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THE NEW SOUTH WALES ARBOVIRUS SURVEILLANCE & MOSQUITO MONITORING PROGRAM

2009-2010 Annual Report

Coquillettidia xanthogaster

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ISBN 1-74080-126-1

EXECUTIVE OVERVIEW

- **For the 2009-2010 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 2009-2010 season for the inland were of extremely low precipitation mid-2009, followed by average rainfall towards the end of the year. The first quarter of 2009 was extremely wet, particularly during February and March, and this was accompanied by a period of warm weather late in the mosquito season. For the coast, conditions were mostly similar although there was above average rainfall along the mid-north coast in the last quarter of 2009 and the summer rainfall tended to be close to average.
- **For the inland**, the dry conditions in late 2009 meant that mosquito numbers were low at the start of the season; however, the wet weather in summer, coupled with warm conditions in both summer and autumn, meant that the mosquito season was extremely protracted, and mosquito numbers remained consistently above average even into March and April. KOKV was quite active this year with seven isolates from the inland plus 3 RRV. There were no seroconversions in the sentinel chickens.
- **Currently, the Forbes' hypothesis is indicating a possible MVEV epidemic** for the upcoming season of 2010-2011. The Nichols' model for autumn is slightly out of the range of past MVEV active years, but well in the range for the winter period.
- **Human notifications from the inland** totalled 534, which was well above the long term average of 298, and included 493 RRV and 41 BFV. The statistical local area with the most cases was Dubbo, with 34 RRV, while many cases occurred in the Riverina and central west. The highest notification rates for the state were experienced from the inland, notably the SLA of Bourke, which had a crude rate of 485 arboviral notifications per 100,000.
- **For the coast**, mosquito numbers were close to average although, like the inland, many large collections were made late in the season, especially from Port Stephens. There was a total of 26 isolates, including 4 RRV, 7 EHV, 1 KOKV, 12 STRV and 2 unknowns. The KOKV isolate was the first ever from the coast. Twenty isolates were from *Aedes vigilax,* and three each from *Aedes procax* and *Aedes notoscriptus*.
- **Coastal disease notifications** totalled 757 cases including 246 BFV and 511 RRV, and this represented an average season. However, BFV notifications were the lowest for the last ten years. The statistical local area that produced the highest case load was Byron, with 73 notifications (39 RRV & 34 BFV).
- **For the Sydney trapping locations,** four sites operated and overall mosquito numbers were around 25% greater than last season. There were seven isolates from the region, including 4 RRV, 1 KOKV and 2 STRV. Human notifications were well above the average of 80, with a total of 125 cases including 119 RRV and 6 BFV.
- **The NSW Arbovirus Surveillance Web Site** http://www.arbovirus.health.nsw.gov.au/ continued to expand and now has over 214MB of information with 1,880+ pages.

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NSW ARBOVIRUS SURVEILLANCE AND MOSQUITO MONITORING PROGRAM 2009-2010

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 cases of disease. 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 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 2009-2010 season follow.

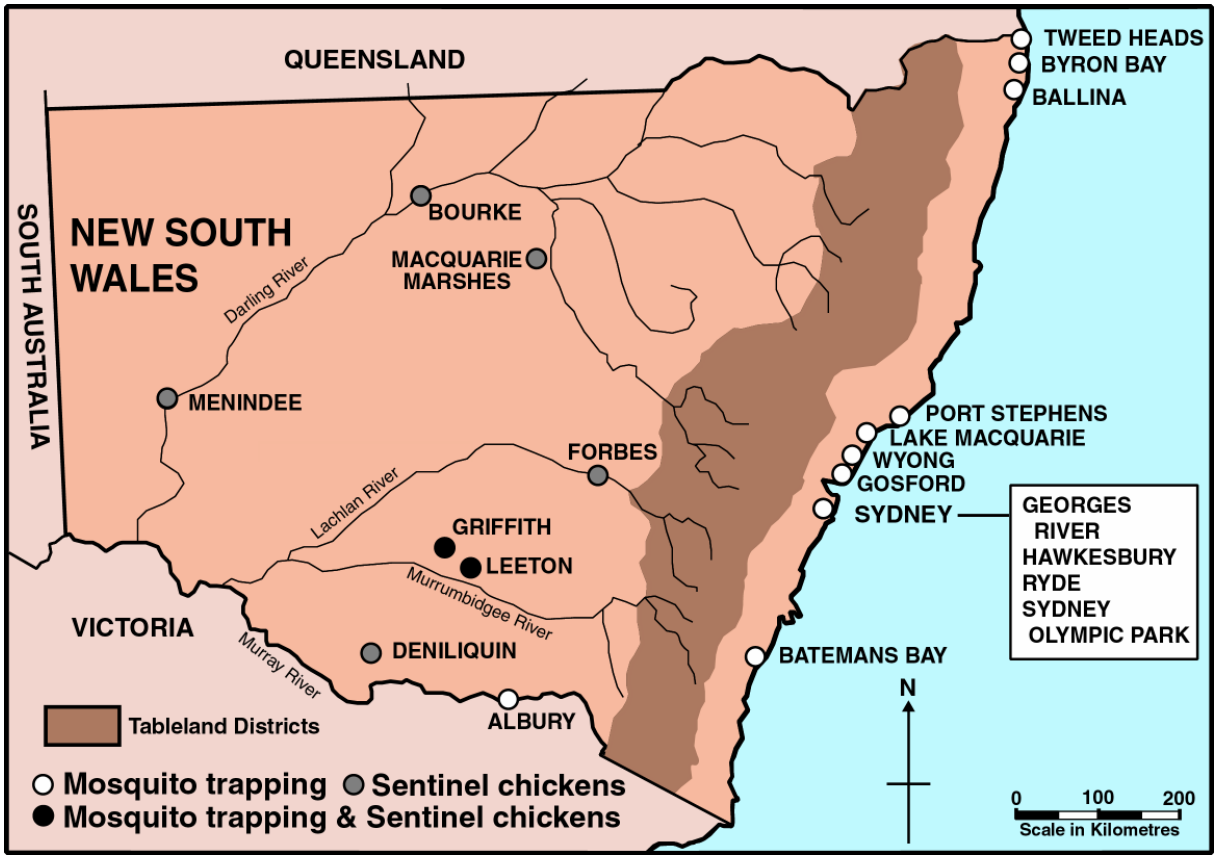


Fig 1. Mosquito trapping locations and Sentinel Chicken sites, 2009-2010.

MONITORING LOCATIONS

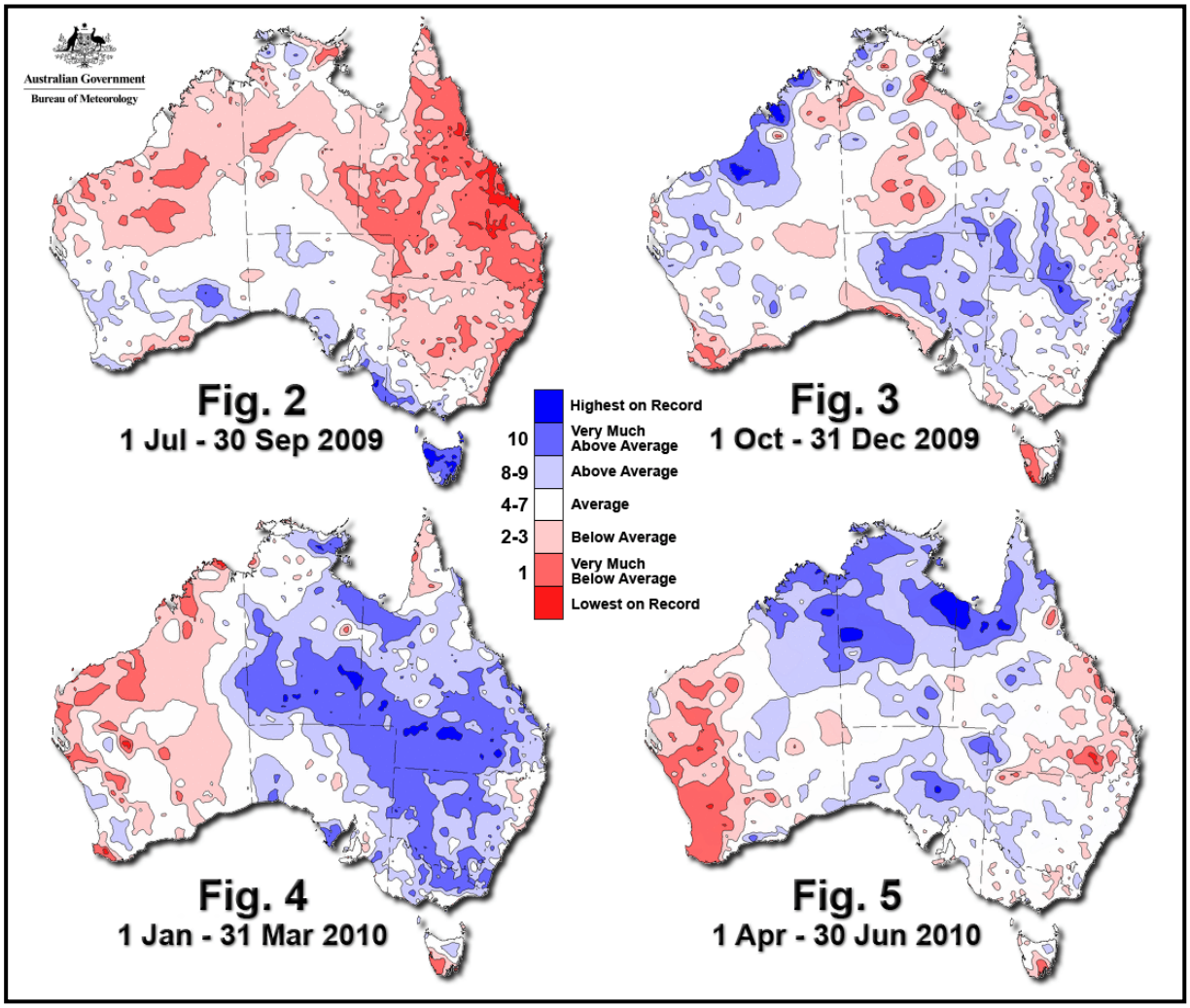
http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/location/locations.htm

For 2009-2010, mosquito-trapping sites were operated at 3 inland, 8 coastal and 4 Sydney locations (Fig 1). Chicken sentinel flocks were located at 7 locations.

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 2009, Oct-Dec 2009, Jan-Mar 2010 & Apr-Jun 2010. The stronger the red, the drier the conditions. Conversely, the stronger the blue, the wetter the conditions. *Modifed from the Australian Bureau of Meterology, 2010*.

For the start of 2009, precipitation levels were average to well below average particularly along the Murray Valley, with January being exceptionally dry throughout much of the state but especially along the coast and southern inland regions. The second quarter of 2009 had more normal conditions and even above average rainfall through central inland, while the north coast was quite wet with very much above average rainfall. For the third quarter of 2009 the entire state experienced below average rainfall, with pockets of very much below average precipitation along the coast (Figure 2). This was followed by a period to the end of December of more average precipitation, with regions of above average precipitation in the central north inland, mid-north coast and far west (Figure 3). For the first quarter of 2010, intense rainfall was experienced right across the inland with much of the region having very much above average precipitation, however the coastal strip had mostly normal rainfall levels (Figure 4). The second quarter of 2010 experienced a return to more normal rainfall patterns (Figure 5).

Temperatures for the last half of 2009 were mostly around normal, although November was extremely warm with temperatures up to six degrees average across the inland and 3-5 degrees above normal along the coast. During November, temperatures were above average in southern areas of the state. January 2010 was also hot, with temperatures 2-3 above normal across the state. February was the opposite; being much cooler with the far north west of the state being 4-5 degrees below average. Early March was relatively cool, while late March had above average temperatures, which continued well into April.

MVEV Predictive Models

Two 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.

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 2008) or the first quarter of the current year (January-March 2009) and the last quarter of the current year (October-December 2009), then a MVEV outbreak is probable. Rainfall was not above decile 7 for all the catchment basins for the last quarter of 2008, nor for the first or last quarter of 2009, and thus the hypothesis was not satisfied for the 2009-2010 season. However, rainfall was above decile 7 in **all** of the catchments for the first quarter of 2010, and thus the first part of Forbes hypothesis has been fulfilled for 2010-2011, indicating a possible risk of an MVEV epidemic for the upcoming season.

Nicholls' hypothesis uses the Southern Oscillation (SO) as a tool to indicate a possible MVEV epidemic. He 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 2009, the SO values were respectively: 1009.47mm, 1012.90mm and 1010.53mm (indicated on Figure 6 by the yellow arrows). Only the winter period was within the range of values for the same period of past MVEV outbreak years. The summer 2009–2010 SO value of 1007.20mm was also not within the range of that experienced during MVEV years. Currently, the autumn Nicholls' value for 2010 is 1009.57mm and is just outside the range of values during past MVEV outbreak years, while the winter value (i.e. for June and July only) of 1012.60 is inside the range.

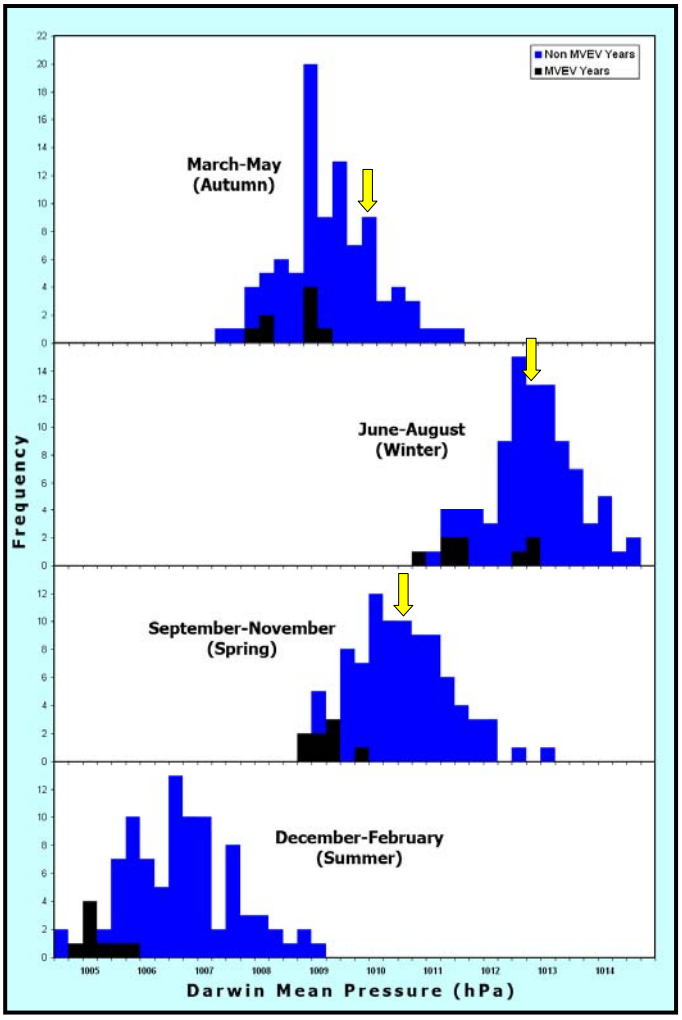


Figure 6. The SO by seasons prior to MVEV active years, according to Nicholls (1986), updated up to Spring 2009. The black bars represent the pre-MVEV active seasons. The yellow arrows indicate the respective SO values relevant to the 2009-2010 season.

It is important to note that both the Forbes' and Nichols' 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 2007-2008, 2003-2004 and the 2000-2001 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. Nor do these models take into account the possibility that the virus exists in cryptic foci, 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.

It was reported in the 2000-2001 Annual Report of the New South Wales Arbovirus Surveillance & Mosquito Monitoring Program (Doggett *et al*. 2001), that the mosquito genus *Aedes* had undergone taxonomic revisions and many species had been given the generic name of '*Ochlerotatus'*. This genus has since been used in the Annual Reports; however, most specialist scientific journals have recently reverted to '*Aedes*', pending further scientific taxonomic clarification, and hence the use of '*Aedes*' in this report. Note that the genus '*Verrallina*', which was also formerly in *Aedes*, has not reverted.

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, 111,981 mosquitoes representing 55 species were collected in NSW during the 2009-2010 season. *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 33,801 mosquitoes trapped, comprising 22 species, was three times larger than that of the previous season's collection. *Culex annulirostris* was the dominant species yielded at most sites and comprised 75.8% of the total inland collections. *Anopheles annulipes* (9.6%) was the next most common species followed by *Culex quinquefasciatus* (7.2%).

Coastal

In total, 82,738 mosquitoes comprising 50 species were collected from coastal NSW and this was considerably higher than the previous season's total collection of around 63,000. The most common species collected were *Aedes vigilax* (50.7% of the total coastal mosquitoes trapped), *Aedes notoscriptus* (10.7%), *Coquillettidia linealis* (9.0%), *Culex sitiens* (7.5%), *Culex annulirostris* (6.2%) *Verrallina funerea* (4.9%), *Aedes procax*

(2.3%), *Aedes multiplex* (1.3%) and *Culex orbostiensis* (1.3%).

Metropolitan Sydney
A total of 15,000 mosquitoes, comprising 28 species, was collected from metropolitan Sydney and this was well up upon the previous season's total collection, by around 25%. *Aedes vigilax* (41.3% of the total Sydney mosquitoes trapped) was the most common species, followed by *Culex annulirostris* (19.0%), *Aedes notoscriptus* (12.7%), *Aedes procax* (5.2%), and *Culex sitiens* (4.5%).

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.

Results

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

Table 1. Arbovirus isolates from Inland NSW, 2009-2010.

LOCATION - Site	Date Trapped	Mosquito Species	Virus			
			RRV	KOKV	Virus?	Tot
GRIFFITH - Hanwood	10-Jan-10	*Culex annulirostris*	1			**1**
GRIFFITH - Hanwood	10-Jan-10	*Aedes theobaldi*	1			**1**
LEETON - Almond Rd	12-Jan-10	*Aedes eidsvoldensis*	1			**1**
GRIFFITH - Barren Box	22-Feb-10	*Culex annulirostris*		2		**2**
GRIFFITH - Hanwood	22-Feb-10	*Culex annulirostris*		1		**1**
GRIFFITH - Hanwood	2-Mar-10	*Culex annulirostris*		1		**1**
LEETON - Farm 347	3-Mar-10	*Culex annulirostris*		1		**1**
GRIFFITH - Hanwood	22-Mar-10	*Culex annulirostris*			1	**1**
GRIFFITH - Hanwood	22-Mar-10	*Culex annulirostris*		1		**1**
GRIFFITH - Hanwood	29-Mar-10	*Culex annulirostris*		1		**1**
MENINDEE - Caravan Park	14-Apr-10	*Culex annulirostris*			1	**1**
GRIFFITH - Barren Box	28-Apr-10	*Anopheles annulipes*			1	**1**
		TOTAL	**3**	**7**	**3**	**13**

RRV = Ross River virus, KOKV = Kokobera virus.

From the mosquitoes processed, there were 34 viral isolates; ten from the inland and 24 from coastal locations. These are listed in Tables 1 and 2.

Table 2. Arbovirus isolates from Coastal NSW, 2009-2010.

LOCATION - Site	Date Trapped	Mosquito Species	Virus					
			RRV	EHV	KOKV	STRV	Virus?	Tot
PORT STEPHENS - Karuah	18-Jan-10	*Ae. vigilax*		1				**1**
BYRON BAY - Wirree Dve	2-Feb-10	*Ae. notoscriptus*				1		**1**
PORT STEPHENS - Karuah	2-Feb-10	*Ae. vigilax*		1		1		**2**
BATEMANS BAY - Council Depot	3-Feb-10	*Ae. vigilax*					1	**1**
GEORGES RIVER - Alfords Pt	8-Feb-10	*Ae. vigilax*				1		**1**
BYRON BAY - Wirree Dve	9-Feb-10	*Ae. notoscriptus*				1		**1**
PORT STEPHENS - Karuah	18-Feb-10	*Ae. vigilax*				1		**1**
PORT STEPHENS - Heatherbrae	18-Feb-10	*Ae. vigilax*		1		2		**3**
BATEMANS BAY - Council Depot	24-Feb-10	*Ae. vigilax*				2		**2**
LAKE MACQUARIE - Teralba	25-Feb-10	*Ae. vigilax*				1		**1**
PORT STEPHENS - Karuah	2-Mar-10	*Ae. vigilax*		1				**1**
PORT STEPHENS - Karuah	10-Mar-10	*Ae. vigilax*					1	**1**
GEORGES RIVER - Alfords Point	18-Mar-10	*Ae. vigilax*	2			1		**3**
BYRON BAY - Wirree Dve	23-Mar-10	*Ae. notoscriptus*				1		**1**
HAWKESBURY - Wheeney Ck	24-Mar-10	*Ae. procax*	1					**1**
RYDE - Lambert Park	24-Mar-10	*Ae. procax*	1					**1**
PORT STEPHENS - Heatherbrae	30-Mar-10	*Ae. vigilax*		2				**2**
HAWKESBURY - Wheeney Ck	7-Apr-10	*Ae. procax*			1			**1**
PORT STEPHENS - Heatherbrae	13-Apr-10	*Ae. vigilax*		1				**1**
		TOTAL	**4**	**7**	**1**	**12**	**2**	**26**

RRV = Ross River virus, EHV = Edge Hill virus, KOKV = Kokobera virus, STRV = Stratford virus.

SENTINEL CHICKEN PROGRAM

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

Location of flocks

The 2009-2010 season began on November 1st 2009 with the first bleed and ended on April 14th 2010 with the last. For 2009-2010, a total of seven flocks each containing 15 Isa Brown pullets was deployed, with one flock each at Bourke, Deniliquin, Forbes, Griffith, Leeton, Macquarie Marshes and Menindee (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 105 pullets and 1 death was recorded over the season. A total of 2,133 samples was received from the six flocks in NSW over the seven-month period in 2009-2010. This represented 4,266 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.

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 3. Arbovirus notifications according to former Area Health Service, July 2009 - June 2010*.

Month	CS	NS	WS	WE	SW	CC	HU	IL	SE	NR	MN	NE	MA	MW	FW	GM	SA	Total
RRV	8	19	22	44	16	48	140	21	10	163	76	77	97	79	60	180	63	**1123**
BFV	1	1	1	1	0	17	51	12	2	87	60	15	6	7	8	5	19	**293**
Total	**9**	**20**	**23**	**45**	**16**	**65**	**191**	**33**	**12**	**250**	**136**	**92**	**103**	**86**	**68**	**185**	**82**	**1416**

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 3 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. 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*.).

The total number of RRV and BFV notifications for the period July 2009 to June 2010 was 1,416 and included 293 BFV and 1,123 RRV. This season had the fifth highest number of notifications since reporting began in 1991, and was above the previous fifteen season average of 1,125. The coastal region accounted for 882 (62.3% of the state total) of the BFV and RRV notifications, which was just above the previous fifteen season average of 826. The 534 notifications (37.7% of the state total) from the inland were well above previous seasonal average of 298. Within the Sydney region there were 125 cases reported, almost 50% greater than the fifteen season average of 80.

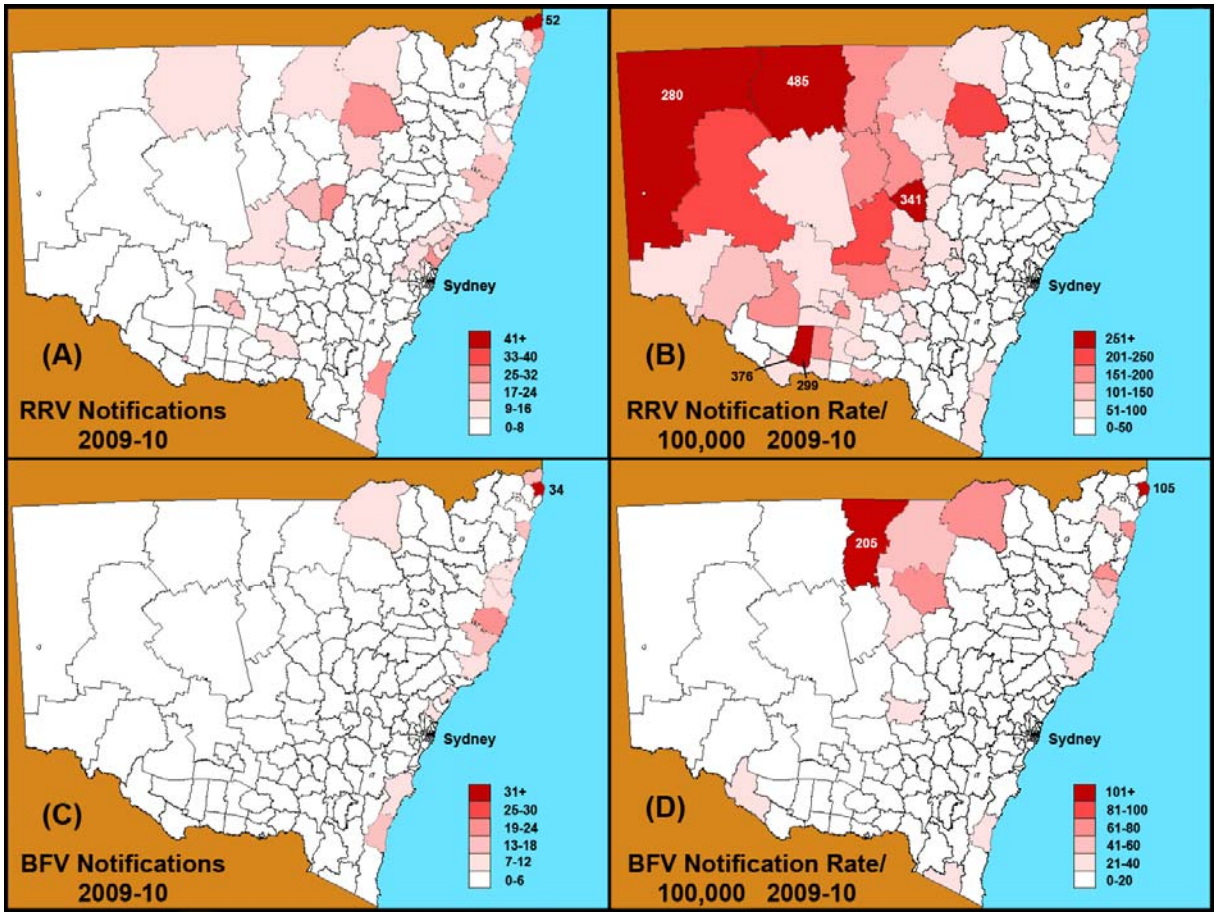


Figure 7. Notifications and notification rates of RRV and BFV by Statistical Local Areas for NSW for Jul 2009 to Jun 2010. (A) RRV notifications. (B) RRV notification rate/100,000 population. (C) BFV notifications. (D) BFV notification rate/100,000 population. Note that different scales are used on each graph. Data from 'GODSEND'.

The Northern Rivers and Hunter Area Health Services received the highest number of notifications (250 and 191 respectively) with the Mid North Coast having 136. Combined, these three areas accounted for 40.7% of all the arbovirus notifications for the state.

From the inland, the Greater Murray AHS had the highest number of notifications (185), with Macquarie having 103.

Figure 7 depicts the notifications and notification rates of RRV and BFV by Statistical Local Area (SLA) for NSW during the 2009-2010 mosquito season.

DISCUSSION

The Inland. The environmental conditions experienced across the inland for the 2009-2010 season were quite atypical compared with recent years, and were to strongly influence the mosquito and arbovirus activity. The mild rainfall during the last quarter of 2009 in the regions where the traps operated meant that mosquito populations were below average early in the season. The wet February coupled with the warm autumn meant that numbers remained consistently elevated and above average late in the season, even into March and April. For example, one collection in late March from Griffith yielded over 1,000 *Culex annulirostris* when the long term average is only around one for that time of the year. Thus the inland had a very protracted mosquito season. This was reflected also in the human notifications (Figure 8). As can be seen from the long term average on this graph, the usual peak in notifications occurs in February. However, this season the pattern of activity was very much skewed towards the latter part of the season, with the peak in cases in March, and each of the months thereafter having at least doubled the average. Thus the correlation between mosquito monitoring and human cases was very strong. The overall number of cases of RRV for 2009-2010 was one of the highest to date with a total of 493 notifications (Table 4) and almost double the average of 271. The statistical local area with the most cases was Dubbo, with 34 RRV (Figure 7A), while many cases occurred in the central and central north districts (e.g. Narrabri with 33 cases, Narromine with 35, Moree with 22) and Riverina (Deniliquin with 30, Griffith having 25, and Leeton with 22).

The high number of human notifications for the inland this season was quite striking, especially considering the mosquito populations compared to those during the 1990's. During this decade there was more land under irrigation and it was not uncommon for weekly collections from Griffith to be regularly in the order of 2,000 mosquitoes per trap night. The ongoing drought through the late 1990s and early 2000s resulted in the reduction in the planting of water intensive crops and, as a result, vector numbers have been much lower of late (usually by a factor of one tenth or less). Despite the smaller mosquito numbers, human notifications have not seen a concomitant order of decrease; thus while mosquito numbers may have declined by around 90%, human RRV cases have not even halved. While for this season RRV cases were almost double the average when the overall number of mosquitoes collected were less then half that trapped during a typical season in the late 1990s. Thus the overall risk factor for arboviral infection has actually appeared to have increased in recent years, despite the reduction in mosquito populations. The reason for this is not known, perhaps the human population has become less vigilant in personal protection measures with the reduced vector numbers, or that more virulent virus strains are presently circulating, or that there are various yet unidentified vertebrate host factors influencing activity. Clearly however, the arboviral disease threat is still a serious issue to those in highly endemic regions despite the

recent dry conditions.

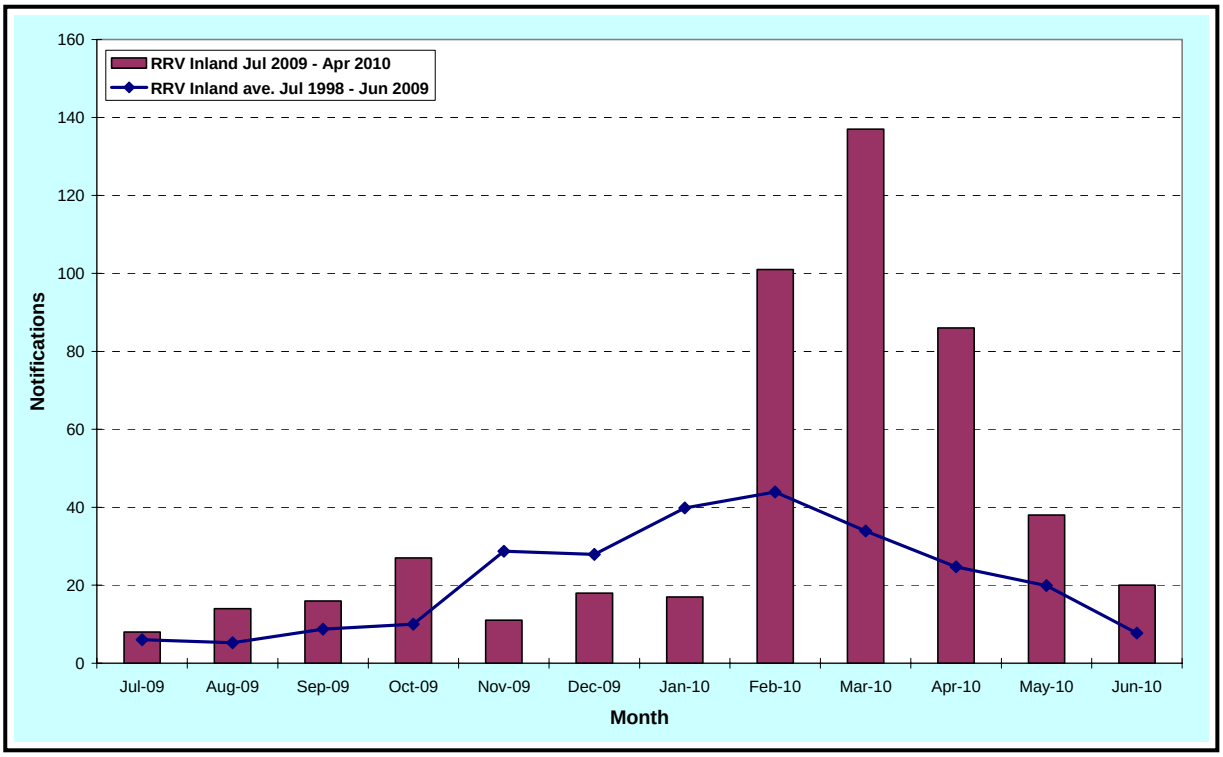


Figure 8. Notifications of RRV per month from inland NSW. The bars are for 2009-2010 season and the line represents the long term average. Data from 'GODSEND'.

In relation to possible MVEV epidemic activity for 2009-2010, neither the Forbes' nor the Nichols' predictive models were suggestive of a possible endemic for the season and no activity of MVEV or KUNV was detected in either the mosquitoes or sentinel chickens.

However there are **indicators of possible activity for the 2010-2011 season**. Currently the Forbes' hypothesis is suggestive of an MVEV epidemic, although the Nichols' theory is more circumspect. There has been extensive rainfall over the first six months of this year through inland NSW, central Australia and, only recently in July, right through these regions to northern WA where MVEV is endemic. Additionally, over recent weeks there have been several reports on the widespread water-bird breeding throughout central Australia, with Prof. Richard Kingsford (UNSW) often being quoted on the size of the event (ABC 2010a,b). The breeding cycle has followed extensive rainfall in northern Australia with the resulting water movement filling Lake Eyre. There has also been very recent extensive flooding in the catchment basement of the Murray with the floodwaters expecting to move down the river during the warmer months. Recent environmental flows along the Murray and Murrumbidgee (Clarke 2010), and increased water allocations for agriculture through the Riverina, are also likely to provide greater opportunity for vector breeding.

In light of the weather patterns and increased water availability, direct observations of water-bird breeding and recent climatic indicators, the risk of an MVEV epidemic for the upcoming summer must be considered high. Currently, surveillance strategies are being reviewed with a view to enhancing the capacity to detect flavivirus activity in NSW for the coming season.

In relation to the MVEV climatic based models, it is also important to note that neither Forbes' nor Nichols' theories were indicating activity during the recent MVEV active seasons, namely 2000-2001, 2003-2004 and 2007-2008. Likewise for these seasons, there were not the other indicators such as the extensive bird breeding and considerable rainfall in central Australia. This reinforces the need for increased surveillance activity for the 2010-2011 season.

The inland region had the highest notification rates of arboviral infection within the state and hence represents the area of greatest risk to the population. In fact of the top twenty highest rates, only two were not from the inland. Bourke again had the highest notification rate for any SLA within NSW with a crude rate of 485 arboviral notifications per 100,000 population (Figure 8b). This was followed by Deniliquin (rate of 376/100,000), Brewarrina (359), Narromine (341), Conargo (299) and Unincorporated Far West (280), The vast majority of notifications at these sites were made up of RRV cases. In terms of actual notifications, the SLA of Dubbo had the highest case numbers from the inland with 34 notifications (all RRV), followed by Narrabri (33 arboviral cases), and Deniliquin (30).

This season saw extensive activity of the flavivirus KOKV with several isolates from Griffith and Leeton. Despite this, no human cases were reported.

The Coast. The coastal strip, particularly along the north coast, had much more normal rainfall patterns over the season, although like the inland, the autumnal conditions were quite warm. This also generally resulted in a more prolonged mosquito season and overall around 30% more were collected than in 2008-2009. Some sites had extremely high mosquito numbers late in the season. For example, Heatherbrae within Port Stephens trapped over 6,000 mosquitos in late March and over 1,000 during mid-April, although the other Port Stephen sites had more normal collections. The number of notifications for RRV during April were around 30% above normal, but were mainly average through the most active mosquito months of November to May (Figure 9). What was curious was the more than double the average RRV notifications during the cooler months of June to October when vector populations are low; the reason for this has yet to be determined, however this was also observed in Queensland (Muller 2010). It is important to note that most of these notifications are based on single IgM (i.e. '*presumptive'*) which in the case of RRV has been shown to be detectable for 18 to 48 months post infection. Thus we have no real way of knowing if these are from this or previous seasons.

Notifications of BFV infection were consistent throughout the year and varied little per month with no major peak in activity (Figure 10). The 246 cases reported (Table 4) was the lowest number since before the year 2000 and indeed no isolates of the virus were made. Why there was such little activity this season compared with recent seasons remains uncertain.

This season experienced one of the most extensive and geographically widespread flavivirus activity years to date along the coast with numerous isolates of EHV and STRV

viruses. While all the EHV isolates were made from Port Stephens, the STRV were isolated from mosquitoes collected from the most northern virus surveillance site of Byron to the most southern site of Batemans Bay, and in between. It is also quite common for this virus to be isolated from *Aedes notoscriptus*. Despite the widespread activity, no human notifications were reported.

In terms of overall notifications for SLAs across the state, Byron had the greatest number with 73 (34 BFV & 39 RRV), followed by Tweed (14 BFV & 51 RRV) and Hastings (20 BFV & 30 RRV, Figures 7a&c). For most years these three localities tend to have the majority of cases. In relation to notification rates (Figures 7b&d), Byron was the highest for the coast with 226/100,000, followed by Maclean (170), Eurobodalla (122) and Bellingen (122).

Table 4. Notifications of BFV & RRV infection* per virogeographic regions of NSW, per season from 1994-1995 to 2009-2010 (*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	**1547**
97/98	103	14	2	**119**	162	129	41	**332**
98/99	208	26	8	**242**	575	522	117	**1214**
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	**1268**
06/07	504	47	38	**589**	428	196	52	**676**
07/08	471	49	17	**537**	638	453	105	**1196**
08/09	355	38	10	**403**	614	275	63	**952**
09/10	246	41	6	**293**	511	493	119	**1123**
Total	**4952**	**443**	**168**	**5563**	**7016**	**4561**	**1150**	**12727**
Ave[4]	314	27	11	351	434	271	69	774

[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 2008-2009. *Data from 'GODSEND'.

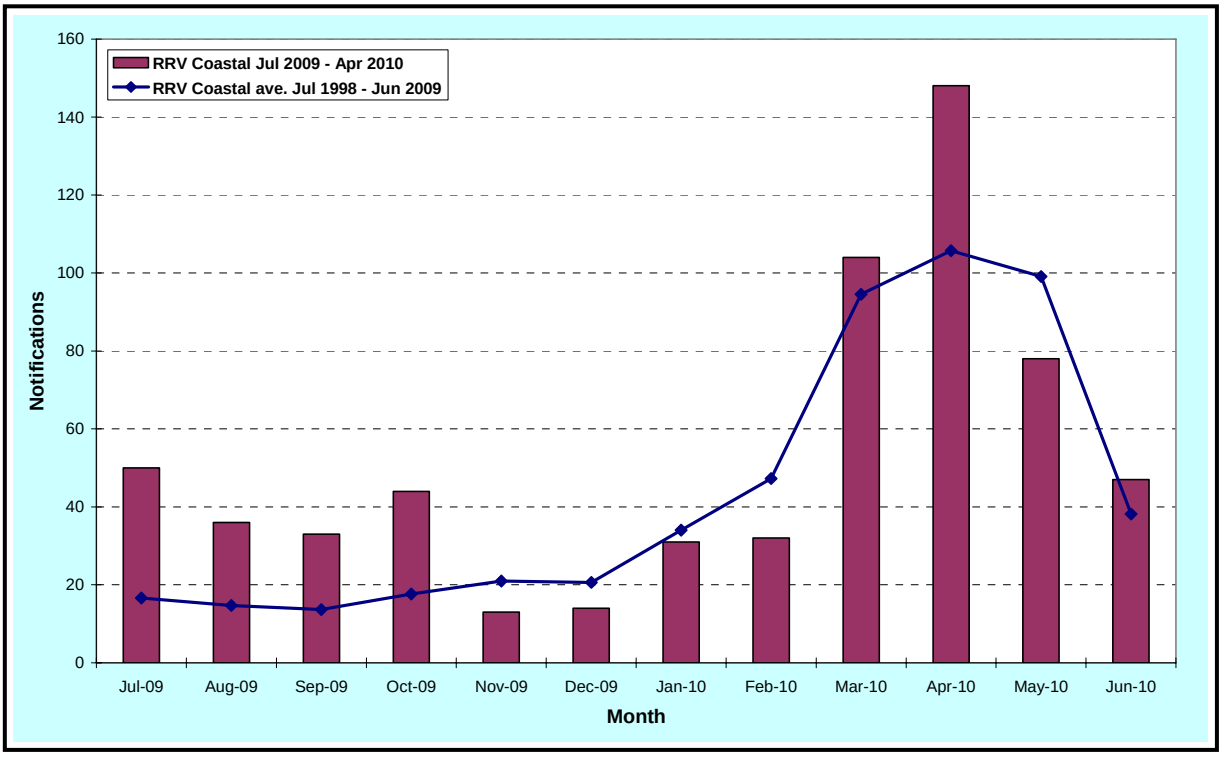


Figure 9. Notifications of RRV per month from coastal NSW. The bars are for 2009-2010 season and the line represents the long term average. Data from 'GODSEND'.

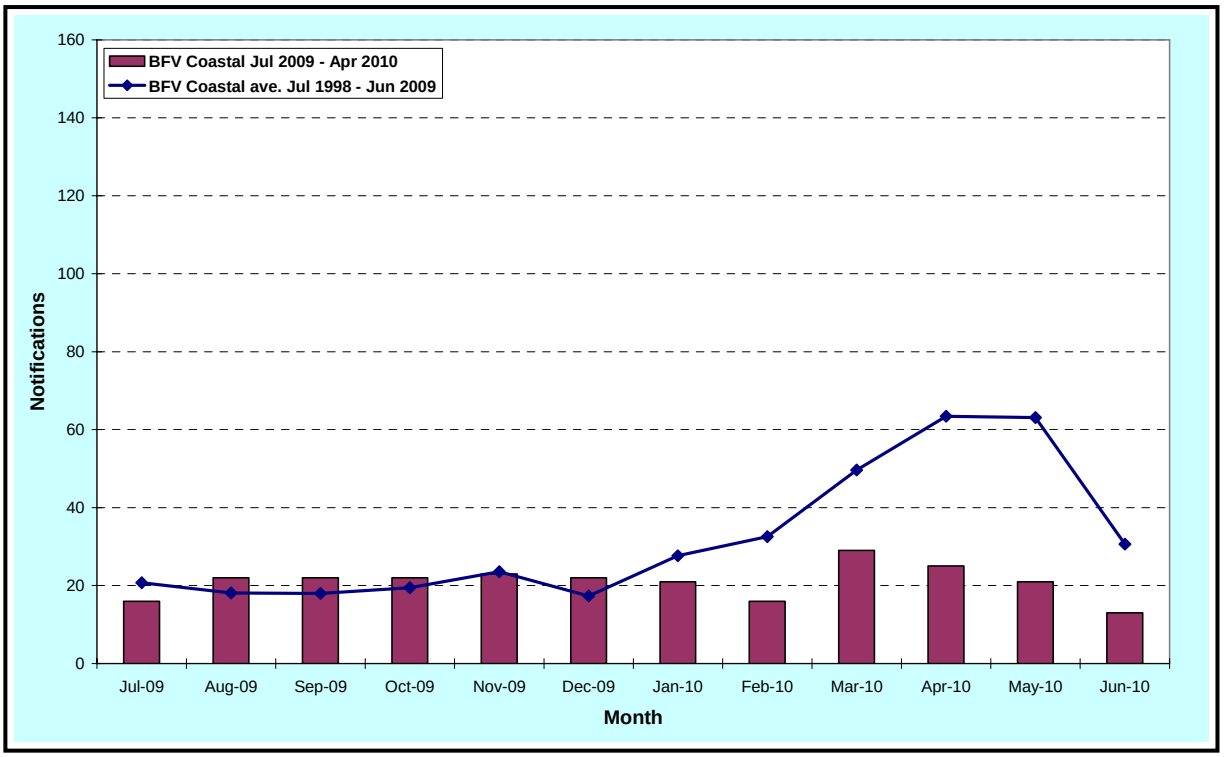


Figure 10. Notifications of BFV per month from coastal NSW. The bars are for 2009-2010 season and the line represents the long term average. Data from 'GODSEND'.

For the south coast, monitoring was confined to Batemans Bay only, where two traps were operated. Despite *Aedes vigilax* numbers being much lower in other coastal localities, at Batemans Bay this mosquito was very much the dominant species trapped, largely due to the fact that one trap site (Council Depot) is situated next to major breeding habitat. Two STRV isolates were made from *Aedes vigilax* collected during late February and there was one unknown virus from the first week of this month, also from *Aedes vigilax*. From the Eurobodalla shire there were 47 human notifications (33 RRV and 14 BFV), which was considerably higher than the average of 29 (13 RRV and 16 BFV).

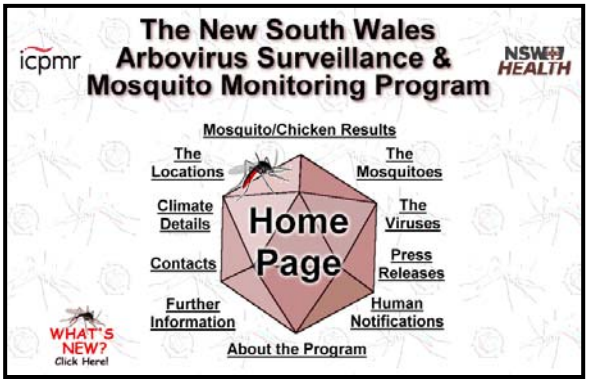
Sydney. For the Sydney region, four trapping sites operated over 2009-2010. Total mosquitoes trapped were around 25% greater than last season due mainly to the extended season with the wet February and the warm autumnal weather. There were 125 human disease notifications and this was well above the average of 80. This season, as per the coast generally, notifications were dominated by RRV (119 cases), with only 6 BFV. The SLAs producing most cases were Hawkesbury (20 RRV), Baulkam Hills (14 RRV), and Blue Mountains (14 RRV). How many of notifications in the Sydney region were locally acquired is presently unknown.

Last season saw considerable local virus activity in the Georges River area, with 26 isolates (19 RRV and 7 EHV) and an increased number of human RRV notifications. This season yielded a further three isolates from the area; 2 RRV and 1 STRV. With the isolate of BFV in 2007-2008, it is now three years in a row that there has been recorded arboviral activity from the Georges River area, highlighting the potential disease risk to the local community.

In additional to the Georges River isolate, there were another three isolates from the Sydney trapping sites including two from Hawkesbury (1 RRV and 1 KOKV) and 1 RRV from Ryde. The latter being the most urban trapping site of the Sydney isolates. The KOKV is the first time this virus was isolated from coastal NSW.

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 214MB, and has 1,880+ pages of

information.

Added to the site since the last annual report includes:

- Archived data for the 2009-2010 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. Collections from mid-December through to March this season were consistently 'medium' to 'high', whereas for the previous season there were few collections above 'low'. One unusual species trapped this season during early December was *Aedes vigilax*. This mosquito is mainly associated with coastal mud flats, although it is known to breed in salt lakes along the lower Murray. Areas along the Murray such as Mildura often experience this mosquito, but it is very rare for it to be found so far up river. There were no arboviral isolates from the trapped mosquitoes.

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

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, and there were no seroconversions to MVEV or KUNV in the sentinel chickens.

Griffith: the overall collection of mosquitoes for this season was one of the greatest for many years. Collections were consistently 'high' or greater from early December until the last collection in late April, with a series of 'very high' catches through January to late March. Mosquito collections remained above average very late in the season. For example, one collection in late March from Barren Box yielded over 1,000 *Culex annulirostris* when the long term average is only around one of that species for this time of the year. Thus Griffith experienced a very prolonged mosquito season. There were a total of ten isolates and these are listed in Table 5 below. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Table 5. Arbovirus isolates from Griffith, 2009-2010.

Site	Date Trapped	Mosquito Species	Virus			
			RRV	KOKV	Virus?	Tot
Hanwood	10-Jan-10	*Culex annulirostris*	1			**1**
Hanwood	10-Jan-10	*Aedes theobaldi*	1			**1**
Barren Box	22-Feb-10	*Culex annulirostris*		2		**2**
Hanwood	22-Feb-10	*Culex annulirostris*		1		**1**
Hanwood	2-Mar-10	*Culex annulirostris*		1		**1**
Hanwood	22-Mar-10	*Culex annulirostris*			1	**1**
Hanwood	22-Mar-10	*Culex annulirostris*		1		**1**
Hanwood	29-Mar-10	*Culex annulirostris*		1		**1**
Barren Box	28-Apr-10	*Anopheles annulipes*			1	**1**
		TOTAL	**2**	**6**	**2**	**10**

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

Leeton: mosquito numbers did not reach the densities they have in previous years, however were consistently 'high' for most of the season, even into mid-April. Like Griffith, the mosquito season was very prolonged, with numbers well above average in March and April. There were two arboviral isolates; one RRV from *Aedes eidsvoldensis* trapped at Almond Road on 12/Jan/10, and one KOKV from *Culex annulirostris* trapped at Farm 347 on 3/Mar/10. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

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

Menindee: There were only four mosquito traps set, which were done late in the season following flood waters that had moved down the Darling River and into the region. As per Griffith, collections were still 'high' and very much above average even with the last collection during mid-April. There was one putative isolate that was not identified by any of the monoclonal antibodies. This was from *Culex annulirostris* trapped at the caravan park on 14/April. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

Coastal Locations

Ballina: trapping was again undertaken at two sites this year; North Creek Road and Pacific Pines. As per last year, the latter site produced mosquito numbers that were 'low' for most weeks, although from mid-March there were a series of 'high' collections through to late-April. The species composition varied quite substantially during this period with *Aedes multiplex* being the most commonly captured mosquito. North Creek Road consistently produced greater mosquito numbers and were 'high' for all but two weeks early in the season during November. These were dominated by the mosquitoes *Verrallina funerea*, *Culex sitiens* and *Aedes vigilax*. There were no arboviral isolates from Ballina this season.

Batemans Bay: mosquito trapping was again conducted at two sites over the season: the Council Deport and Watergardens. The former site produced 'high' numbers for every trap during the entire season, with *Aedes vigilax* dominating the collections. Collections from Watergardens were consistently 'low' to 'medium', with one trap yielding 'high' numbers in mid-February. There were three arboviral isolates from the Council Depot site; two STRV isolated from *Aedes vigilax* trapped on 24/Feb/10 and one unidentified virus from *Aedes vigilax* trapped on 3/Feb/10.

Byron Bay: two mosquito traps operating and mosquito collections were notably greater than the previous season. Wirree Dive trapped consistently 'high' number for most of the trapping period with *Aedes notoscriptus* being the main species collected. Ocean Shores started off by producing mostly 'low' mosquito numbers until late January and thereafter had several 'high' trap collections. Again, *Aedes notoscriptus* was the main species yielded. There were three arboviral isolates, all STRV and all were isolated from *Aedes notoscriptus* collected at Wirree Drive. These mosquito were collected on; 2/Feb/10, 9/Feb/10 and 23/Mar/10.

Gosford: two sites at Gosford were again monitored this year: Empire Bay and Killcare Heights. For both sites, collection varied considerably over the season and fluctuated from 'low' to 'high' depending *Aedes vigilax* breeding, which was the main species trapped. Some collections were quite large during January and February when around 500 mosquitoes were collected. No viruses were isolated from the mosquitoes.

Lake Macquarie: collections were undertaken from three sites; Belmont Lagoon, Dora Creek and Teralba, and most sites produced 'low' trap numbers for the entire season. There were only two 'high' collections and these were late in the season and dominated by *Aedes vigilax* and *Culex sitiens*. No viruses were isolated from the mosquitoes.

Port Stephens: monitoring of mosquitoes was undertaken at the usual five sites and trapping was undertaken until mid-April. 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. Gan Gan had mostly 'low' to 'medium' collections, with 'high' catches in December and early January season. *Coquillettidia linealis* was the main species collected. Saltash had not dissimilar numbers and these were down upon usual for this site. There were some collections that were 'high' in number early and mid in the season, and *Coquillettidia linealis* was again generally the predominate species. Normally Saltash has a much higher proportion of *Aedes vigilax*. Medowie collected mostly 'high' mosquito densities, with one 'very high' catch in mid-February. *Aedes vigilax* was the dominant mosquito species in most of the collections, although *Coquillettidia linealis* was more common early in the season. Karuah produced similar collections to Medowie, albeit slightly higher. Thus mosquito numbers were 'high' throughout the season, with two 'very high' traps in February. *Aedes vigilax* was by far the most predominant mosquito collected. As per usual, Heatherbrae yielded the most mosquitoes for any site within NSW. There were nine weeks of 'very high' collections and even the last trapping week in mid-April produced over one thousand mosquitoes. Numbers were especially abundant in late March, when almost 6,400 mosquitoes were trapped. *Aedes vigilax* dominated most of the larger collections, although *Coquillettidia linealis* was higher in adundance early in the season. There were 12 arboviral isolates and these are listed in Table 6 below.

Table 6. Arbovirus isolates from Port Stephens, 2009-2010.

Site	Date Trapped	Mosquito Species	Virus			
			EHV	STRV	Virus?	Tot
Karuah	18-Jan-10	*Aedes vigilax*	1			**1**
Karuah	2-Feb-10	*Aedes vigilax*	1	1		**2**
Karuah	18-Feb-10	*Aedes vigilax*		1		**1**
Heatherbrae	18-Feb-10	*Aedes vigilax*	1	2		**3**
Karuah	2-Mar-10	*Aedes vigilax*	1			**1**
Karuah	10-Mar-10	*Aedes vigilax*			1	**1**
Heatherbrae	30-Mar-10	*Aedes vigilax*	2			**2**
Heatherbrae	13-Apr-10	*Aedes vigilax*	1			**1**
		TOTAL	**7**	**4**	**1**	**12**

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

Tweed Heads: mosquito collections were much greater this season with a series of 'high' traps made from both sites from January to March. The collections were mostly dominated by *Culex sitiens*, however 'high' numbers of *Aedes vigilax* were yielded during the second week of February. 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 moderate numbers of *Aedes vigilax* trapped from the latter site. No viruses were isolated from the mosquitoes.

Sydney Locations

Georges River: trapping was again undertaken at the same three sites of Alfords Point, Lugarno and Illawong. Mosquito numbers were not as big as last season when there was considerable RRV activity, with 19 isolates as well as 7 EHV. Alfords Point produced the greatest collections and were 'high' for most of the season, with one 'very high' catch in mid-January. Lugarno generally trapped 'medium' numbers, with one 'high' catch the same week numbers peaked at Alfords Point. Likewise, a similar peak occurred at Illawong and numbers tended to be mainly 'high'. *Aedes vigilax* was the most common mosquito at all sites, although the domestic species *Aedes notoscriptus* was occasionally more regularly captured at Lugarno. There were four arboviral isolates, all from *Aedes vigilax* trapped from Alfords Point. The first was a STRV isolated from collections on the 8/Feb/10, then there were two RRV and one STRV from mosquitoes trapped on 18/Mar/10.

Hawkesbury: trapping was undertaken at the five sites on various weeks including Wheeney Creek, Yarramundi, Freemans Reach, Sackville and McGraths Hill. Most of the sites produced 'low' to 'medium' collections. Wheeney Creek and Sackville produced the occasional 'high' collection and the main species that dominated the collections were *Culex annulirostris*, *Coquillettidia linealis* and *Aedes procax*. There were two arboviral isolates, all from *Aedes procax* trapped at Wheeney Creek; one STRV from 24/Mar/10 and one KOKV from 7/Apr/10. Interestingly this KOKV is the first time this virus has been isolated from the coast.

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 February to late March. Initially *Aedes vigilax* was the main species trapped, however by late in the season Culex annulirostris and Culex sitiens were the predominant mosquitoes. Lambert also had a series of 'high' collections through February and March, although *Aedes procax* was the main species yielded. Maze Park had mainly 'medium' numbers with *Aedes notoscriptus* predominating. It was mainly mosquitoes from Lambert Park were continually tested for the presence of arboviruses and there was one RRV isolate from *Aedes procax* trapped on 24/Mar/10.

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. This site produced mostly 'low' to 'medium' collections up until late January

and thereafter were mostly ‘high’ until the end of April. This season saw large collections of *Culex sitiens*, although *Aedes vigilax* was the most common species trapped. Virus isolation was undertaken but no 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 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 collected throughout NSW, although is most abundant 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.
	**The Brown House Mosquito**, ***Culex quinquefasciatus***. A common species throughout Australia and tends to breed in polluted ground pools. While this species is an important nuisance biter, it appears to be a poor vector of most of the arboviruses.

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 becoming more recognised in NSW, with around 3-400 cases annually. Despite being first isolated from an inland region, cases of BFV disease tend occur mainly in coastal regions in NSW. The main vector in NSW is *Aedes vigilax* although other species are involved, notably *Aedes procax*.

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 species are undoubtedly involved in the transmission of the virus.

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; 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 such as macropods, cattle, dogs and humans. The virus has been isolated from many mosquito species, but most notably *Culex annulirostris* in south eastern Australia.

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 south east Australia, although it has been isolated from several other mosquito species. The vertebrate hosts may be wallabies and bandicoots, however studies are limited.

Kokobera virus (KOKV): only three cases of illness associated with KOKV infection have been reported and all were from south east 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. *Culex annulirostris* appears to be the principal vector.

Kunjin virus (KUNV): disease from this virus is uncommon, with only two cases were notified from 1995-2003 (Doggett 2004). Activity is confined to the inland region of NSW

where it is detected every few years. *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 three seasons when MVEV activity has been detected within the state; 2000-2001, 2003-2004 and 2007-2008. With the latest activity there was one human case. 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 include *Aedes notoscriptus* and *Aedes procax*.

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:

Glenis Lloyd (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); Linda George (Bourke 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; Linda George (Bourke), Ronda Smith (Deniliquin), Brendan Hayes & Mat Teale (Forbes), David Sanders (Griffith), Ben Lang (Leeton), Linda McLellan (Macquarie Marshes), Patricia Doyle (Menindee). The laboratory staff within CIDM are acknowledged including; 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.

Our apologies to anyone inadvertently omitted.

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