been isolated from southeastern 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). 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 made it to the coast, which resulted in an outbreak amongst horses with a number of animal 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 four seasons when MVEV activity has been detected within the state: 2000-2001, 2003-2004, 2007-2008 and 2010-2011. With the latest two seasons of activity, there were two human cases. 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.

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
GODSEND	Graphical Online Data Surveillance and Evaluation for Notifiable Diseases
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
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)

ACKNOWLEDGMENTS

This project is funded and supported by the Environmental Health Branch of NSW Health. The following are acknowledged for their efforts in the Arbovirus Program:

Sarah Potter (Environmental Health Branch, NSW Health, Gladesville); Tracey Oakman, James Allwood & Warren Matthews (Greater Southern Area Health Service); Tony Brown, Bill Balding, David Ferrall, Gerard vanYzendoorn (Greater Western Area Health Service); Dr David Durrheim (Hunter New England Area Health Service); Paul Corben, Kerryn Allen, David Basso, Greg Bell and Geoff Sullivan (North Coast Public Health Unit), Dr Peter Lewis, Sam Curtis, John James, Adam McEwen (Central Coast Public Health Unit, Gosford); Prof. Mark Ferson, Santo Cannata (South Eastern Sydney/Illawarra Area Health Service); Helen Ptolomy (Sydney West Area Health Service); Lindsay Mack & Lauriston Muirhead (Albury City Council); Graham Plumb, Kristy Beard, Kerri Watts, Rachael Currie, Richard & Alison Lucas (Ballina Shire Council, Ballina); Nancy Bird (The Hills Shire Council); David Bell and Jon Rushforth (Byron Bay Shire Council), David Sanders, Pauline Porter and Cassie Vitucci & Abby Smith (Griffith Shire Council, Griffith); Laura Craddock, Dianne Tierney, Edward White, Andrea Horan & Christine Mitchell (Hawkesbury Council); Ben Lang (Leeton Shire Council, Leeton); the McLellan family (especially Linda) (Macquarie Marshes); Ivan Cowie, David Ferrall and Jason Harwood (Menindee); Graeme Pritchard, Bruce Peterson, & Leigh Ernst (Port Stephens Shire Council, Raymond Terrace); Gith Striid (Ryde Council); Karen Willems & Cameron Webb (Sydney Olympic Park Authority); Clive Easton & Brian Falkner (Tweed Shire Council, Murwillumbah).

The chicken handlers included: Tom Orcher (Bourke), Ronda Smith (Deniliquin), Brendan Hayes (Forbes), Abby Smith (Griffith), Ben Lang (Leeton), Linda McLellan (Macquarie Marshes), Patricia Doyle (Menindee), and David Dundee (Moama). The laboratory staff within CIDM are acknowledged, particularly Jennifer Goder and Sue Howard.

Human case numbers and epidemiological information were obtained through 'GODSEND', the Graphical Online Data Surveillance and Evaluation for Notifiable Diseases, which is part of NSW Health's Notifiable Diseases Database. The input of Dr Craig Godfrey, Director of Animal Care, Westmead Hospital in the continuation of the chicken surveillance program is greatly appreciated. We are grateful to the Arbovirus Laboratory, Department of Microbiology, University of Western Australia, particularly Dr Cheryl Johansen for the supply of monoclonal antibodies for antigen detection. Dr Kim Andrews of the Victorian Arbovirus Disease Control Program, Department of Primary Industries, Attwood kindly provided information on the Victorian flavivirus activity for the 2010-2011 season.

Our apologies to anyone inadvertently omitted.

REFERENCES

Andrews K., Brown K., Crowder J., Valenzuela I., Goulter R. and Thompson C. (2011). **VADCP Annual Report 2010-2011**. *Department of Primary Industries, Melbourne*. 125pp.

Bennett N.McK., Ummenhofer C.C. and Moran R. (2009). **Peculiarities of Murray Valley encephalitis (MVE) epidemics in south-eastern Australia: the Indian Ocean dipole (IOD) as a predictor of epidemics**. *Victorian Infectious Diseases Bulletin*, 12(4): 112-115.

Broom A.K., Lindsay M.D.A., Johansen C.A., Wright A.E. and MacKenzie J.S. (1995). **Two possible mechanisms for survival and initiation of Murray Valley encephalitis virus activity in the Kimberley region of Western Australia**. *American Journal of Tropical Medicine & Hygiene*, 53: 95-99.

Bureau of Meteorology, Australia. (2011). Rainfall Maps. http://www.bom.gov.au/cgi-bin/climate/rainmaps.cgi, *accessed 30/Jul/2011.*

Cashman P. Hueston L., Durrheim D., Massey P. Doggett S. and Russell R. (2008). **Barmah Forest virus serology; implications for diagnosis and public health action**. *Communicable Diseases Intelligence*, 32(2): 263-266.

Dobrotworsky N.V. (1965). **The Mosquitoes of Victoria**. *Melbourne University Press, Carlton*.

Doggett S., Russell R. and Dwyer D. (1999). **NSW Arbovirus Surveillance Web Site**. *NSW Public Health Bulletin,* 10: 7.

Doggett S. (2004). **Population health aspects of mosquito-borne disease in New South Wales**. *NSW Public Health Bulletin*, 15: 193-199.

Doggett S., Clancy J., Haniotis J., Russell R.C., Hueston L., Marchetti M. and Dwyer D. (2001). **The New South Wales Arbovirus Surveillance & Mosquito Monitoring Program. 2000 – 2001 Annual Report**. *Department of Medical Entomology, Westmead*. 27pp.

Doggett S., Clancy J., Haniotis J., Russell R.C., Hueston L., Marchetti M. and Dwyer D. (2004). **The New South Wales Arbovirus Surveillance & Mosquito Monitoring Program. 2003 – 2004 Annual Report**. *Department of Medical Entomology, Westmead*. 23pp.

Finlaison D.S., Read A. J. and Kirkland P.D. (2008). **An epizootic of bovine ephemeral fever in New South Wales in 2008 associated with long-distance dispersal of vectors**. *Australian Veterinary Journal*, 88(8): 301-306.

Forbes J.A. (1978). **Murray Valley encephalitis 1974 - also the epidemic variance since 1914 and predisposing rainfall patterns**. *Australasian Medical Publishing Co., Glebe*. 20pp.

JAMSTEC (2011). **Japanese Agency for Marine-Earth Science and Technology web site**. Indian Indian Ocean Dipole Mode Index (click on drop down tab). http://www.jamstec.go.jp/frsgc/research/d1/iod/2007/observations/iod_observations.html.en

Lee D.J., Hicks M.M., Griffiths M., Russell R.C., Geary M. and Marks E.N. (1980 – 1989). **The Culicidae of the Australian Region. Vols. 1 - 11**. *Australian Government Publishing Service, Canberra*.

Mackenzie J.S., Broom A.K., Calisher C.H. *et al.* (1993). **Diagnosis and reporting of arbovirus infections in Australia**. *Communicable Diseases Intelligence*, 17(10): 202-206.

Moran R. (2011). **Public Health Implications and Consequences of the Recent Floods; Future Predictions; Victoria**. *Arboviruses, Public Health and recent Floods Symposium. CIDMLS, Westmead Hospital, Westmead,24/Jun/2011.* Available from:
www.cidmpublichealth.org/resources/pdf/symposiums/aug-10-2011/rodney-moran.pdf

Muscatello, G. (2011). **Arbovirus Outbreak Impacting Horses in Australia**. *Arboviruses, Public Health and recent Floods Symposium. CIDMLS, Westmead Hospital, Westmead, 24/Jun/2011.* Available from:
www.cidmpublichealth.org/resources/pdf/symposiums/aug-10-2011/gary-muscatello.pdf

Nicholls N. (1986). **A method for predicting Murray Valley encephalitis in southeast Australia using the Southern Oscillation**. *Australian Journal of Experimental Biology and Medical Science,* 64: 587-94.

Russell R.C. (1993). **Mosquitoes and mosquito-borne disease in southeastern Australia**. *Department of Medical Entomology, Westmead, NSW*, 310pp.

Russell R.C. (1996). **A Colour Photo Atlas of Mosquitoes of Southeastern Australia**. *Department of Medical Entomology, Westmead, NSW*, 193pp.

Victorian Department of Health. (2010). **Contingency plan for the reappearance of Murray Valley Encephalitis virus in Victoria**. *Victorian Department of Health, Melbourne*.