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THE NEW SOUTH WALES ARBOVIRUS SURVEILLANCE & MOSQUITO MONITORING PROGRAM

2007-2008 Annual Report

Culex annulirostris

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EXECUTIVE OVERVIEW

- **For the 2007-2008 season**, the NSW Arbovirus Surveillance Program: (i) monitored mosquito vector populations and undertook surveillance of arbovirus activity through virus isolation on the NSW western slopes and plains, north coast region 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 2007-2008 season for the inland were of average rainfall during the first quarter of 2007, followed by very good rainfall to the end of June. The third quarter of 2007 was exceptionally dry but was followed by a period of very high rainfall, which continued into the start of 2008. By the second quarter of 2008 (i.e. April to June), conditions had again become very dry. For the coast, rainfall was more variable, although the north coast had mostly above average precipitation from July 2007 to March 2008. Two major climatic variables that influenced mosquito abundance and arbovirus activity for this season along the coastal region were the small high tides during January to April 2008, which ensured that populations of the major vector, *Aedes vigilax*, remained low, and the sudden and prolonged cold spell that began in late February, which kept mosquito numbers down for the remainder of the season.

- **For the inland**, the good rainfall patterns meant that mosquito numbers were well up upon the previous season, although not as high as experienced when water intensive agriculture was more common place. There was widespread and varied arbovirus activity; human notifications of RRV disease were among the highest to date and MVEV was active through the inland, with nine isolates from *Culex annulirostris* mosquitoes (6 from Griffith and 3 from Leeton) and four seroconversions in the sentinel chickens (2 from Macquarie Marshes and one each from Leeton and Griffith. Activity of MVEV was first detected with a mosquito isolate on 5/Feb/2008 and the last detection was a seroconversion on 24/Mar/2008. One human case of mild MVEV was reported and the patient made a full recovery. Additionally, there were four seroconversions in the sentinel flocks to KUNV and a variety of arboviruses isolated from the trapped mosquitoes, including RRV, BFV, SINV, EHV, and KOKV as well as the MVEV.

- **An atypical weather pattern** that occurred this season was a low pressure cell that began in the Gulf of Carpentaria and moved through Qld and into central western NSW during mid-January. This low pressure cell has been associated with southerly movement of Bovine Ephemeral Fever virus (BEFV, Andrew Read, NSW DPI, *pers. comm*.) and may have facilitated the spread of the MVEV virus from the north to the south, possibly through the transportation of vectors. The pattern of MVEV activity in NSW this season was coincidentally similar to that of the BEFV.

- **Neither the Forbes' nor the Nichol's** models suggested a possible MVEV epidemic during this season, however the first part of the Forbes' hypothesis has been fulfilled for the coming season of 2008-2009, whereas the Nichol's has not.

- **Human notifications from the inland** totalled 502, and included 453 RRV and 49

BFV. The statistical local area with the most cases was Dubbo, with 52 RRV and 7 BFV. Notification rates tended to be highest in the northwest inland, although some high rates were recorded along the Murray Valley.

- **For the coast**, overall mosquito numbers were higher this season despite the very low collections of *Aedes vigilax*. Freshwater species dominated the collections and included *Culex annulirostris*, *Coquillettidia linealis*, *Aedes multiplex*, *Aedes notoscriptus* and *Aedes procax*. This latter species produced most isolates, with 7 BFV and 1 STRV.

- **Coastal disease notifications** were the second highest on record since reporting began, with a total of 1,109 including 471 BFV and 638 RRV. The statistical local area that produced the highest case load was Byron, with 105 notifications (53 BFV & 52 RRV). This area also had the highest notification rates. The cold spell that began during February resulted in fewer notifications late in the season and the peak in cases of both RRV and BFV occurred around one month earlier than normal.

- **For the Sydney trapping locations,** six sites were operating this season; however, overall mosquito numbers were lower than the last season (when there were only two sites operating) due to the low *Aedes vigilax* numbers. Three isolates were made, one each from Georges River (BFV), Hawkesbury (EHV) and Ryde (EHV). Human notifications from the region were much higher than average (122 in total), and included 105 RRV and 17 BFV.

- **The NSW Arbovirus Surveillance Web Site** http://www.arbovirus.health.nsw.gov.au/ continued to expand and now has over 189MB of information with 1,590+ pages.

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NSW ARBOVIRUS SURVEILLANCE AND MOSQUITO MONITORING PROGRAM 2007-2008

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 2007-2008 season follow.

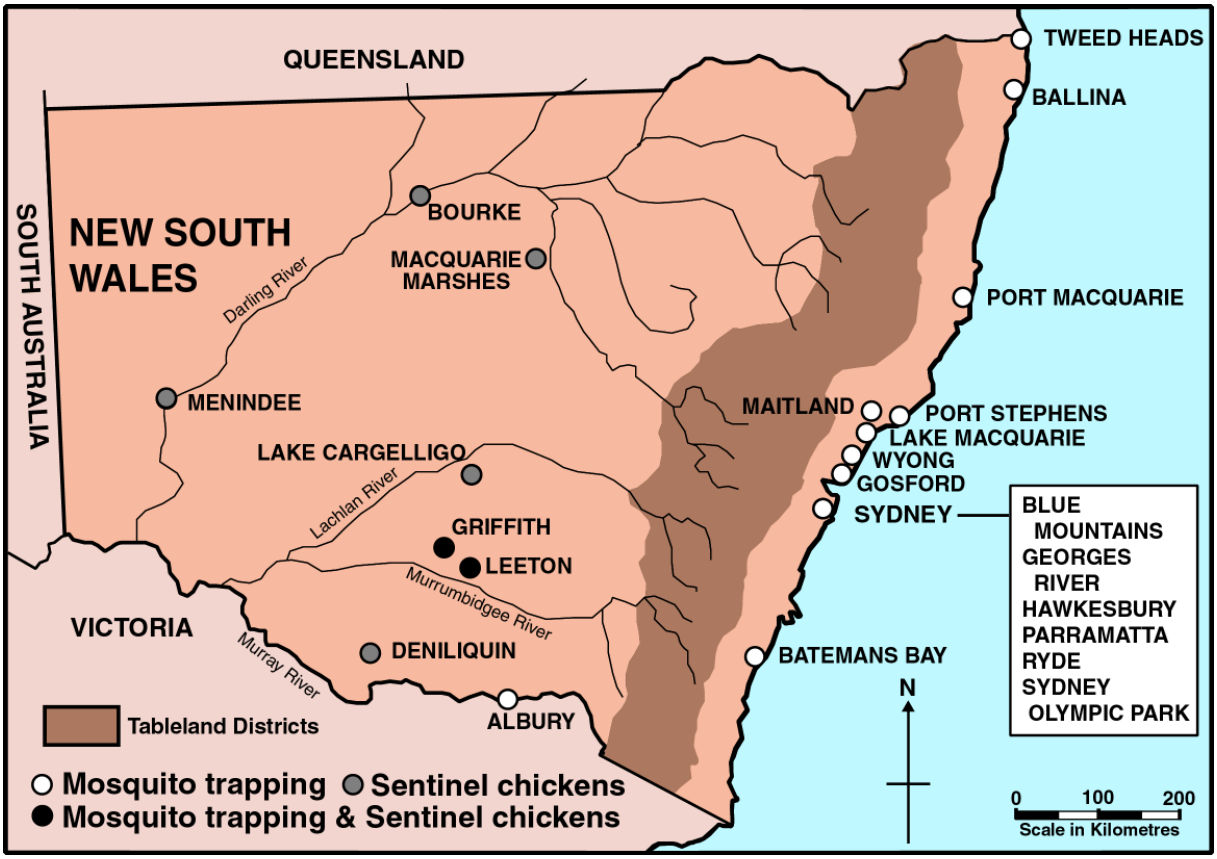


Fig 1. Mosquito trapping locations and Sentinel Chicken sites, 2007-2008.

MONITORING LOCATIONS

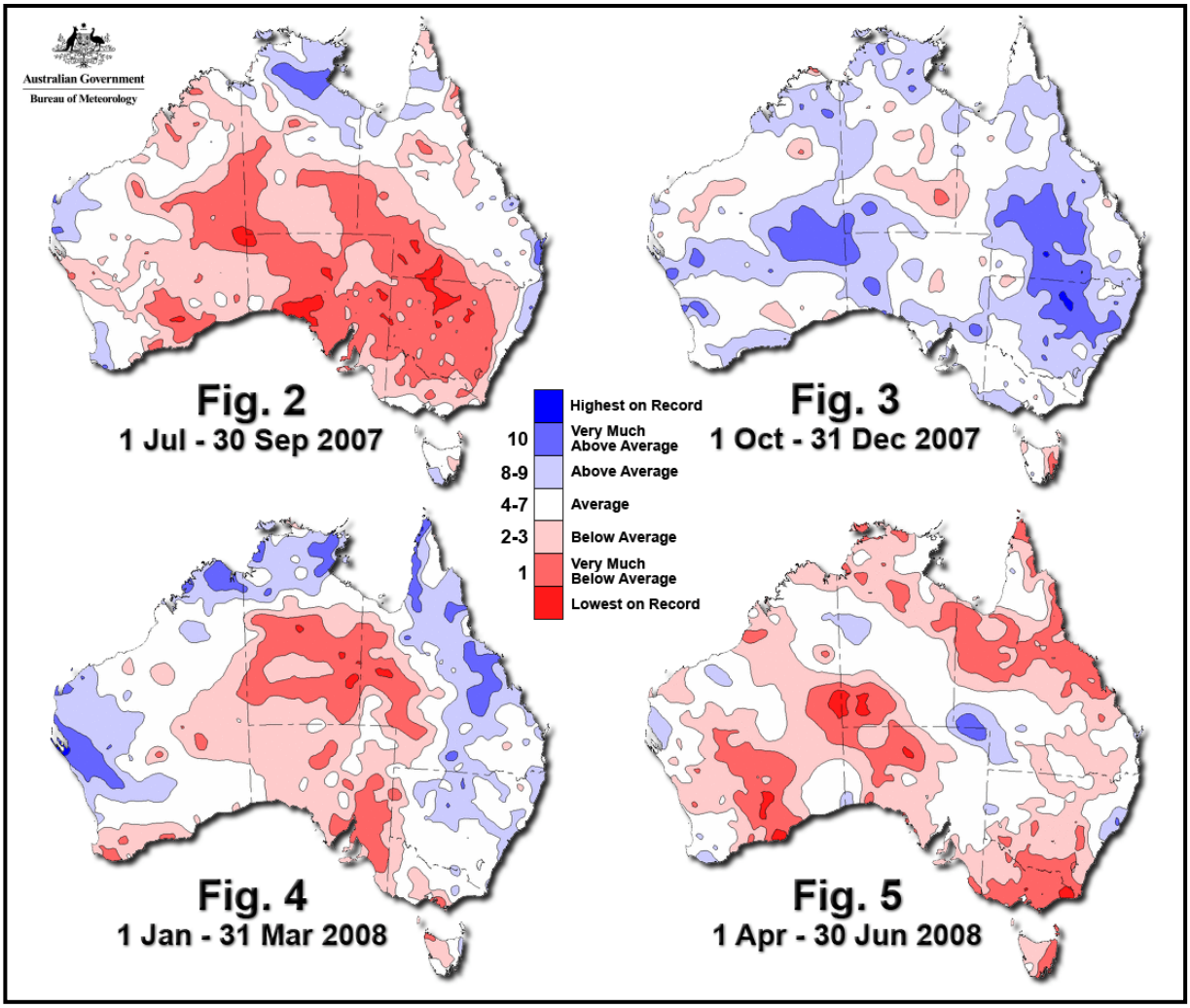
http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/location/locations.htm

For 2007-2008, mosquito-trapping sites were operated at 2 inland, 9 coastal and 7 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 2007, Oct-Dec 2007, Jan-Mar 2008 & Apr-Jun 2008. The stronger the red, the drier the conditions. Conversely, the stronger the blue, the wetter the conditions. *Modifed from the Australian Bureau of Meterology, 2008*.

For the inland, the first quarter of 2007 experienced average rainfall conditions, and was followed by a period of good precipitation to the end of June. For the third quarter of 2007, some of the driest conditions to date occurred, with areas in the north of the state having record low rainfall (Figure 2). Conversely, the last quarter of 2007 was a period of good rainfall, with sections of the northern inland having very much above average amounts of rain (Figure 3). For the start of 2008, precipitation levels were average to above average (Figure 4) but then the second quarter (Figure 5) became dry, especially along the Murray Valley. Rainfall along the coastal strip was somewhat variable between regions. The north coast had mostly above average precipitation from July 2007 through to March 2008, and thereafter levels were around normal. The south coast experienced more normal conditions of rain, although levels were below average during the second quarter of 2008 (Figure 5).

Temperatures for the last half of 2007 and into January 2008 were around normal. The second week of February heralded an extreme cold spell, with some parts of the state being done to 5^{o}C below average. For the remainder of the mosquito season most of the state was between 1-3^{o}C below usual, with minimum temperatures especially well below the norm. It was not until June that conditions became warmer than average, well past the end of peak mosquito activity.

One unusual weather pattern this season that may have had a significant influence in light of this season's MVEV activity, was a low pressure cell that began as tropical cyclone Helen in the Gulf of Carpentaria in early January. This then moved down through Queensland producing extensive flooding, and then through central inland NSW in mid-January and thence into Victoria (Finlaison *et al*., 2008).

MVEV Predictive Models

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

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 2006) or the first quarter of the current year (January-March 2007) and the last quarter of the current year (October-December 2007), then a MVEV outbreak is probable. Rainfall was not above decile 7 for all the catchment basins for the last quarter

of 2006 and the first quarter of 2007, but it was for the last quarter of 2007. Thus, the hypothesis was not satisfied for the 2007-2008 season. Despite rainfall not being above decile 7 in any of the catchments for the first quarter of 2008, it was for all catchments for the end of 2007 and thus the first part of Forbes hypothesis has been fulfilled for 2008-2009, suggesting the possibility of an MVEV epidemic for the upcoming season.

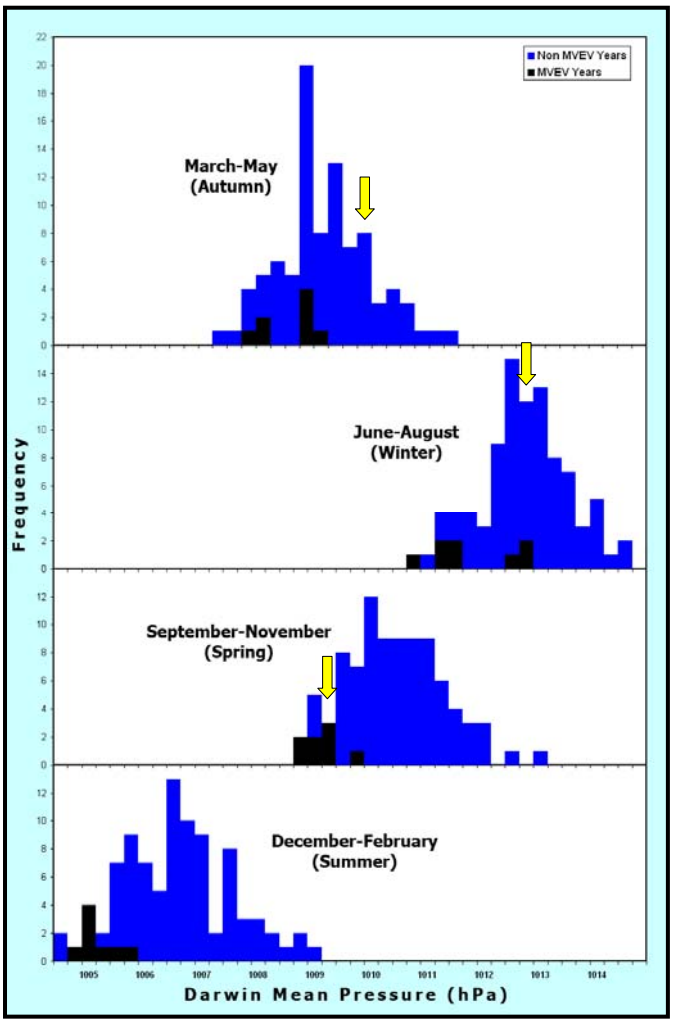


Figure 6. The SO by seasons prior to MVEV active years, according to Nicholls (1986), updated up to Spring 2008. The black bars represent the pre-MVEV active seasons. The yellow arrows indicate the respective SO values relevant to the 2007-2008 season.

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 2007, the SO values were respectively: 1009.87mm, 1012.93mm and 1009.87mm (indicated on Figure 6 by the yellow arrows). The autumn figure was not within the range of values for the same period of past MVEV outbreak years; however, the winter and spring periods were (Figure 6). Likewise, the summer 2007–2008 SO value of 1005.30mm was within the range of that experienced during MVEV years. Currently, the autumn Nicholls' value for 2008 is 1010.03mm, which is outside the range of values during past MVEV outbreak years.

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 level activity, such as during the recent and the 2000-2001 seasons. Thus negative MVEV models do not necessarily indicate nil MVEV activity.

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, 104,797 mosquitoes representing 54 species were collected in NSW during the 2007-2008 season. *Culex annulirostris* was the most abundant and most important of the inland mosquito species during the summer months, whereas *Aedes vigilax*, *Culex annulirostris*, *Coquillettidia linealis*, *Culex sitiens* and *Aedes notoscriptus* 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 26,190 mosquitoes trapped, comprising 21 species, was more than double that of the previous season's collection. *Culex annulirostris* was the dominant species yielded at most sites and comprised 77.2% of the total inland collections. *Culex quinquefasciatus* (6.4%) was the next most common species. For most years, *Anopheles annulipes* comprises around 20-30% of the mosquitoes collected from the inland, but for the recent season it was down to only 2% of all the collections.

Coastal

In total, 76,053 mosquitoes comprising 48 species were collected from coastal NSW and this was almost 70% above the previous season's total collection. The most common species collected were *Aedes vigilax* (18.1% of the total coastal mosquitoes trapped), *Culex annulirostris* (17.9%), *Coquillettidia linealis* (14.3%), *Culex sitiens* (9.0%), *Aedes*

multiplex (6.9), *Aedes notoscriptus* (6.8%) and *Aedes procax* (5.5%).

Metropolitan Sydney
A total of 15,224 mosquitoes, comprising 30 species, was collected from metropolitan Sydney, slightly down upon the previous season's total collection. *Aedes notoscriptus* (36.7% of the total Sydney mosquitoes trapped) was the most common species, followed by *Culex sitiens* (17.4), *Culex annulirostris* (14.1 %), and *Aedes vigilax* (9.9).

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). The MVEV isolates were confirmed by immunofluorescence and sequence analyses. 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

From the mosquitoes processed, there were 41 viral isolates: 18 from the inland and 23 from the coastal locations. These are listed in Tables 1 and 2 below.

Table 1. Arbovirus isolates from inland NSW, 2007-2008.

LOCATION - Site	Date Trapped	Mosquito Species	Virus							
			BFV	RRV	EHV	KOKV	MVEV	SINV	Virus?	TOT
GRIFFITH - Hanwood	17-Jan-08	*Culex annulirostris*		1						**1**
LEETON-Almond Rd	24-Jan-08	*Culex annulirostris*	1							**1**
GRIFFITH - Hanwood	29-Jan-08	*Culex annulirostris*				1				**1**
GRIFFITH - Hanwood	05-Feb-08	*Culex annulirostris*					1			**1**
GRIFFITH - Hanwood	05-Feb-08	*Aedes theobaldi*							1	**1**
GRIFFITH - Hanwood	11-Feb-08	*Culex annulirostris*						2		**2**
LEETON-Farm 347	06-Feb-08	*Culex annulirostris*			1					**1**
GRIFFITH - Hanwood	18-Feb-08	*Culex annulirostris*				1	2			**3**
GRIFFITH - Hanwood	25-Feb-08	*Culex annulirostris*						1		**1**
GRIFFITH - Barren Box	03-Mar-08	*Culex annulirostris*					3			**3**
LEETON-Farm 347	04-Mar-08	*Culex annulirostris*					3			**3**
		TOTAL	**1**	**1**	**1**	**2**	**9**	**3**	**1**	**18**

BFV = Barmah Forest virus, RRV = Ross River virus, EHV = Edge Hill virus, KOKV = Kokobera virus, MVEV = Murray Valley Encephalitis virus, SINV = Sindbis virus, Virus? = unknown (not

MVEV, KUNV, EHV, STRV, KOKV, RRV, BFV or SINV).

Table 2. Arbovirus isolates from coastal NSW, 2007-2008.

LOCATION - Site	Date Trapped	Mosquito Species	Virus					
			BFV	RRV	EHV	STRV	Vir?	TOT
BATEMANS BAY- Watergardens	13-Dec-07	*Aedes camptorhynchus*		1				**1**
PORT STEPHENS - Karuah	18-Dec-07	*Aedes procax*	1					**1**
PORT STEPHENS - Karuah	18-Dec-07	*Aedes vigilax*		1				**1**
PORT STEPHENS - Medowie	08-Jan-08	*Aedes procax*	1					**1**
PORT STEPHENS - Medowie	15-Jan-08	*Aedes procax*				1		**1**
PORT STEPHENS - Medowie	15-Jan-08	*Aedes vigilax*	1					**1**
PORT STEPHENS - Karuah	15-Jan-08	*Aedes vigilax*					1	**1**
PORT STEPHENS - Medowie	22-Jan-08	*Aedes procax*	1					**1**
PORT STEPHENS - Karuah	23-Jan-08	*Aedes vigilax*				1		**1**
PORT STEPHENS - Gan Gan	15-Jan-08	*Aedes notoscriptus*				1		**1**
PORT MACQUARIE - Partridge Ck	23-Jan-08	*Aedes alternans*		1				**1**
PORT MACQUARIE - Partridge Ck	23-Jan-08	*Anopheles atratipes*					1	**1**
PORT STEPHENS - Karuah	23-Jan-08	*Aedes notoscriptus*				1		**1**
PORT STEPHENS - Medowie	31-Jan-08	*Aedes procax*	1					**1**
PORT STEPHENS - Saltash	05-Feb-08	*Aedes procax*	1					**1**
PORT MACQUARIE - Partridge Ck	05-Feb-08	*Culex annulirostris*					1	**1**
PORT MACQUARIE - Partridge Ck	12-Feb-08	*Aedes procax*	1					**1**
BALLINA – North Creek Rd	12-Feb-08	*Aedes procax*					1	**1**
HAWKESBURY-Wheeney Ck	14-Feb-08	*Aedes* sp. Marks no. 51			1			**1**
PORT STEPHENS - Medowie	27-Feb-08	*Aedes multiplex*					1	**1**
RYDE-Lambert Park	11-Mar-08	*Culex annulirostris*			1			**1**
GEORGES RIVER - Lugarno	19-Mar-08	*Aedes procax*	1					**1**
LAKE MACQUARIE-Dora Ck	19-Mar-08	*Aedes multiplex*			1			**1**
		TOTAL	**8**	**3**	**3**	**4**		**23**

BFV = Barmah Forest virus, RRV = Ross River virus, EHV = Edge Hill virus, STRV = Stratford virus, Vir? = unknown (not MVEV, KUNV, EHV, STRV, KOKV, RRV, BFV or SINV).

SENTINEL CHICKEN PROGRAM

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

Location of flocks

The 2007-2008 season began on November 12th 2007 with the first bleed and ended on April 20th 2007 with the last. For 2007-2008, at total of seven flocks each containing 15 Isa Brown pullets was deployed, with one flock each at Bourke, Deniliquin, Griffith, Lake Cargelligo, Leeton, Macquarie Marshes and Menindee (Figure 1).

Methods

The NSW Chicken Sentinel Program was approved by the WSAHS 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, under the supervision of a veterinarian, 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 five deaths were recorded for the entire season. A total of 1,601 samples was received from the seven flocks in NSW over the six-month period in 2007-2008. This represented 3,202 ELISA tests (excluding controls and quality assurance samples), with each specimen being tested for MVEV and KUNV antibodies.

There were four seroconversions to MVEV and four to KUNV. Full details are in Table 4.

HUMAN NOTIFICATIONS

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

Table 2 contains the number of laboratory notifications of human RRV and BFV disease 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 these are laboratory notifications often based on a single IgM positive specimen, and may not always represent infections from this season, as IgM can persist for long periods.

The total number of RRV and BFV notifications for the period July 2007 to June 2008 was 1,733 and included 537 BFV and 1,196 RRV. This season had the third highest number of notifications since reporting began in 1991, and was around 20% above the previous thirteen season average of 1,060. The coastal region accounted for 1,109 (64% of the state total) of the BFV and RRV notifications, which was almost 60% above the previous thirteen season average of 702 (Table 3). The 502 notifications (29% of the state total) from the inland were almost 80% above the previous thirteen year seasonal average of 281. Within the Sydney region there were 122 cases reported, again well above the thirteen season average of 77.

The Northern Rivers and Hunter Area Health Services received the highest number of notifications (358 and 354 respectively) with the Mid North Coast having 221. Combined, these three areas accounted for 42% of all the arbovirus notifications for the state. From

the inland, the Greater Murray AHS had the highest number of notifications (157), although the Macquarie AHS only had a few less (145).

Figure 7 depicts the notifications and notification rates of RRV and BFV by Statistical Local Area (SLA) for NSW during the 2007-2008 mosquito season.

Table 3. Arbovirus disease notifications according to former Area Health Service, July 2007 - June 2008*.

Month	CS	NS	WS	WE	SW	CC	HU	IL	SE	NR	MN	NE	MA	MW	FW	GM	SA	Total
RRV	14	15	29	18	9	50	240	38	20	173	110	78	133	36	56	150	27	**1196**
BFV	5	7	1	1	0	17	114	20	3	185	111	20	12	3	7	7	24	**537**
Total	**19**	**22**	**30**	**19**	**9**	**67**	**354**	**58**	**23**	**358**	**221**	**98**	**145**	**39**	**63**	**157**	**51**	**1733**

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'.

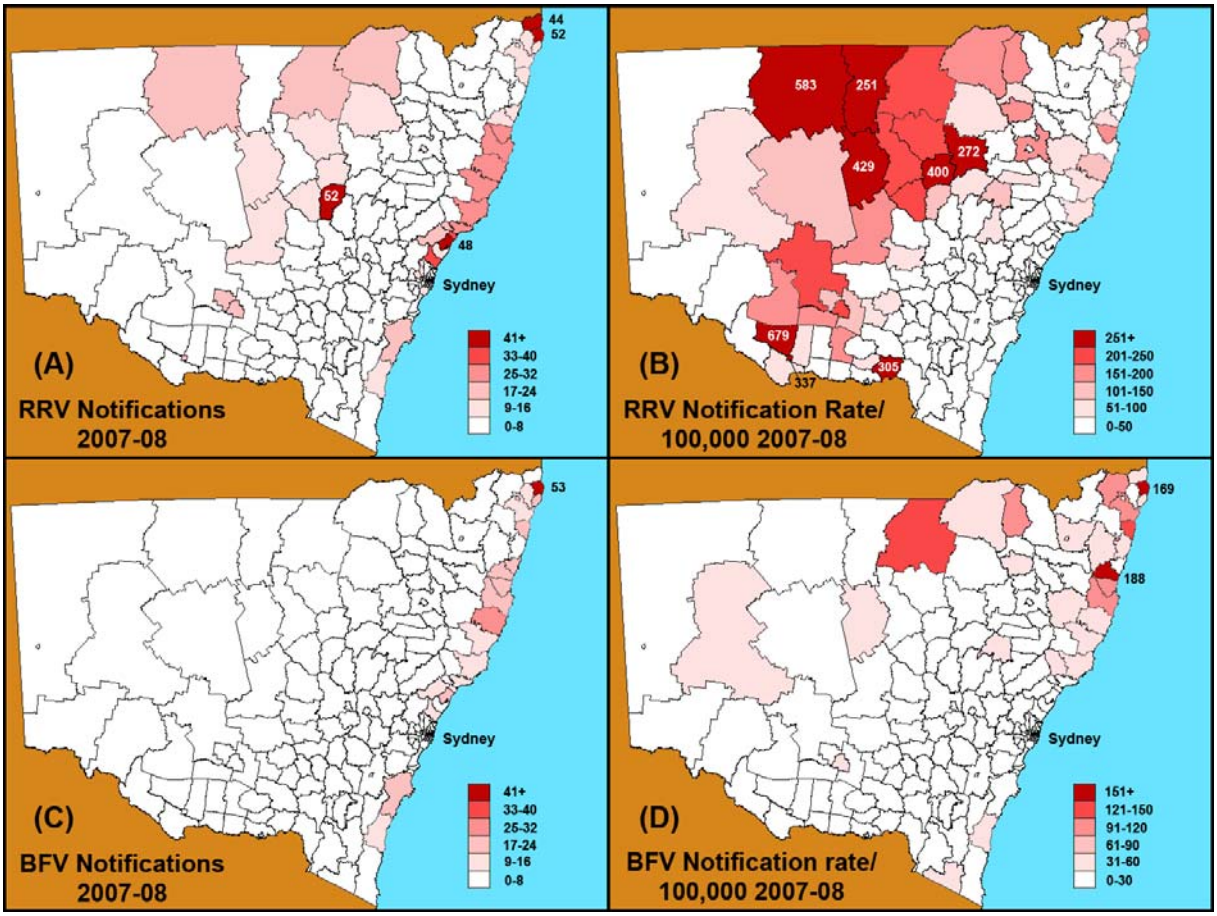


Figure 7. Notifications and notification rates of RRV and BFV by Statistical Local Areas for NSW during 2007-2008, up to May 2008. (A) RRV notifications. (B). RRV notification rate/100,000 population. (C) BFV notifications. (D) BFV notification rate/100,000 population. Data from 'GODSEND'.

There was one human case of MVEV reported from the Macquarie AHS in a mid-60s

year old male who developed minor symptoms and made a full recovery. The onset date of symptoms was reported as 16/Mar/2008.

DISCUSSION

The Inland. The ongoing drought over the last decade has changed the face of irrigation practices across inland NSW, and this has directly influenced mosquito productivity and potential arboviral disease activity. There has been a reduction in the planting of irrigation intensive crops and water use has been more wisely undertaken, as evidenced by the decline of Willbriggie swamp, an artificial swamp created from runoff from nearby properties. The reduction in free standing water has meant that there has been less available habitat for vector breeding and mosquito populations have dramatically reduced. Despite the good rainfall during late 2007 and early 2008, total mosquito numbers during 2007-2008 were only around one eighth that of the years when irrigation practices were more intense. This has meant that a new 'normal' for vector abundance needs to be redefined and it is probable that arboviral disease risks to the inland human population have changed substantially. The ongoing small mosquito densities over recent years, with the low levels of arboviral activity, have probably resulted in the animal and human population becoming more susceptible to infection through reduced immunity levels. Despite the recent season having relatively low mosquito numbers, collections were well up on the 2006-2007 season, and this season's numbers were presumably high enough (perhaps along with the low immunity status of vertebrate host populations) to initiate considerable arboviral activity. The total number of notifications for the region was one of the highest since notifications began (Table 5) and there was a wide range of arboviruses detected, including BFV, RRV, SINV, EHV, KOKV, KUNV and MVEV.

Table 4. Flavivirus activity for NSW during the 2007-2008 season.

LOCATION-Site	Date*	Virus	Isolates/Seroconversions**
GRIFFITH-Hanwood	5/Feb/08	MVEV	
GRIFFITH-Hanwood	18/Feb/08	MVEV	
MACQUARIE MARSHES	26/Feb/08	MVEV	
LEETON-Farm 347	2/Mar/08	MVEV	
GRIFFITH-Barren Box	3/Mar/08	MVEV	
LEETON-Farm 347	4/Mar/08	MVEV	
GRIFFITH-Hanwood	24/Mar/08	MVEV	
GRIFFITH-Hanwood	24/Mar/08	KUNV	

*The dates represent either the mosquito collection date or the date the chickens were bled.
**Each mosquito/chicken icon represents one mosquito isolate or one chicken seroconversion.

In relation to the MVEV activity, neither the Forbes' nor the Nichols' predictive models were suggestive of a possible epidemic. Nor were they during the other recent 'MVEV active' seasons, namely 2000-2001 and 2003-2004. However, both theories were

developed on the basis of major epidemics and not low level enzootic activity. Thus negative models do not negate the possibility of potential MVEV activity. Currently, the first part of the Forbes' hypothesis has been fulfilled for the upcoming 2008-2009 season and there is a real possibility of activity occurring in sequential seasons. It is well known that MVEV can be passed vertically from adult to progeny, and surveillance measures should ideally be enhanced for this reason alone at the start of the next season.

MVEV activity this season was first recognised with a mosquito isolate from the Hanwood site at Griffith, from the collection made on the 5/Feb/2008 (Table 4). A further two mosquito isolates occurred at the same site two weeks later and, then in the following week, two chickens seroconverted in the flock at Macquarie Marshes (note that mosquito monitoring was not undertaken at this site), indicating that activity was geographically disparate; no further seroconversions occurred at this site but there was a human infection reported (as mentioned above). Due to the low mosquito numbers at Willbriggie, as a result of the drying of the swamp as mentioned above, the Griffith flock was relocated to Hanwood and the mosquito trap moved to Barren Box swamp (west of Griffith) in the first week of March. This serendipitously coincided with the peak in MVEV activity, as during this week there were three MVEV mosquito isolates and one chicken seroconversion at Leeton, and three MVEV mosquito isolates from the new Barren Box swamp site, indicating that the virus had spread around the city of Griffith. The last sign of activity was from Hanwood, with one more MVEV seroconversion in the sentinel flock on 24/Mar/2008, along with four KUNV seroconversions. As the second quarter of 2008 (i.e. April to June) became exceptionally dry along the Murrumbidgee valley, this may have helped to curtail the MVEV activity.

In response to the activity, NSW Health undertook several initiatives. Local medical practitioners in the region were notified of the presence of MVEV with hospitals and general practitioners surveyed for the presence of cases, several press releases were issued and health agencies were regularly updated via teleconference. No additional mosquito trapping was undertaken nor was there any additional sentinel chicken flocks employed.

Activity of MVEV was not confined only to NSW as a number of seroconversions occurred in chicken sentinel flocks located along the Murray Valley as part of the Victorian Arbovirus Surveillance Program. These seroconversions began later than the NSW activity and continued much later as well. The first confirmed seroconversions were detected at Kerang in two sentinel chickens bled on the 17th March with three more on the 31st March. At Mildura there were five seroconversions on the 25th March, with a further three on the 7th April, two on the 21st April and a further six on the 4th May. There was one seroconversion at Barooga near Cobram on the 7th April. No KUNV activity was detected during this period. Like NSW, the Victorian Department of Health Services (VDHS) notified all medical practitioners in the region of the presence of the virus and with no human cases being reported. The NSW case at the Macquarie Marshes was the only identified MVEV patient in SE Australia. Additionally, VDHS have maintained surveillance through the winter months up to and including the 2008-2009 season, with the sentinel chicken flocks being bled and tested weekly along with mosquito monitoring and virus isolation from the trapped mosquitoes.

In relation to MVEV activity within southeastern Australia, there are two schools of

thought; firstly the virus is endemic to the region but exists in localised cryptic foci and secondly, that the virus is introduced into the region via opportunistic movements of water birds. Of course, both situations may pertain as well, as they are not mutually exclusive.

In the context of these hypotheses it is worth reviewing the activity in NSW over recent seasons. Since the year 2000, MVEV has been detected in the state on three occasions; eight sentinel chickens seroconverted at four separate flocks between January and March 2001 (Doggett *et al*. 2001), there was one chicken seroconversion in December 2003 (Doggett *et al*. 2004), as well as the recent season's activity. Prior to the 2001 activity, there was extensive flooding through inland Australia and western NSW, and MVEV was active in central Australia with human cases at Alice Springs. This is consistent with the virus being down into NSW from the north, so supporting the second hypothesis, although it cannot be discounted that conditions became suitable for local focal activity. The one chicken seroconverson in 2003 occurred at Menindee in western NSW, in the same location as where the flock seroconverted in 2001. There was exceptionally low rainfall from early 2001 to the end of 2003 throughout western NSW with no flooding or apparent MVEV activity in central Australia; this then could give credence to the first hypothesis, namely the presence of cryptic MVEV foci. It is known that MVEV can 'overwinter' (or more correctly survive) in desiccation resistant *Aedes* mosquito eggs (Broom *et al*. 1995). The virus in 2003 was detected after a period of heavy localised rainfall and as the region had received little precipitation since the previous activity, it is possible that the virus had been maintained in the local mosquito population. This is a method by which cryptic foci could exist.

For the recent season, little information on MVEV vertebrate host activity for the recent season is available. Water birds, particularly the Nankeen Night Heron (*Nycticorax caledonicus*), are thought to be the main vertebrate host for MVEV. This season Night Herons had only a small breeding event on the Paroo and Warrego River systems at Yantabulla Swamp (Prof. Richard Kingsford, University of New South Wales, *pers. comm*.) following the large floods in southwestern Queensland earlier this year. The numbers of these birds are also thought to be down (Glenis Lloyd, Environmental Health Branch, *pers. comm*.) and it seems unlikely that the birds would have brought the virus down into NSW and Victoria.

Around the same time as the MVEV in NSW, there was an outbreak of Bovine Ephemeral Fever virus (BEFV) that coincided with the low pressure system that moved from northern Australia down through central inland NSW and Victoria (Finlaison *et al*., 2008). The pattern of the BEFV epidemic was similar to the detected MVEV activity, with positives through the central inland region and not in the west towards Menindee. Serosurveys of cattle during March revealed the presence of BEFV along the Murray, again demonstrating a similar pattern of activity to the MVEV in Victoria. The overall BEFV pattern produced an hour glass type distribution of activity in NSW (i.e. widespread in the north and south of the state, restricted centrally). The later detection of MVEV in Victoria compared with NSW could be a reflection of the movement of the low pressure cell. It is possible that the low pressure system aided the spread of both viruses to the south via the movement of vectors. The remarkably similar pattern of BEFV and MVEV activity seems to be too much of a coincidence not to be related. This now suggests a third possible hypothesis for how MVEV activity may occur in NSW.

Arbovirus surveillance across NSW has been continuous for around 25 years, through the use of sentinel chickens and/or the isolation of viruses from mosquitoes. Despite this MVEV has been detected on only the three occasions mentioned above suggesting that the virus may not be endemic to the state. However limited human serosurveys within the Macquarie Marshes region have suggested the presence of the virus after the 1974 outbreak indicating the virus may be endemic within that region (Hueston & Lloyd, 2008). In light of the ongoing surveillance, it would appear then that if cryptic foci do exist, they must be extremely localised and probably uncommon. However, the limited number and spread of surveillance sites in western NSW severely hampers any significant assessment of focal or introduced and endemic or epidemic virus activity, and with such few surveillance locations it is impossible to quantify the extent of possible cryptic foci.

One method of examining the origins of a virus isolate is by comparing its genetic sequence with other isolates. Currently the MVEV isolates from this season have yet to be fully sequenced, but once done this could provide further evidence to the nature of the virus. It is important in future that wherever MVEV has been or is subsequently recorded NSW that mosquito collections are undertaken with the hope of obtaining further viral isolates for sequence analysis.

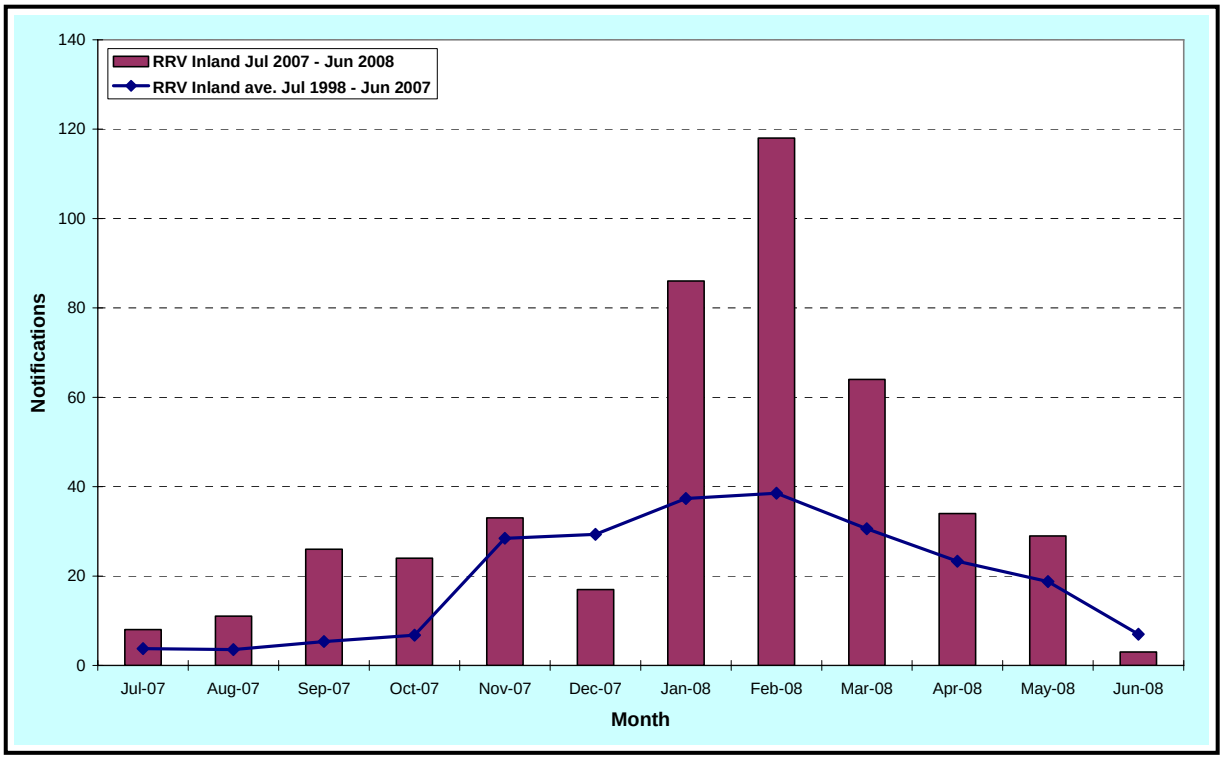


Figure 8. Notifications of RRV per month from inland NSW. The bars are for 2007-2008 season and the line is the long term average. Data from 'GODSEND'.

The other virus that was particularly active this season across the inland was RRV. The total of 453 notifications was the fourth highest since notifications began. The SLA that reported the most cases was Dubbo with 52 (Figure 7A), although notification rates tended to be higher in the north (Figure 7B). The SLA of Windouran in the south near Deniliquin, reported the highest notification rate (679/100,000); however, this represented only two cases and thus the rate was inflated by the small local population.

Of the top twenty SLAs in terms of notification rates, seventeen were from the inland (Table 7), demonstrating the greater risk of arboviral disease to the inland community during the recent season. Despite mosquito numbers being relatively low, one factor that would have influenced arboviral disease numbers was that mosquito activity went on well into March and April, when populations normally decline to very low numbers. Despite this, the distribution of disease case numbers per month corresponded with long term averages (Figure 8). The isolate of BFV from Leeton is only the second time this virus has been detected in mosquitoes collected from the inland, even though it was from the inland where the virus was first isolated. As usual, human disease notifications of BFV from the inland were very low (Figure 7C).

The Coast. The monitoring of mosquito populations and the surveillance of arboviruses along the coast for 2007-2008 revealed a very unusual season; the mosquito species mix was atypical, the species that yielded most viruses was not *Aedes vigilax* and the virus activity was skewed such that the peak in notifications occurred much earlier. Much of this can be explained by the prevailing climatic patterns.

Table 5. Notifications of BFV & RRV disease per virogeographic regions of NSW, per season from 1994-1995 to 2007-2008 (*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**
Total	**4351**	**364**	**152**	**4867**	**5891**	**3793**	**968**	**10652**
Ave[4]	298	24	10	333	404	257	66	727

[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 thirteen season average from 1994-1995 to 2006-2007. *Data from 'GODSEND'.

Normally, the saltmarsh mosquito, *Aedes vigilax*, comprises around 50-60% of the total mosquitoes captured, whereas for 2007-2008 it was down to just over 18%. This lower percentage can be readily explained by the tidal patterns experienced during the recent season. *Aedes vigilax* breeds on mud flats following inundation by monthly 'spring' tides,

and normally these tides need to be of a minimum height (1.8m or more for coastal NSW) to ensure that the mud flats are inundated and initiate hatching of the eggs. Generally, the greater the tide height, the more water is available for breeding and thus the larger the mosquito population. For the recent season, a series of exceptionally high tides occurred in November and December; however, thereafter, the high tides were relatively small and thus *Aedes vigilax* populations remained relatively low.

Even though *Aedes vigilax* densities were much lower than normal, overall mosquito numbers were much higher than the last as the good rainfalls in both the last quarter of 2007 and first of 2008 ensured that freshwater mosquitoes were abundant. Species including *Culex annulirostris*, *Coquillettidia linealis*, *Aedes multiplex*, *Aedes notoscriptus* and *Aedes procax*, were all commonly collected throughout many of the coastal sites, and it was the latter species that produced the majority of isolates for the recent season. From *Aedes procax* there were eight arboviruses isolated including 7 BFV and 1 STRV. Over recent years, this mosquito has yielded a number of isolates, particularly BFV, and must be considered to be a vector of emerging importance. As noted above, *Aedes vigilax* usually produces the most isolates and is considered the major mosquito vector. Even though this species' population was low this season, numbers of human disease notifications were quite high. The 1,109 cases (including 471 BFV and 338 RRV, Table 5) were the second highest since reporting began. While presently there is no definitive evidence to explain this, perhaps as the freshwater mosquitoes dominated this season both in quantity and the number of isolates, then maybe a somewhat different human demographic was being exposed during this recent season. There is now evidence suggesting that many notified cases of BFV disease do not represent recent infections, with probable disease over reporting (Cashman *et al*., 2008). Further research needs to be undertaken to determine the extent of this.

The onset of the cooler weather in February led to a dramatic reduction in mosquito abundance, these populations failed to rise again and the mosquito season ended much sooner than normal. This also led to an earlier reduction in arbovirus activity and the peak in both RRV and BFV notifications was around one month before usual (Figures 9 and 10). Considering the high number of notifications up until March, it was fortunate that the weather did become cool when it did.

The SLA that produced the most cases was Byron, with 105 reports (53 BFV and 52 RRV, Figure 7 and Table 6), followed by Tweed (79 cases; 35 BFV and 44 RRV), Lake Macquarie (68; 20 BFV and 48 RRV), Hastings (53; 27 BFV and 26 RRV) and Newcastle (53; 16 BFV and 37 RRV). Byron also had the highest overall notification rates for the coast with 338/100,000 (Figure 7, Table 7), although Bellingen had a higher rate for BFV notifications with 187.5/100,000 (compared to 169.2/100,000 for Byron).

Following a growing incidence of mosquito borne disease and an increasing awareness about mosquitoes within the Hunter region, a group of local Councils formed a committee to address these mounting concerns. An outcome of the committee was the document 'Living with Mosquitoes in the Lower Hunter and Mid North Coast' (http://www.hnehealth.nsw.gov.au/hneph/LivingWithMosquitos.htm) in 2005. One of the key recommendations within this awareness plan was that steps should be taken to fill gaps in knowledge of regional mosquito fauna. In response to this recommendation,

trapping was initiated in the Lake Macquarie area during 2006-2007 and at Maitland during the recent 2007-2008 season.

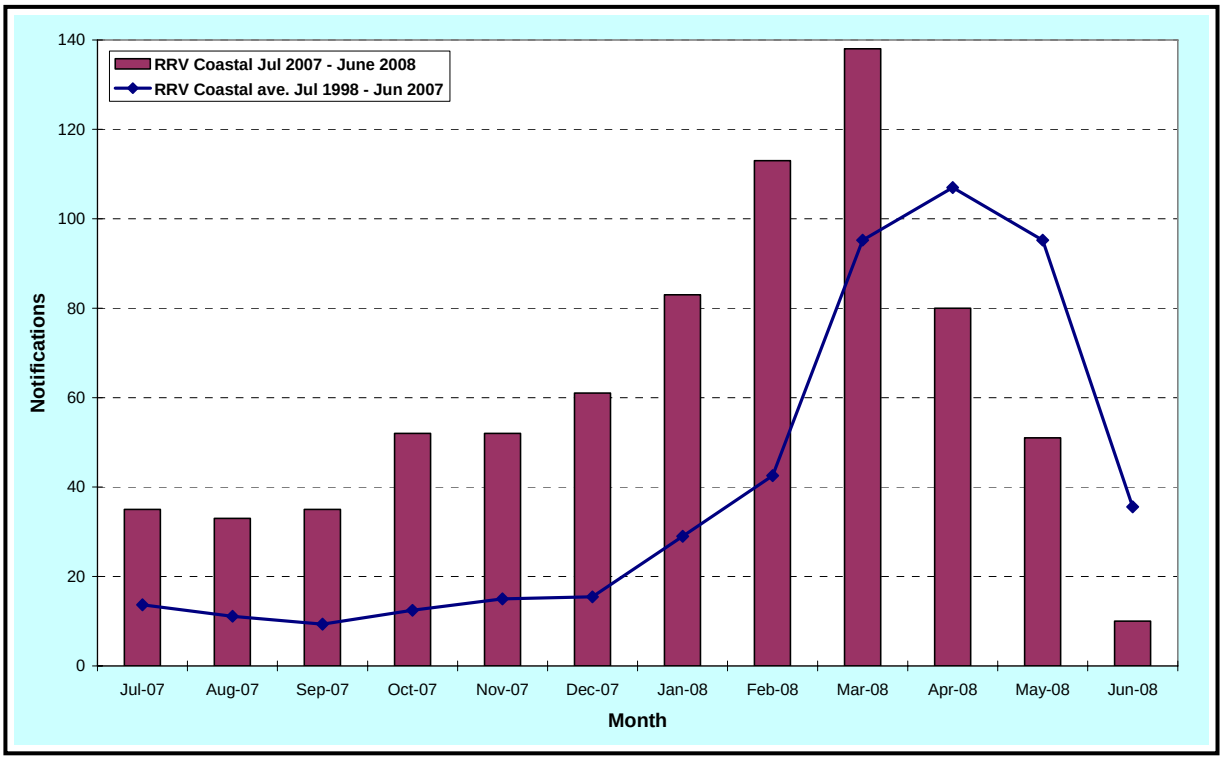


Figure 9. Notifications of RRV per month from coastal NSW. The bars are for 2007-2008 season and the line is the long term average. Data from 'GODSEND'.

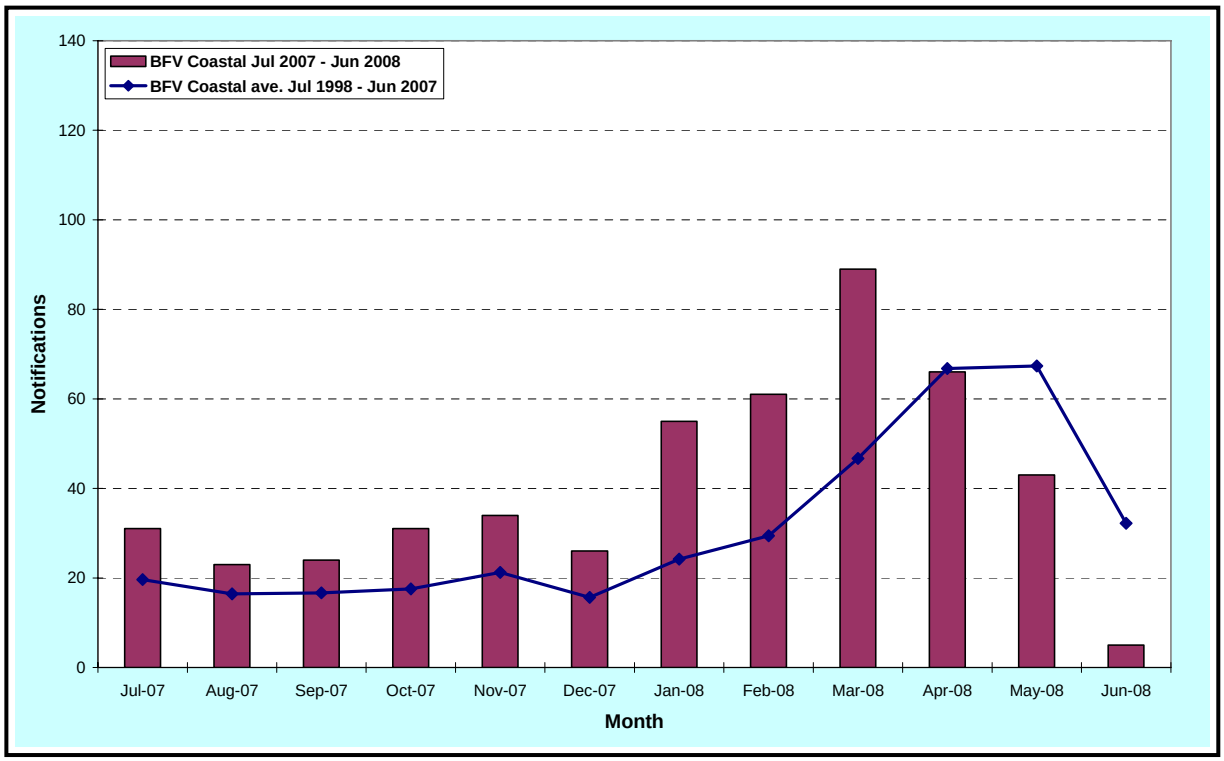


Figure 10. Notifications of RRV per month from coastal NSW. The bars are for 2007-2008 season and the line is the long term average. Data from 'GODSEND'.

Table 6. Notifications of BFV & RRV by Statistical Local Area for NSW during 2007-2008 with >16 notifications/disease*.

SLA	BFV	RRV	Total
Byron	53	52	**105**
Tweed	35	44	**79**
Lake Macquarie	20	48	**68**
Dubbo	7	52	**59**
Hastings	27	26	**53**
Newcastle	16	37	**53**
Nambucca	21	28	**49**
Gosford	12	34	**46**
Kempsey	17	29	**46**
Great Lakes	16	27	**43**
Port Stephens	14	29	**43**
Shoalhaven	19	21	**40**
Greater Taree	13	25	**38**
Bellingen	23	11	**34**
Maclean	21	13	**34**

SLA	BFV	RRV	Total
Ballina	18	14	**32**
Coffs Harbour	18	13	**31**
Grafton	17	12	**29**
Cessnock	10	18	**28**
Leeton	4	24	**28**
Moree Plains	5	22	**27**
Maitland	7	19	**26**
Griffith	0	24	**24**
Lismore	12	12	**24**
Deniliquin	0	23	**23**
Eurobodalla	13	10	**23**
Bourke	1	19	**20**
Walgett	2	18	**20**
Richmond River	10	9	**19**
Wyong	4	13	**17**

*Data from 'GODSEND', up to May 2008.

Table 7. Crude notification rates/100,000 of BFV & RRV by Statistical Local Area for NSW during 2007-2008 with >100 notifications /100,000*.

SLA	BFV	RRV	Total
Windouran	0.0	678.7	**678.7**
Bourke	30.7	583.0	**613.8**
Bogan	35.8	429.4	**465.2**
Brewarrina	150.9	251.4	**402.3**
Gilgandra	0.0	400.1	**400.1**
Byron	169.2	168.8	**338.0**
Deniliquin	0.0	336.9	**336.9**
Holbrook	0.0	304.5	**304.5**
Bellingen	187.5	92.4	**279.9**
Nambucca	118.7	161.0	**279.7**
Coonabarabran	0.0	272.3	**272.3**
Walgett	26.6	245.7	**272.3**
Leeton	39.6	231.2	**270.7**
Yallaroi	73.3	183.3	**256.7**
Narromine	17.0	238.3	**255.3**
Carrathool	0.0	242.8	**242.8**
Barraba	52.7	157.9	**210.6**
Moree Plains	38.3	172.0	**210.3**
Lachlan	16.1	193.2	**209.3**
Warren	0.0	203.9	**203.9**

SLA	BFV	RRV	Total
Merriwa	49.6	148.6	**198.2**
Severn	39.6	158.3	**197.8**
Maclean	121.2	75.1	**196.3**
Grafton	109.8	80.1	**189.9**
Hay		187.9	**187.9**
Richmond River	96.0	87.0	**183.0**
Kempsey	67.4	115.5	**182.9**
Murrumbidgee		175.5	**175.5**
Dubbo	19.3	141.1	**160.4**
Urana		154.5	**154.5**
Central Darling	49.1	97.7	**146.8**
Great Lakes	50.4	86.5	**136.9**
Cobar	20.8	104.0	**124.8**
Kyogle	65.6	54.6	**120.2**
Narrandera		116.4	**116.4**
Glen Innes	19.3	97.0	**116.3**
Forbes	22.3	89.4	**111.7**
Griffith		108.6	**108.6**
Walcha	35.8	71.7	**107.5**
Tweed	46.3	58.7	**104.9**

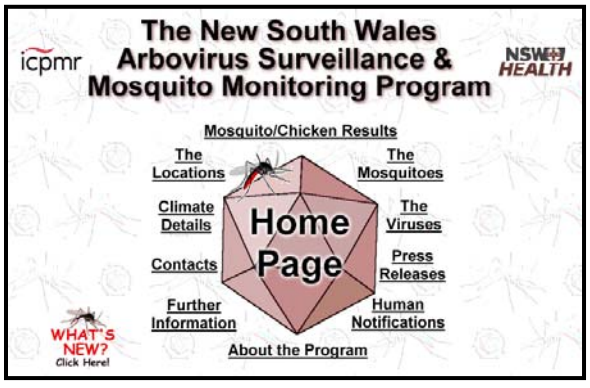
*Data from 'GODSEND', up to May 2008.

For the south coast, monitoring was confined to Batemans Bay only, where two traps were operated over 13 weeks. Despite *Aedes vigilax* numbers being much lower in other coastal localities, at Batemans Bay this mosquito was still the main species collected. In fact, collections were well above average at the start of the season, almost ten times the norm from the first collection. Evidence of virus activity was also seasonally early, with one RRV isolated from *Aedes camptorhynchus* in mid-December. For the SLA of Eurobodalla, in which Batemans Bay is the major town, there were 23 notifications (13 BFV and 10 RRV), which was well down upon the previous season of 77 (66 BFV and 11 BFV). Last season saw the largest outbreak of BFV in the region and it is usual for disease case numbers to be much lower in seasons following epidemic years.

Sydney. For the Sydney region, six trapping sites were operated over the 2007-2008 season. Despite the extra traps, compared with the last season, fewer mosquitoes were captured, due mainly to the very low collections of *Aedes vigilax* as a result of the smaller high tides. Human notifications were around 50% higher than average, with 122 notifications that included 105 RRV and 17 BFV (Table 5), although how many of these were locally acquired is unknown. There certainly was evidence of local virus activity, with three arboviral isolates, including two EHV (one each from Hawkesbury and Ryde) and one BFV (from Georges River), although there were no notifications of human disease associated with these viruses from their respective locations.

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 189MB, and has 1,250+ pages of information.

Added to the site since the last annual report includes:

- Archived data for the 2007-2008 season,
- Weekly rainfall summaries,
- Monthly rainfall summaries, with long-term averages,
- Monthly rainfall and temperatures maps,
- 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 consistently 'low' through the entire season, with only the occasional 'medium' collection. There were no arboviral isolates from the trapped mosquitoes.

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

Griffith: mosquito numbers were well below average for the entire season. Willbriggie Swamp has been drying up in recent years and so mosquito numbers have been relatively low. During early March, this trap was moved to Barren Box Swamp, which produced two 'very high' collections during this month. The sentinel chicken flock was also moved from Willbriggie, back to Hanwood. Mosquito numbers from Hanwood were continually 'high' from late December 2007 until the end of March 2008. By this time, both sites saw a rapid reduction in mosquito numbers. There were twelve arboviral isolates, all from *Culex annulirostris*, this included; 1 RRV isolated from mosquitoes trapped on 17/Jan/2008 at Hanwood, 1 KOKV (29/Jan/2008, Hanwood), 6 MVEV (1 from 5/Feb/2008 at Hanwood, 2 from 18/Feb/2008 at Hanwood, 3 from 3/Mar/2008 at Barren Box Swamp), 3 SINV (2 from 11/Feb/2008, 1 from 25/Feb/2008, all Hanwood) and one unknown (5/Mar/2008 at Hanwood). There were 5 flavivirus seronversions (1 MVEV and 4 KUNV) in the sentinel chicken flocks at Hanwood all from the 24/Mar/2008.

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

Leeton: mosquito numbers continue to be relatively low in comparison to recent years. The Almond Road site trapped mostly 'low' numbers, with only two 'high' collections for the season. Farm 347 produced consistently higher collections being mostly 'high' through February and March. Numbers at both sites rapidly declined after the end of March. There were 5 isolates from Leeton, all from *Culex annulirostris*, this included; one BFV from 24/Jan/2008 collected at the Almond Rd site, 1 EHV (6/Feb/2008, Farm 347) and 3 MVEV (4/Mar/2008, Farm 347). There was one seroconversion to MVEV in the sentinel chicken flock, which occurred on 2/Mar/2008.

Macquarie Marshes: there were no mosquito collections undertaken this year. There were two seroconversions to MVEV from the sentinel chickens, which occurred on 26/Feb/08.

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

Coastal Locations

Ballina: trapping was undertaken at two sites this year; North Creek Road and Lennox Heads. From the latter site, mosquito numbers were mostly 'low', with one 'high' collection in early March. North Creek Road consistently produced higher mosquito numbers, with a series of 'very high' collections during February. This was dominated by the mosquitoes, *Verrallina funerea* and *Culex annulirostris*. *Aedes vigilax* was never the dominant mosquito collected and only once was collected in densities of 'high'. There was one unidentified isolate collected from North Creek Rd on 12/Feb/2008 from *Aedes procax*.

Batemans Bay: mosquito trapping was conducted at two sites over the season: the Council Deport and Watergardens. The former site produced 'high' numbers every week (except for the very last), even during the very start of the season in mid November. Mosquito numbers were smaller from the Watergardens site, although several 'high' collections were made. There was one isolate of RRV from *Aedes camptorhynchus* trapped on 13/Dec/2007.

Byron Bay: there were no mosquito collections made this season.

Gosford: two sites at Gosford were again monitored this year: Empire Bay and Killcare Heights. For both sites, mosquito numbers were mostly 'medium' to 'high. This year, the collections were not strongly dominated by *Aedes vigilax*; *Aedes notoscriptus* was often the main species collected, with moderate catches of *Culex annulirostris.* No viruses were isolated from the mosquitoes.

Lake Macquarie: collections were undertaken from three sites; Belmont Lagoon, Dora Creek and Teralba. Dora Creek produced the highest mosquito numbers, with mostly 'high' numbers collected from February to the end of the season. *Aedes multiplex* was the dominant species in these traps. Collections were mostly 'low' to 'medium' from the other two sites, with occasional 'high' numbers in late February. There was one EHV isolated from *Aedes multiplex* collected at Dora Creek on 19/March/2008.

Maitland: Mosquito trapping began in early March and was conducted over seven trapping nights. Collections through the early weeks were mostly 'high' and dominated by *Culex annulirostris* and *Coquillettidia linealis*. No viruses were isolated from the mosquitoes.

Port Macquarie: mosquito trapping was conducted at two sites; Lord Street and Partridge Creek. The Lord Street trap continually yielded 'high' mosquito numbers, with *Coquillettidia linealis* being the main species captured. Partridge Creek tend to produce greater numbers and had a more diverse mosquito fauna. Collections were consistently 'high' and dominated by *Mansonia uniformis* and *Culex annulirostris*. There were four arboviral isolates, all from Partridge Creek: one RRV from *Aedes alternans* trapped on 23/Jan/2008, one BFV from *Aedes procax* trapped 12/Feb/2008, one unknown from *Anopheles atratipes* trapped 23/Jan/2008 and one unknown from *Culex annulirostris* trapped 5/Feb/2008.

Port Stephens: monitoring of mosquitoes was undertaken at the usual five sites and

trapping was undertaken until mid-March. 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 the occasional 'high' trap during late February and early March. Saltash numbers were mostly 'high' with one 'very high' catch in the last week of February, and *Aedes vigilax* was the main species collected. Medowie produced similar numbers to Saltash, being 'high' for most weeks, with large numbers of *Culex annulirostris*. Karuah started the season with a 'very high' collection in mid-December, mostly comprising *Aedes vigilax*. Thereafter, collections tended to be 'high' and the saltmarsh mosquitoes were not as dominant, with numerous freshwater species being trapped. As per recent years, Heatherbrae yielded the most mosquitoes for any site within NSW, and all but three of the collections produced 'very high' numbers. A range of species were collected and *Aedes vigilax* numbers were down upon previous seasons. The two main species trapped were *Coquillettidia linealis* and *Culex annulirostris*. There were 11 arboviral isolates from Port Stephens, including 6 BFV, 1 RRV, 4 STRV and 2 unknowns. Full details of the identified viruses are in Table 8.

Table 8. Arbovirus isolates from Port Stephens, 2007-2008.

Site	Date Trapped	Mosquito Species	Virus			
			BFV	RRV	STRV	TOT
Karuah	18-Dec-07	*Aedes procax*	1			**1**
Karuah	18-Dec-07	*Aedes vigilax*		1		**1**
Medowie	8-Jan-08	*Aedes procax*	1			**1**
Medowie	15-Jan-08	*Aedes procax*			1	**1**
Medowie	15-Jan-08	*Aedes vigilax*	1			**1**
Medowie	22-Jan-08	*Aedes procax*	1			**1**
Karuah	23-Jan-08	*Aedes vigilax*			1	**1**
Gan Gan	15-Jan-08	*Aedes notoscriptus*			1	**1**
Karuah	23-Jan-08	*Aedes notoscriptus*			1	**1**
Medowie	31-Jan-08	*Aedes procax*	1			**1**
Saltash	5-Feb-08	*Aedes procax*	1			**1**
		TOTAL	**6**	**1**	**4**	**11**

Tweed Heads: of the two sites, Piggabeen Road mainly yielded 'low' numbers. Beltana Road consistently yielded greater mosquito densities with many 'high' collections, which tended to be dominated by *Culex sitiens*. No virus isolation was undertaken.

Wyong: trapping was undertaken only at the one site of Ourimbah and collections were mostly 'low', dominated by *Aedes notoscriptus*. No viruses were isolated from the mosquitoes.

Sydney Locations

Blue Mountains: Trapping was undertaken on three occasions only, with 'high' collections yielded each time. These traps were dominated by *Aedes notoscriptus*. No viruses were isolated from the mosquitoes.

Georges River: trapping began in early March at three sites; Illawong, Lugarno and Alfords Point. All sites collected 'high' numbers during the first week and thereafter were mostly 'low'. There was one isolate of BFV from *Aedes procax*, collected on 19/Mar/2008.

Hawkesbury: trapping was undertaken at the three sites of Wheeney Creek, Yarramundi and McGraths Hill. Most of the collections were 'low', with the occasional 'medium' to 'high' collection. There was one isolate of EHV from *Aedes* sp. Marks 51 (a similar species to *Aedes procax*) collected on 14/Feb/2008.

Parramatta: George Kendall Reserve usually produces the greatest mosquito numbers, due to its close proximity to major saltmarsh habitat at Homebush Bay, and did so again this season with mainly 'high' collections, which tended to be dominated by *Culex sitiens*. Most of the other sites collected 'low' to 'medium' mosquito numbers, although Eric Primrose Reserve yielded a number of 'high' collections. Virus isolation was undertaken but no isolates were yielded.

Penrith: no mosquito collections were made this season.

Ryde: Wharf Road consistently trapped the most mosquitoes for any sites at Ryde, with several 'high' collections during March that were dominated by *Culex sitiens*. Most others sites tended to trap 'low' numbers, although Maze Park had several 'high' collections through February and March, and these were dominated by *Aedes notoscriptus*. Only mosquitoes from Lambert Park were continually tested for the presence of arboviruses, with one isolate of EHV from *Culex annulirostris*, collected on 11/Mar/2008.

Sydney Olympic Park: mosquito monitoring at this location has been occurring for a number of years and just one site was included in the processing for arbovirus surveillance. This site produced mostly 'medium' collections with some 'high' numbers. *Culex annulirostris* 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 common 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. The main vector in NSW is *Aedes vigilax* although other species are involved.

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 fevers, 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 cases 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 clinical cases of MVEV disease (before this season) occurred in 1974. The virus occurs only in inland regions of the state and the last major activity was in the summer/spring of 2001, although no human cases were reported. 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*.

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