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THE NEW SOUTH WALES ARBOVIRUS SURVEILLANCE & MOSQUITO MONITORING PROGRAM

2006-2007 Annual Report

Aedes procax

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EXECUTIVE OVERVIEW

- **For the 2006-2007 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 and south coast 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 dry conditions** that began during the first quarter of 2006 continued for the remainder of the year with the result that the inland region experienced one of the lowest precipitation years on record. The dry conditions were not ameliorated to any great extent with the start of 2007 as only average rainfall was recorded. The coastal strip mostly had below average rainfall, particularly along the south coast during late 2006, although the summer months recorded average levels. The north coast mostly had average precipitation amounts over the 2006-2007 season, although the first quarter of 2007 was drier than normal.

- **For the inland,** the extremely dry conditions resulted in minimal mosquito activity with the lowest number collected to date. Arbovirus activity was reduced with only the one isolate of KUNV from *Culex annulirostris* collected at Leeton during February, and human notifications of RRV were less than half of the previous year and well down on average. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

- **Along the coast,** the relatively dry conditions meant that mosquito populations were much lower this season, around half of the previous. There were relatively few arboviral isolates with a total of 9 (5 RRV, 1 BFV, 1 EHV & 2 unknowns). Most of the isolates were from *Aedes vigilax* (2 RRV, 1 EHV & 1 unknown), although *Aedes procax* yielded 3 (1 BFV, 1 RRV & 1 unknown) and there was one isolate of RRV each from *Culex annulirostris* and *Aedes flavifrons*.

- **Coastal disease notifications** were slightly above average with a total of 932 including 504 BFV and 428 RRV. The area that produced the highest case load was the Hunter with 289 notifications (128 BFV & 160 RRV), and this was despite the dry conditions. The **South Coast experienced the largest BFV outbreak to date** with 154 notifications and the epidemic was concentrated in the SLA of Eurobodalla. This SLA also had the greatest number of notifications for the state (77) and the highest notification rate for the season (219.1 cases/100,000). Notification rates for BFV in Eurobodalla peaked during April with 887.3 notifications/100,000.

- **For the Sydney trapping locations,** only two sites were operated this season, however mosquito numbers were noticeably higher than the previous year due to some very large collections of *Aedes vigilax* during January. Human notifications from the region were around average (90 in total), and included 52 RRV and 38 BFV.

- **The NSW Arbovirus Surveillance Web Site** http://www.arbovirus.health.nsw.gov.au/ continued to expand and now has over 178MB of information with 1,420+ pages.

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NSW ARBOVIRUS SURVEILLANCE AND MOSQUITO MONITORING PROGRAM 2006-2007

INTRODUCTION

The aim of the Program is to provide an early warning of the presence of Murray Valley encephalitis virus (MVEV) and Kunjin (KUNV) viruses 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) viruses, 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 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). As a consequence, arboviral disease epidemiology often can be vastly different 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 comes 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 2006-2007 season follow.

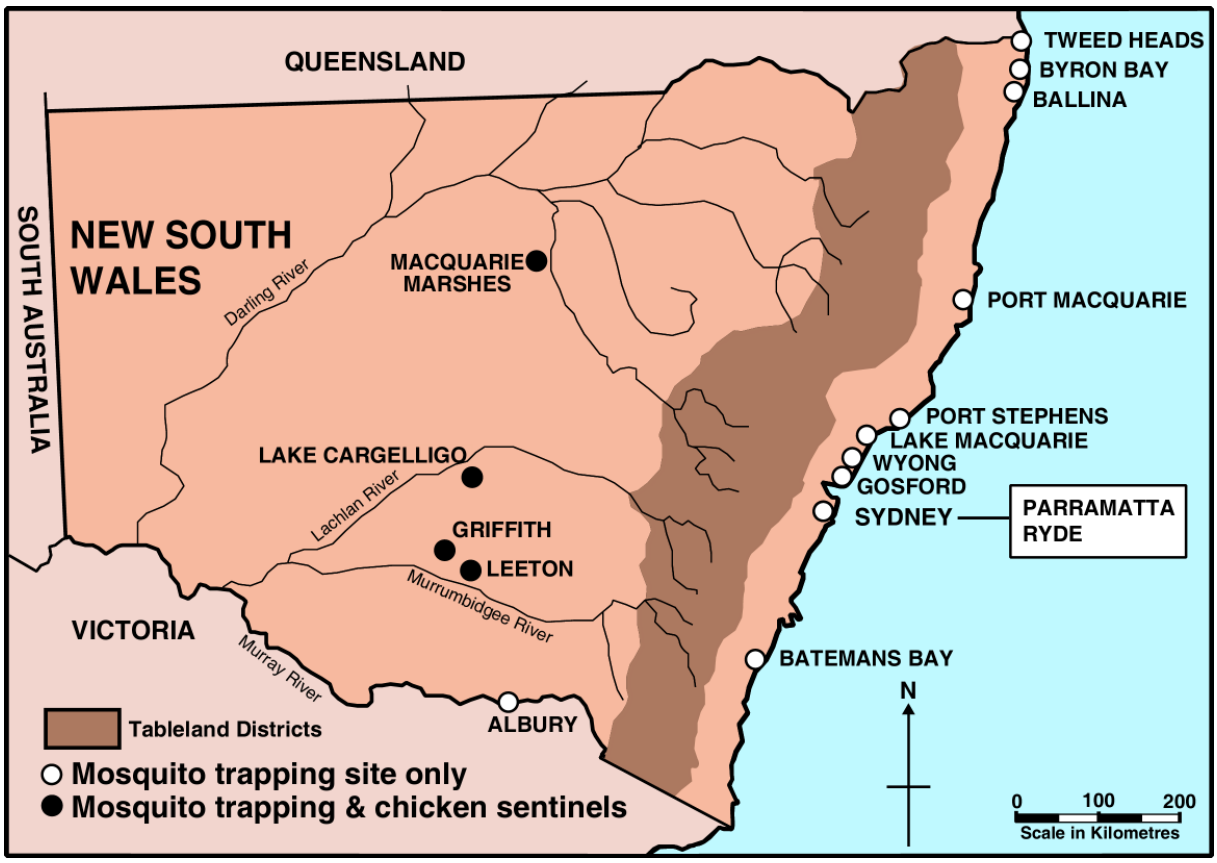


Fig 1. Mosquito trapping locations and Sentinel Chicken sites, 2006-2007.

MONITORING LOCATIONS

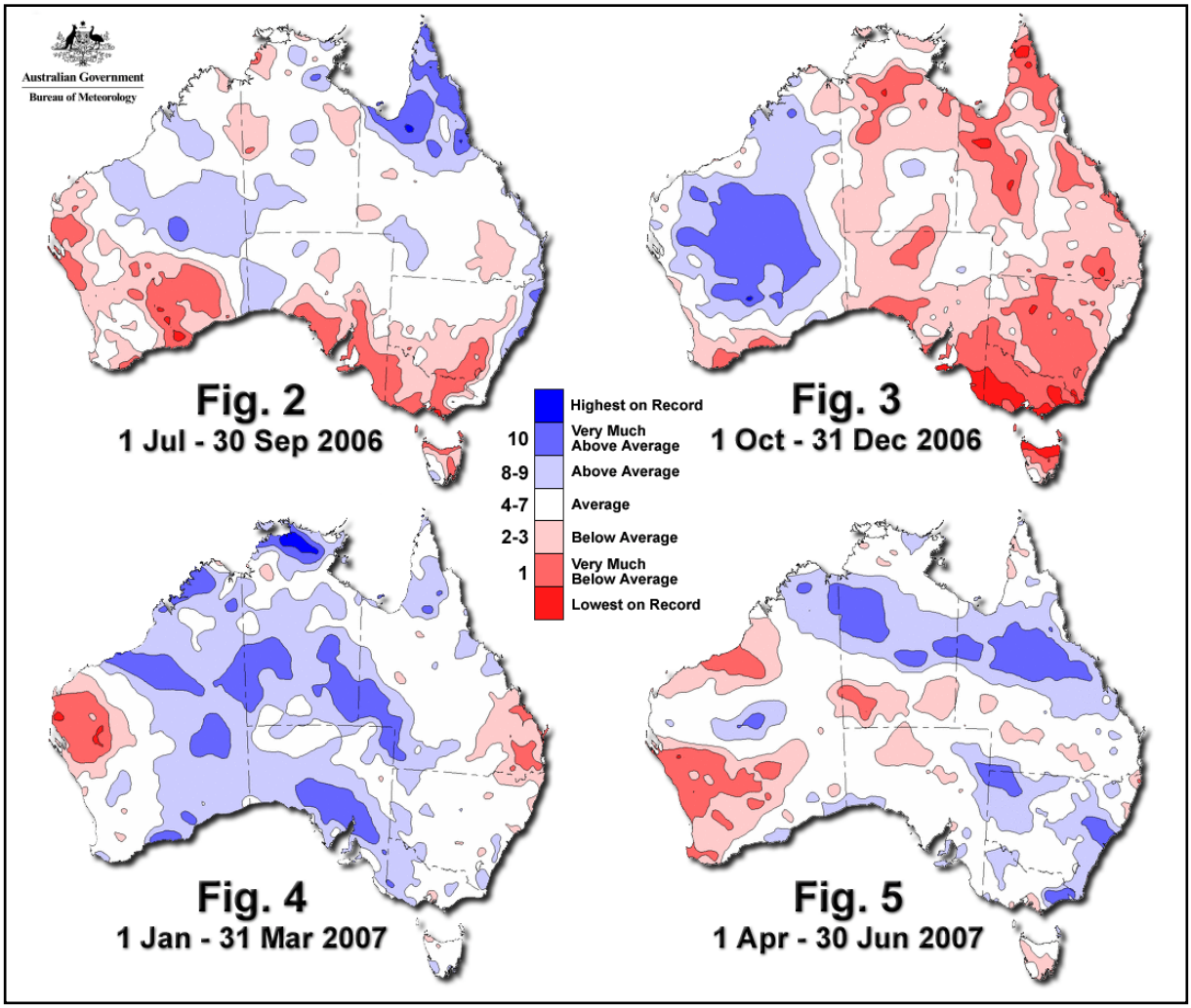
http://www.arbovirus.health.nsw.gov.au/areas/arbovirus/location/locations.htm

For 2006-2007, mosquito-trapping sites were operated at 4 inland, 9 coastal and 2 Sydney locations (Fig 1). Chicken sentinel flocks were located at 4 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 3 month periods, Jul-Sep 2006, Oct-Dec 2006, Jan-Mar 2007 & Apr-Jun 2007. The stronger the red, the drier the conditions. Conversely, the stronger the blue, the wetter the conditions. *Modifed from the Australian Bureau of Meterology, 2007*.

The dry conditions for the inland beginning during the first quarter of 2006 continued for the remainder of the year, with the last quarter being exceptionally low in rainfall (Figure 3), with much of inland region having very much below average precipitation. In fact, 2006 was one of the driest years on record for the inland, with the southern slopes having record low precipitation. Even for the start of 2007 (Figure 4), rainfall conditions were only average, although the quarter of April to June (Figure 5) saw some moderate rainfalls. Rainfall along the coastal strip was variable and mostly below average. The south coast had below average rainfall during late 2006 (Figure 3) and average during early 2007. For much of the north coast average precipitation occurred over the 2006-2007 season, although the first quarter of 2007 was notably drier than normal.

As per the previous two seasons, temperatures were well above average for 2006-2007, particularly during September to November. Over these months, many inland regions had temperatures of up to four degrees above average. Much of the coast was consistently 1-2 degrees above normal.

MVEV Predictive Models

Two models have been developed for the prediction of MVEV outbreaks 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.

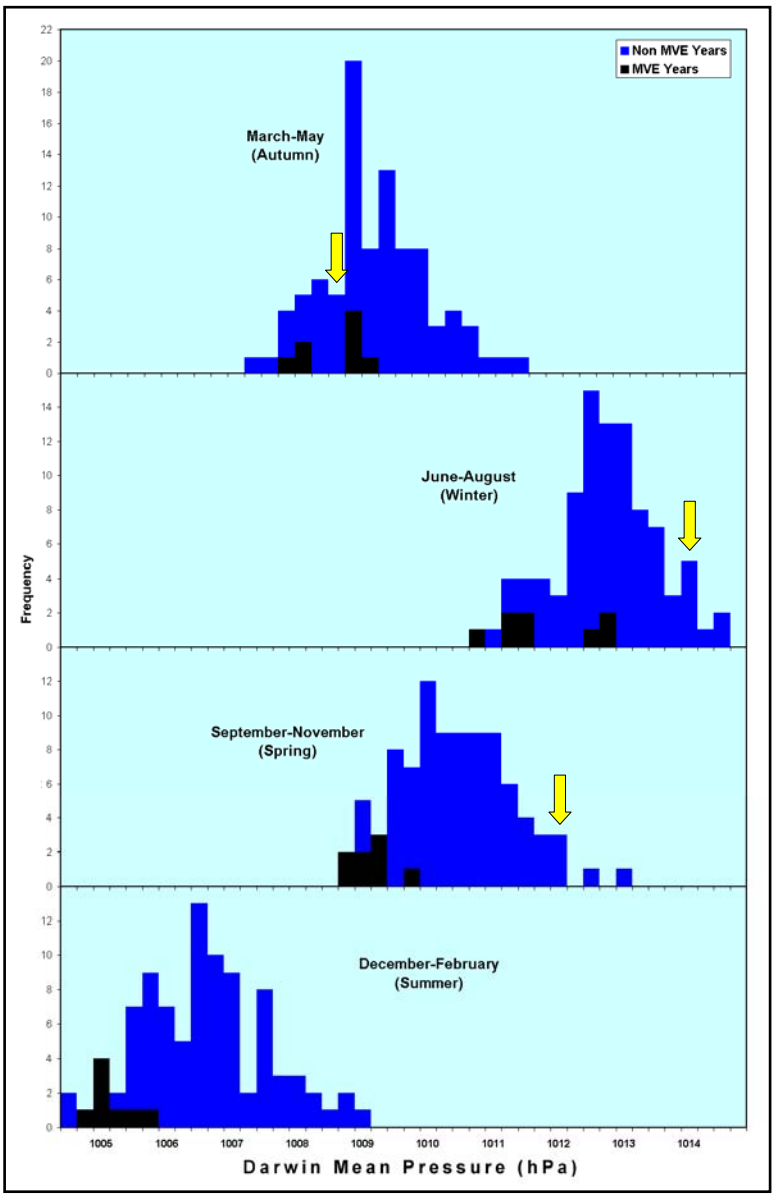


Figure 6. The SO by seasons prior to MVEV active years, according to Nicholls (1986), updated up to Winter 2007. The black bars represent the pre-MVEV active seasons. The yellow arrows indicate the respective SO values relevant to the 2006-2007 season.

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 2005) or the first quarter of the current year (January-March 2006) and the last quarter of the current year (October-December 2006), then a MVEV outbreak is probable. Rainfall was not above decile 7 for all the catchment basins for the last quarter of 2005, the first quarter of 2006 or the last quarter of 2006. Thus, the hypothesis was not satisfied for the 2006-2007 season. As rainfall was only above decile 7 in one of the catchments for the first quarter of 2006 (the Northern Rivers), the hypothesis would suggest that an MVEV outbreak in southeastern Australia would be unlikely for the 2006-2007 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 in mm) for the autumn, winter and spring period prior to a disease outbreak. For the autumn, winter and spring periods of 2006, the SO values were respectively; 1008.50mm, 1014.10mm and 1012.1mm (indicated on Figure 6 by the yellow arrows). While the autumn figure was within the range of values for the same period of past MVEV outbreak years, the winter or spring periods were not (Figure 6). Likewise, the summer 2006–2007 SO value of 1007.53mm was higher than that experienced during MVEV years. Currently, the autumn and winter Nicholls' values for 2007 are 1009.87mm and 1012.93mm, respectively, and while the winter figure is in the range of past MVEV outbreak years, the autumn value is not.

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; 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, 73,694 mosquitoes representing 45 species were collected in NSW during the 2006-2007 season. This total was close to around one third that of the previous season. *Culex annulirostris* and *Anopheles annulipes* were the most abundant and most important of the inland mosquito species during the summer months, whereas *Aedes vigilax*, *Culex annulirostris*, *Culex sitiens, Coquillettidia linealis* 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 exceptionally dry conditions coupled with the hot weather during late 2006 meant that mosquito numbers were well below normal across the inland. The total of 10,729 mosquitoes trapped, comprising 11 species, was only one tenth of the previous season's collection. *Culex annulirostris* was the dominant species at most sites and comprised 59.0% of the total inland collections. *Anopheles annulipes* (18.6%) was the next most common species.

Coastal

In total, 45,162 mosquitoes comprising 44 species were collected from coastal NSW and this was around half of the previous seasons total collection. The most common species collected were *Aedes vigilax* (46.0% of the total coastal mosquitoes trapped), *Culex sitiens* (10.7%), *Aedes notoscriptus* (10.2%), *Culex annulirostris* (9.5%), *Aedes procax* (5.6%) and *Coquillettidia linealis* (5.3%).

Metropolitan Sydney

A total of 17,803 mosquitoes, comprising 20 species, was collected from metropolitan Sydney. This was around 50% up on the previous season's total collection. *Aedes vigilax* (54.6% of the total Sydney mosquitoes trapped) was the most common species followed by *Aedes notoscriptus* (20.3%) and *Culex annulirostris* (14.2%).

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

From the mosquitoes processed, there were 10 viral isolates; 1 from the inland and 9 from the coastal locations. These are listed in Table 1 below.

Table 1. Arbovirus isolates, 2006-2007.

LOCATION - Site	Date	Mosquito Species	Virus					TOT
			RRV	BFV	EHV	KUNV	Virus?	
LEETON - Farm 347	14-Feb-07	*Culex annulirostris*				1		**1**
PORT STEPHENS - Heatherbrae	27-Feb-07	*Aedes procax*	1					**1**
PORT STEPHENS - Karuah	7-Mar-07	*Aedes vigilax*					1	**1**
GOSFORD - Killcare	23-Mar-07	*Aedes vigilax*			1			**1**
PORT STEPHENS - Heatherbrae	3-Apr-07	*Aedes vigilax*	1					**1**
PORT STEPHENS - Heatherbrae	3-Apr-07	*Culex annulirostris*	1					**1**
PORT STEPHENS - Medowie	17-Apr-07	*Aedes vigilax*	1					**1**
PORT STEPHENS - Heatherbrae	17-Apr-07	*Aedes flavifrons*	1					**1**
PORT STEPHENS - Heatherbrae	17-Apr-07	*Aedes procax*					1	**1**
LAKE MACQUARIE - Dora Creek	16-May-07	*Aedes procax*		1				**1**
		TOTAL	**5**	**1**	**1**	**1**	**2**	**10**

RRV = Ross River virus, BFV = Barmah Forest virus, EHV = Edge Hill virus, KUNV = Kunjin virus, Virus? = 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 2006-2007 season began on November 28th 2006 with the first bleed and ended on April 30th 2007 with the last. For 2006-2007, four flocks each containing 15 Isa Brown pullets were deployed at Griffith, Lake Cargelligo, Leeton and Macquarie Marshes (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 the Communicable Diseases Network, Australia.

Results

The season began with 60 pullets and no deaths were recorded for the entire season. A total of 943 samples were received from the four flocks in NSW over the six-month period in 2006-2007. This represented 1,886 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. Likewise, no cases of MVEV or KUNV disease were detected in humans in NSW, Vic or SA in 2006-2007.

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 notifications for the period July 2006 to June 2007 was 1,336 and included 589 BFV, 676 RRV and 71 Dengue virus notifications (note that all the Dengue notifications necessarily were acquired outside of NSW as the vector is not known in this state). This season had the fourth highest number of notifications since reporting began in 1991 and was around 20% above the previous twelve season average of 1,043. The coastal region accounted for 932 (74% of the state total) of the BFV and RRV notifications, which was around 50% above the previous twelve season average of 683

(Table 3). The 243 notifications (19% of the state total) from the inland were down upon the previous twelve year seasonal average of 284. Within the Sydney region there were 90 cases reported, slightly above the twelve season average of 76.

The Hunter Area Health Service received the highest number of notifications (289) with the Mid North Coast having 221 and the Northern Rivers with 170. Combined, these three areas accounted for 54% of all the arbovirus notifications for the state.

Table 2. Arbovirus disease notifications according to former Area Health Service, July 2006 - June 2007*.

Month	CS	NS	WS	WE	SW	CC	HU	IL	SE	NR	MN	NE	MA	MW	FW	GM	SA	Total
RRV	8	18	4	9	4	35	160	25	9	65	117	55	58	23	23	37	26	**676**
BFV	8	6	7	3	3	23	128	59	11	98	101	14	13	2	6	12	95	**589**
DENV*	4	14	3	1	8	3	1	3	19	7	3	1	1	1	0	0	2	**71**
Total	**20**	**38**	**14**	**13**	**15**	**61**	**289**	**87**	**39**	**170**	**221**	**70**	**72**	**26**	**29**	**49**	**123**	**1336**

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. *All the DENV cases have been acquired outside of NSW. *Data from the NSW Notifiable Diseases Database, 'GODSEND'.

DISCUSSION

The Inland. With the result of 2006 being one of the driest and warmest years on record, mosquito populations failed to increase any where near the levels seen over previous seasons. In fact the total collected was the lowest to date and only around one tenth that of the previous season. Despite some rainfall during the summer months, albeit at average levels, mosquito production remained low. The dry conditions across the inland meant that less water had been available for irrigation with the result that there were fewer habitats available for vector breeding. This was particularly evident at the Griffith site of Willbriggie, whereby the major mosquito breeding swamp has been drying out and mosquito numbers were at times during this season, less than one hundredth that of the long term average. The lower mosquito populations correlated with reduced arboviral activity; there was only the one isolate of KUNV from Leeton (there were no notified human cases of KUNV). The 243 human cases notified, including 196 RRV & 47 BFV (Table 3), was less than half of the previous season total of 477 (419 RRV & 58 BFV) and below the long term average of 284 (262 RRV & 22 BFV).

The Coast. The below average rainfall meant that mosquito numbers were well down upon the previous season with only around 50% of the previous season's total collected this year. There were relatively few arboviral isolates; the total of nine from the coast (5 RRV, 1 BFV, 1 EHV & 2 unknowns) was well below the previous season total of 73. Despite the low number of isolates, these were yielded from a range of mosquito species breeding in disparate habitats. The saltmarsh mosquito, *Aedes vigilax*, produced most isolates as per normal, however there were three (1 RRV, 1 BFV & 1 unknown) from *Aedes procax*, a species that breeds in freshwater bushland ground pools. This is a species that over recent years has produced a number of isolates, particularly BFV, and must now be considered a vector of some significance. The other two isolates where

from the major vector, *Culex annulirostris*, and *Aedes flavifrons*. The latter is another species that breeds in bushland freshwater ground pools. The range of species yielding isolates and the different habitats they represent, demonstrated the complex nature of arboviral ecology within coastal regions and the difficulty in predicting the risk of transmission to humans.

Table 3. Notifications of BFV & RRV disease per virogeographic regions of NSW per season, 1994-1995 to 2006-2007 (after Doggett 2004 and 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**
Total	**3880**	**315**	**135**	**4330**	**5253**	**3340**	**863**	**9456**
Ave[4]	281	22	8	**312**	402	262	68	**732**

[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 twelve season average from 1994-1995 to 2005-2006.
*Data from the NSW Notifiable Diseases Database, courtesy Mr Mark Bartlett and GODSEND.

The total number of human notifications from the coast was 932 (Table 3) and comprised 504 BFV and 428 RRV. Despite the reduced mosquito numbers and relatively few arboviral isolates, the total number of notifications was around 30% greater than the average long term average of 683. This season saw increased notifications from the Hunter region, with 289 cases in total (128 BFV & 160 RRV) and this was despite some very dry conditions during the early summer months whereby trapping even ceased for several weeks at Port Stephens. Within the Hunter region the most prominent SLAs for arboviral notifications were Lake Macquarie (52), Newcastle (44) and Port Stephens (37).

Table 4. Notifications of BFV & RRV by Statistical Local Area for NSW during 2006-2007 with >10 notifications/disease*.

SLA	BFV	RRV	Total
Eurobodalla	66	11	**77**
Hastings	23	49	**72**
Shoalhaven	53	9	**62**
Kempsey	29	29	**58**
Great Lakes	28	29	**57**
Lake Macquarie	27	25	**52**
Greater Taree	25	24	**49**
Newcastle	18	26	**44**
Gosford	14	24	**39**
Coffs Harbour	19	19	**38**
Tweed	23	13	**36**
Dubbo	8	30	**38**
Port Stephens	18	19	**37**
Bega	25	9	**34**
Byron	17	10	**27**

SLA	BFV	RRV	Total
Nambucca	15	11	**26**
Maclean	13	12	**25**
Bellingen	15	9	**24**
Cessnock	6	18	**24**
Ballina	13	6	**19**
Wyong	8	11	**19**
Moree	3	15	**18**
Lismore	7	6	**13**
Maitland	2	11	**13**
Coonabarabran	0	12	**12**
Grafton	6	5	**11**
Richmond River	8	3	**11**
Warringah	4	7	**11**
Wollongong	5	6	**11**

*Data from the NSW Notifiable Diseases Database, courtesy Mr Mark Bartlett and GODSEND.

Table 5. Crude notification rates/100,000 of BFV & RRV by Statistical Local Area for NSW during 2006-2007 with >50 notifications /100,000*.

SLA	BFV	RRV	Total
Eurobodalla	187.8	31.3	**219.1**
Kempsey	104.5	104.5	**209.0**
Coonabarabran	0.0	191.5	**191.5**
Brewarrina	0.0	184.8	**184.8**
Bellingen	111.6	66.9	**178.5**
Bourke	0.0	167.2	**167.2**
Great Lakes	81.8	84.5	**166.3**
Gilgandra	0.0	154.7	**154.7**
Barraba	95.4	47.7	**143.1**
Nambucca	78.3	57.4	**135.6**
Maclean	69.7	64.3	**133.9**
Moree	20.9	104.2	**125.0**
Murrumbidgee	36.2	72.3	**108.5**
Hastings	34.6	73.6	**108.2**
Greater Taree	55.2	53.0	**108.1**
Bega	78.6	28.3	**106.9**
Bingara	0.0	106.0	**106.0**
Carrathool	0.0	101.9	**101.9**
Walgett	12.1	85.1	**97.2**
Richmond River	70.6	26.4	**97.0**

SLA	BFV	RRV	Total
Dubbo	20.1	75.2	**95.2**
Deniliquin	25.5	63.9	**89.5**
Quirindi	44.2	44.1	**88.3**
Leeton	17.6	70.5	**88.1**
Kyogle	40.1	40.1	**80.1**
Byron	50.3	29.5	**79.8**
Holbrook	39.7	39.7	**79.3**
Narramine	15.6	62.2	**77.7**
Casino	48.0	28.8	**76.8**
Shoalhaven	58.3	9.9	**68.2**
Grafton	35.2	29.3	**64.4**
Narrabri	0.0	61.9	**61.9**
Forbes	0.0	61.1	**61.1**
Lachlan	0.0	58.4	**58.4**
Port Stephens	28.1	29.6	**57.7**
Coolah	0.0	56.9	**56.9**
Hay	0.0	56.7	**56.7**
Coffs Harbour	27.7	27.7	**55.3**
Cessnock	12.7	38.1	**50.8**

*Data from the NSW Notifiable Diseases Database, courtesy Mr Mark Bartlett and GODSEND.

Contributing to the above average notifications was a major BFV epidemic from the south coast, where there were 154 cases reported (95 from SA AHS and 59 from Ill AHS). This surpasses the 1995 outbreak (Doggett *et al*. 1999a), thus making the 2006-

2007 the largest outbreak of BFV to date from the south coast. The focus of the activity was in the SLA of Eurobodalla (Batemans Bay being the major town in the area) with 65 notifications. This SLA also had the greatest number of arboviral disease notifications for the state (77, Table 4) and the highest notification rate for the season (219.1/100,000, Table 5), with a peak rate during April of 887.3 notifications/100,000. The Shoalhaven had 53 BFV cases and was the third highest in the state for all arboviral notifications this season.

As indicated in Table 2, there was again a high number of BFV notifications reported from the north coast, with some 350 cases combined for the regions north of Sydney. The Hunter area had the majority of cases (128), followed by the Mid-North Coast (101) and Northern Rivers (98). Per SLA for the north coast, Kempsey had the highest number of BFV notifications (29, Table 4) and the highest notification rate (103.5/100,000, Table 5).

The following is a summary of the BFV activity in coastal NSW since 2000-2001 season. In 2000-2001, BFV activity was mainly confined to the Kempsey region on the mid north coast and followed upon heavy flooding as a result of record rainfall, along with high spring tides. The 2001-2002 activity was more diffuse along the coast, with the first ever cases being reported in western Sydney, and it is thought that this outbreak may have had a greater involvement of freshwater vectors. For 2002-2003, the far north coast had most activity, although the mid north coast had 136 cases, and this was the largest recorded outbreak of BFV in Australia to date. For the 2003-2004 season the mid north coast was again the most active BFV region. During 2004-2005, the outbreak again focused on the mid-north coast especially around Port Macquarie. While for 2005-2006, which produced the largest number of notifications to date, activity was widespread along the coast, with cases peaking around the Hastings and Kempsey area.

Table 6. Notifications of BFV & RRV disease from the Northern Rivers & Mid North Coast AHSs, over the last five mosquito seasons*.

Virus	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Total
BFV	307	250	350	274	337	309	119	2026
RRV	215	82	347	305	230	430	117	1726
Total	**522**	**332**	**697**	**579**	**567**	**739**	**318**	**3752**
NSW Total	1161	711	901	988	873	1882	1265	7781

*Data from the NSW Notifiable Diseases Database, courtesy Mr Mark Bartlett and GODSEND.

Over recent years, the north coast of NSW has been the region that has produced the majority of human arbovirus notifications for the state. Combining the Mid North Coast and the Northern Rivers AHSs for 2006-2007, there were 119 BFV cases and 117 RRV. The total (318) for this season represented almost 25% of all BFV/RRV reports from the state. This was well down upon recent years, whereby over the last six seasons, these AHSs have accounted for close to 53% of all the state wide BFV/RRV disease notifications (Table 6).

Human notifications since the 1994-1995 season by SLA, reveal that nine of the top ten in terms of numbers are all within the north coast of NSW (a total of 4,219 cases for

these SLAs) and a further eight are in the top 21 (6,366 cases for all the north coast SLAs in the top 21). The Hastings area, with 722 notifications (376 BFV & 346 RRV, Table 7) continues to rates the number one 'hot spot' for arbovirus activity in NSW. The adjoining SLA of Kempsey had the second highest notification rate for the state during 2006-2007 and the highest for the north coast with 209.0 cases/100,000 (Table 5). Why these two geographically close regions result in so many notifications is unknown, although the region does comprise numerous and diverse waterways, with many native animals that may act as viral reservoir and amplifying hosts.

Table 7. Notifications of RRV & BFV by Statistical Local Area for 1994-1995 to 2006-2007, for areas with total notifications of over 200 and includes the ranking*.

Statistical Local Area	RRV	RRV Rank	BFV	BFV Rank	Total	Total Rank
Hastings	346	2	376	1	**722**	**1**
Tweed	352	1	189	6	**541**	**2**
Byron	296	3	220	4	**516**	**3**
Kempsey	236	7	277	2	**513**	**4**
Port Stephens	284	5	131	13	**415**	**5**
Greater Taree	194	13	192	5	**386**	**6**
Lake Macquarie	294	4	92	16	**386**	**7**
Lismore	222	9	161	8	**383**	**8**
Eurobodalla	150	21	222	3	**372**	**9**
Great Lakes	175	17	182	7	**357**	**10**
Shoalhaven	205	11	145	10	**350**	**11**
Coffs Harbour	186	15	156	9	**342**	**12**
Ballina	172	18	117	15	**289**	**13**
Gosford	223	8	61	20	**284**	**14**
Griffith	252	6	21	29	**273**	**15**
Maclean	136	22	127	14	**263**	**16**
Newcastle	189	14	64	19	**253**	**17**
Nambucca	114	27	134	12	**248**	**18**
Bellingen	102	28	139	11	**241**	**19**
Walgett	208	10	22	28	**230**	**20**
Wyong	195	12	32	25	**227**	**21**

*Data from the NSW Notifiable Diseases Database, courtesy Mr Mark Bartlett and GODSEND.

It was noted in last season's report that 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 the mounting concerns. An outcome was the document 'Living with Mosquitoes in the Lower Hunter and Mid North Coast' (http://www.hnehealth.nsw.gov.au/hneph/LivingWithMosquitos.htm). 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 there was one isolate of BFV (from *Aedes procax*). For this season, the Lake Macquarie area had the eleventh highest total of arboviral notifications for any SLA within NSW and since 1994 has the seventh highest number of notifications within the state (Table 7).

For the south coast, monitoring was confined to two weeks only at one site within

Batemans Bay. Despite the intense BFV activity within the region as noted above, and the 'high' mosquito collections, there were no arboviral isolates from the trapped mosquitoes. Unfortunately, trapping had not begun until very late in the season, at the end of March, and it is most likely that the BFV activity was on the wane by that time.

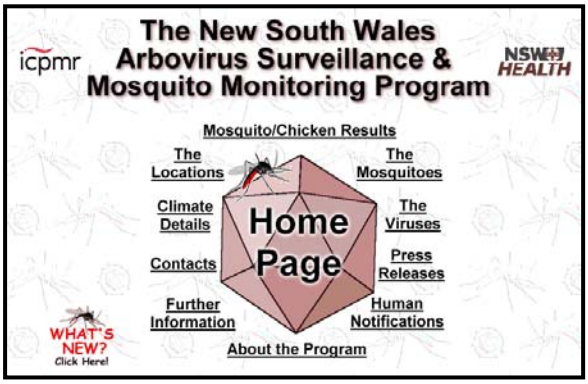
Sydney. For the Sydney trapping sites, only two operated over the 2006-2007 season. Despite this, mosquito numbers were well up this season and around 50% above that of the previous year. The increase was due to large hatchings of *Aedes vigilax* around the Parramatta area, with some 'very high' mosquito collections during late January.

Human notifications were around average with 90 notifications including 52 RRV and 38 BFV. The Statistical Local Areas that produced the most cases included Warringah (7 RRV & 4 BFV), although it is unlikely that any of these were locally acquired, and Sutherland (4 RRV & 5 BFV). For Sutherland it is possible that some of these may have been locally acquired as there has been recent RRV activity in the area (Spokes *et al*., 2007), as well as the BFV outbreak on the south coast this season.

Following RRV activity around the Sutherland/Georges River region in which there was a number of locally acquired cases during early 2006, a trapping program was initiated in the area during the 2006-2007 season. Relatively large numbers of mosquitoes were collected in this study; one trap at Alfords Point produced a 'very high' catch of 3,125 *Aedes vigilax*, and mosquito numbers were consistently 'high' at this site, averaging around 600/night. The presence of the major coastal vector in large numbers, along with numerous macropod virus reservoir hosts and past evidence of RRV activity, suggests that the local community is at risk of future arbovirus disease activity.

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 178MB, and has 1,420+ pages of information.

Added to the site since the last annual report includes:

- Archived data for the 2006-2007 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 one 'medium' collection made in February at the Water Treatment Works. There were no arboviral isolates from the trapped mosquitoes.

Bourke: only one collection was made this season with 'low' mosquito numbers trapped. There were no viral isolates, nor any seroconversion to MVEV or KUNV in the sentinel chickens.

Condobolin: no mosquito collections were undertaken this season.

Griffith: mosquito numbers were well below average for the entire season. At Willbriggie, there were only three 'high' collections and no 'very high' from either site. Numbers from Hanwood where mostly 'high' from late December to March. There were no viral isolates, or any seroconversion to MVEV or KUNV in the sentinel chickens.

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 were well down upon the previous season. Most collections from January through to March were 'high', with no 'very high' collections yielded. There was 1 isolate from Leeton; a KUNV from *Culex annulirostris* trapped 14/Feb/2007 at Farm 347. There were no seroconversions to MVEV or KUNV in the sentinel chickens.

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

Menindee: there were no surveillance activities undertaken at Menindee this season.

Coastal Locations

Ballina: trapping was undertaken at Greenfield Road only. Mosquito numbers were below average and mainly 'medium' in number for most of the season, with only the two 'high' collections. There were no arboviral isolates from Ballina this season.

Batemans Bay: only two trapping nights were conducted, both late in the season (late March) and, unfortunately, the first night resulted in the Mogo State Forest trap being stolen. Both collections at the Council Depot produced 'high' mosquito numbers, dominated by *Aedes vigilax*. There were no arboviral isolates.

Byron Bay: only the one collection was made from two sites and mosquito numbers were 'low'. There were no arboviral isolates.

Gosford: two sites at Gosford were again monitored this year: Empire Bay and Killcare

Heights. For Empire Bay, mosquito numbers were mostly 'low' to 'medium'. As per previous seasons, mosquito numbers tended to be higher at Killcare Heights and there were several 'high' collections, particularly during March. These collections were strongly dominated by *Aedes vigilax.* No viruses were isolated from the mosquitoes.

Lake Macquarie:
There was one BFV isolated from *Aedes procax* collected at Dora Creek on 16/May/2007.

Port Macquarie: no mosquito collections were made this season.

Port Stephens: there were few collections made due to the dry weather between late December and early February. 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 throughout the entire season. Saltash had variable numbers; collections were 'low' in number until mid-November followed by some 'high' densities in early December, which persisted mostly until the end of the season. Medowie mosquito populations failed to reach the heights of the previous season, with many 'low' mosquito collections made and only two 'high' numbers trapped. Karuah consistently produced 'high' numbers throughout much of the season and were strongly dominated by *Aedes vigilax*. As usual, Heatherbrae continued to trap the most mosquitoes for any site within NSW, and mosquito numbers tended to be 'high' from early November, becoming 'very high' from February until the end of the season. *Aedes vigilax* was the most common species trapped at Heatherbrae comprising over half the mosquitoes collected. There were 7 arboviral isolates from Port Stephens, including 5RRV and 2 unknowns. Full details are in the summary table below.

Table 8. Arbovirus isolates from Port Stephens, 2006-2007.

LOCATION - Site	Date	Mosquito Species	Virus		TOT
			RRV	Virus?	
PORT STEPHENS - Heatherbrae	27-Feb-07	*Aedes procax*	1		**1**
PORT STEPHENS - Karuah	7-Mar-07	*Aedes vigilax*		1	**1**
PORT STEPHENS - Heatherbrae	3-Apr-07	*Aedes vigilax*	1		**1**
PORT STEPHENS - Heatherbrae	3-Apr-07	*Culex annulirostris*	1		**1**
PORT STEPHENS - Medowie	17-Apr-07	*Aedes vigilax*	1		**1**
PORT STEPHENS - Heatherbrae	17-Apr-07	*Aedes flavifrons*	1		**1**
PORT STEPHENS - Heatherbrae	17-Apr-07	*Aedes procax*		1	**1**
		TOTAL	**5**	**2**	**7**

Tweed Heads: all collections were 'low' from Piggabeen Road, while Beltana Road consistently yielded greater mosquito densities with several 'high' collections through February and March. These tended to be dominated by *Culex sitiens*. No virus isolation was undertaken.

Wyong: there were two sites where trapping was undertaken; Ourimbah and Halekulani. The former site produced only 'low' numbers dominated by *Aedes notoscriptus*. Halekulani had several 'medium' collections and one 'high' collection in mid-February.

This trap site was dominated by *Coquillettidia linealis* and *Culex annulirostris*. No viruses were isolated from the mosquitoes.

Sydney Locations

Baulkham Hills: no mosquito collections were made this season.

Concord: no mosquito collections were made this season.

Hawkesbury: no mosquito collections were made this season.

Parramatta: mosquito numbers were much higher this season, with two 'very high' collections during late January from George Kendall Reserve, and this collection was strongly dominated by *Aedes vigilax*. Collections at this site were 'high' from January through until mid-March. The reason for the increase relates to a combination of rainfall and tidal events. George Kendall Reserve was the most productive of the Parramatta sites, mainly because it is in close proximity to major saltmarsh habitat at Homebush Bay. Most of the other sites collected 'low' to 'medium' mosquito numbers. Virus isolation was undertaken but no isolates were yielded.

Penrith: no mosquito collections were made this season.

Ryde: as there was increased *Aedes vigilax* production at Homebush this season, as mentioned under the Parramatta details, collections were also much greater at Ryde. Wharf Road had consistently 'high' mosquito numbers from late December through to mid-March, with one 'very high' catch in early February. All of these large collections were strongly dominated by *Aedes vigilax*. Most of the other sites collected 'low' to 'medium' mosquito numbers, with the occasional 'high' catch due to elevated populations of either *Aedes vigilax* or *Aedes notoscriptus*. 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 300-400 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 on average 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 which can have large outbreaks, disease from SINV is relatively uncommon in Australia; 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 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 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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REFERENCES

Bureau of Meteorology, Australia. (2007). Rainfall Maps. http://www.bom.gov.au/cgi-bin/climate/rainmaps.cgi, *accessed 17/Sep/2007.*

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

Doggett S.L., Russell R.C., Clancy J., Haniotis J. and Cloonan M.J. (1999a). **Barmah Forest virus epidemic on the south coast of New South Wales, Australia, 1994-1995: Viruses, Vectors, Human Cases, and Environmental Factors**. *Journal of Medical Entomology*, 36: 861-868.

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

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

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

Doggett S., Clancy J., Haniotis J., Russell R.C., Hueston L., Marchetti M. and Dwyer D. (2006). **The New South Wales Arbovirus Surveillance & Mosquito Monitoring Program. 2006 – 2007 Annual Report**. *Department of Medical Entomology, Westmead*. 32.

Doggett S.L. and Russell R.C. (2005). **The epidemiology of Ross River and Barmah Forest viruses in New South Wales.** *Arbovirus Research in Australia*, 9: 86-100.

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

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

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

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

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

Spokes P.J., Doggett S.L. and Webb C.W. (2007). **Bug breakfast in the Bulletin: Ross River virus**. *NSW Public Health Bulletin*, 18(3-4): 63-64

Webb C.A. and Russell R.C. (2005). **Living with Mosquitos**. *Department of Medical Entomology, Westmead*. 72pp. This can be downloaded for free from: www.hnehealth.nsw.gov.au/hneph/LivingWithMosquitoes/LivingWithMosquitosInTheLowerHunterAndMidNorthCoastRegionOfNSW.pdf

Webb C.A. and Russell R.C. (2007). **Mosquito Population & Arbovirus Survey: Georges River, NSW.** A report for the South Eastern Sydney & Illawarra Public Health Unit. *Department of Medical Entomology, Westmead*. 44pp.