Government of Western Australia
Department of Health

Medical Entomology

Annual Report

Disease case statistics/epidemiology and entomological summary for 2014-2015

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Acknowledgements

The extensive and diverse work program undertaken by the Department of Health’s Medical Entomology team outlined in this Annual Report could not have been completed without very significant assistance and collaboration from many partners and stakeholders.

In particular, the Medical Entomology team wishes to thank the Department of Health for its ongoing support in regards to this important public health program including the:

the Environmental Health Directorate;
the Communicable Disease Control Directorate;
PathWest;
Communications Directorate; and
the Office of Mental Health.

The Arbovirus Surveillance and Research Laboratory at The University of Western Australia continued to have a significant involvement in the program through provision of laboratory services for key components of the surveillance program for detection of arboviruses of public health significance to the State.

We also acknowledge and thank the Population Health Units and the Western Australian Country Health Service for their role in reporting and follow-up of human cases of disease, and especially the role of Local Governments in the management of mosquitoes and the diseases they transmit. These organisations play an active role in the provision of data, case follow up investigations, care and bleeding of chickens for the sentinel chicken program, trapping of mosquitoes, mosquito control treatments and advice to the Western Australian community about disease risk through the media.

In particular we thank Environmental Health Officers from the 139 Local Governments across WA [especially those within Contiguous Local Authority Groups (CLAGs)] who respond to public complaints, undertake larval and adult mosquito surveys, and constantly assess the risk of mosquito-borne disease transmission as part of their complex, integrated programs to manage the risks to public health and amenity within their regions.

The collaborative approach and effort by the teams and agencies described above is a feature of this truly state-wide, integrated program, and its effective delivery across the largest jurisdiction in Australia.

Contents

Executive Summary

This annual report summarises the mosquito-borne disease case data and associated significant events for 2014-2015 (1 July 2014 to 30 June 2015).

Mosquito-borne disease case data:

Ross River virus (RRV): The total number of notified human cases of RRV disease for 2014-2015 was 1250. July to November 2014 and May to June 2015 had significantly more cases compared to the long term average for those months.

Barmah Forest virus (BFV): A total of 44 human cases of BFV disease were notified in WA for the 2014-2015 period. The number of cases was similar to or below the long term monthly average for all months except May 2015 during which 9 cases were reported compared to the long term monthly average of 5.

Murray Valley encephalitis (MVE) virus: No human cases of MVE were notified to the Department of Health during 2014-2015.

West Nile virus Kunjin strain (WNV_{KUN}): No human cases of Kunjin disease were notified to the Department of Health during 2014-2015.

Climatic Conditions:

Rainfall was above average during 2014-2015 for the majority of the northern interior of WA while most of the Southwest region experienced below average rainfall. Minimum temperatures were significantly above average across most of WA except northern parts where it was below average. Three tropical cyclones affected WA during 2014-2015 with the most severe, tropical Cyclone Olwyn, bringing very heavy rains and destructive winds to the Midwest and Gascoyne regions resulting in outbreaks of RRV and BFV from May until June.

Mosquito-Borne Disease Surveillance

Southwest Surveillance: In summary, a total of 96,577 mosquitoes were collected in 443 traps, of which, 69,534 were processed for virus detection. In total there were 16 detections of RRV, comprising 15 by PCR and 11 by virus isolation.

Northern Surveillance: In total, 23 arbovirus isolates were obtained from mosquitoes collected in the Northeast Kimberley region in 2014, comprising three KUNV, two SINV and 18 non-alphavirus/non-flavivirus isolates

Sentinel Chicken Program: A total of 40 arbovirus isolates were obtained from Sentinel chicken blood samples including 12 MVEV, 27 $WNV_{(KUN)}$ and 1 undetermined flavivirus.

Contiguous Local Authorities Groups (CLAGs):

The Department of Health provided funding to the amount of $198,594.43 to Local Governments (LGs) within CLAGs to assist with the management of mosquitoes and mosquito-borne diseases during 2014-2015.

Funding Initiative for Mosquito Management in Western Australia (FIMMWA):

Through FIMMWA, funding was distributed as follows:

- $148,434.66 was directly provided to Local Governments to assist with mosquito management, resources and capacity building.
- $166,800.00 was distributed to Research Institutions and other bodies for successful research grant applications.

- $583,000 was spent on capability projects across the State to build long-term capacity within Local Governments for the management of mosquitoes.

Aerial Larviciding Program:

In addition, the Department of Health spent $155,569.20 in the provision of aerial larviciding treatments through procurement of helicopter services in the Southwest region. A total of 17 aerial treatments were performed in the Peel Region while an additional six aerial treatments occurred in both the Leschenault and Geographe regions of the Southwest.

Introduction

There are 300 different species of mosquitoes in Australia, of which approximately 100 are known to occur in WA. Of these, mosquito-borne viruses have been isolated from over 30 species across Australia and many other species have not been tested for their ability to transmit viruses. The main disease-causing viruses of concern to WA residents that can be transmitted by mosquitoes are:

1) Ross River virus (RRV) – (all of WA);
2) Barmah Forest virus (BFV) – (all of WA);
3) Murray Valley encephalitis virus (MVEV) – (northern WA – Kimberley, Pilbara, Gascoyne, Midwest)*; and
4) West Nile virus Kunjin strain (WNV_{KUN}) – (northern WA – Kimberley, Pilbara, Gascoyne, Midwest)*.

   *See Appendix 1 for a map of WA regions.

Furthermore, the Medical Entomology (ME) program monitors the occurrence of exotic diseases that impact on people returning from countries outside of Australia. These diseases include:

1) Malaria;
2) Dengue fever;
3) Japanese encephalitis; and
4) Chikungunya.

The Role of Medical Entomology

The ME program is responsible for:

- monitoring human cases of mosquito-borne diseases through the Western Australian Notifiable Infectious Disease Database (WANIDD) to determine patterns of disease occurrence and provide warnings to at risk communities;

- the provision of expert advice to the Minister for Health, senior WA Department of Health (DoH) staff, other State Government agencies, Local Government Authorities (LGAs) and members of the public on matters concerning mosquitoes and the diseases they carry;

- the provision of specialist advice for development projects through the identification of existing mosquito breeding sites and to minimise the potential for newly created mosquito breeding habitat that may impact the development sites;

- undertaking State-wide surveillance of mosquito-borne diseases in conjunction with PathWest, including surveillance of mosquitoes for RRV/BFV activity in the Southwest region and surveillance of MVEV, WNV_{KUN} and the potential incursion of Japanese encephalitis virus through sentinel chicken flocks in the northern two-thirds of WA;

- issuing warnings and media statements when virus activity escalates, environmental conditions are suitable to vector breeding or surveillance activities identify particular risks;

- conducting field investigations and surveys of mosquito-borne disease outbreaks and mosquito-breeding habitat;

- conducting and assisting other agencies in research projects focusing on mosquito ecology, arboviruses, innovative mosquito management practices, mosquito management equipment trials and calibration and newly available chemicals and/or formulations for mosquito control;

- the development of policies for best practice mosquito control and use of chemicals, mosquito management plans, minimising risks for residential developments and avoidance of man-made mosquito breeding;

- the provision of training courses, seminars and lectures to train personnel involved in mosquito management and to disseminate information to stakeholders and the public;

- the coordination of the aerial larviciding program in the Southwest region of WA; and

- the coordination of the Contiguous Local Authority Group (CLAG) Funding Scheme and the Funding Initiative for Mosquito Management in Western Australia (FIMMWA).

Endemic Arboviruses

Ross River virus (RRV)

RRV is the most common arbovirus known to cause human disease in WA. Patients with RRV infection experience a polyarthritic condition with or without other symptoms such as fever, sore muscles, rash, lethargy and headaches. These symptoms can last from weeks to months, and in very rare cases, even up to years.

Overview

The total number of notified human cases of RRV infections for WA in 2014-2015 was 1250. During most months, the reported number of cases exceeded the long term monthly averages (red line). This was statistically significant from July to November 2014 and from April to June 2015 (Figure 1).

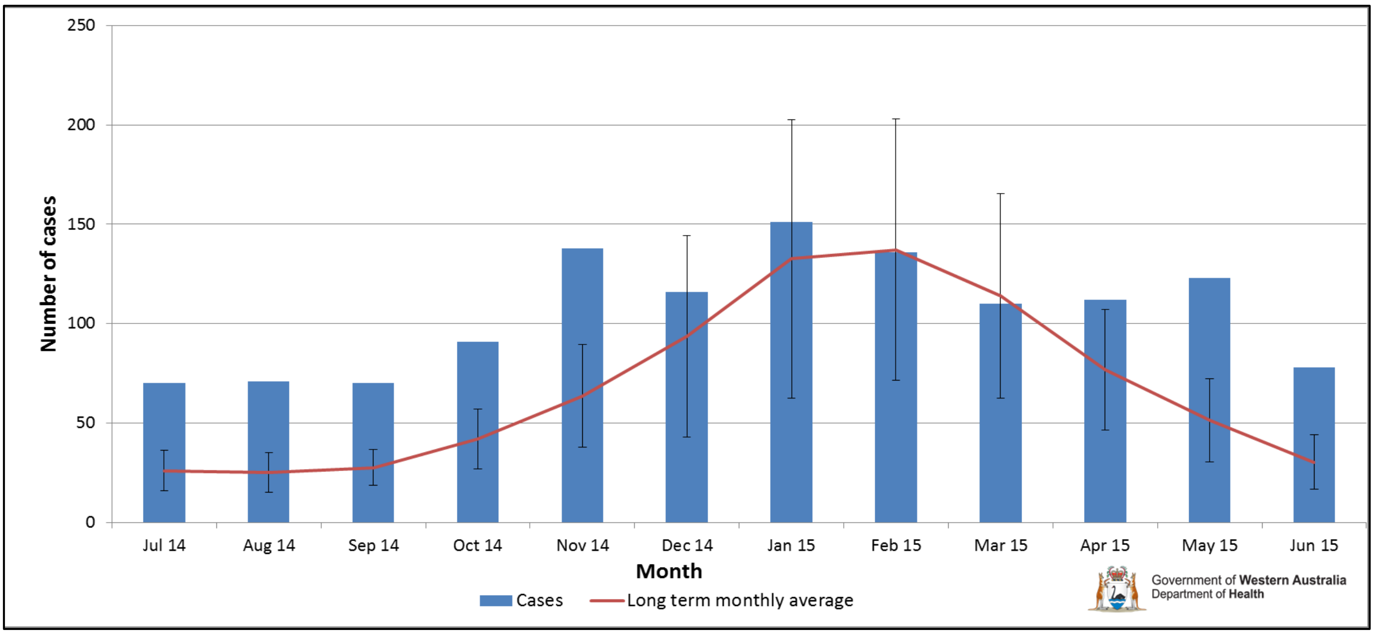


Figure 1: The total number of notified human cases of RRV per month across WA from July 2014 to June 2015*.

**Based on enhanced notified human cases from the West Australian Notifiable Infectious Disease Database (WANIDD) and includes enhanced surveillance data from follow-up questionnaires.*

Regional Summaries

The majority of RRV cases were recorded in the Perth metropolitan, Southwest and Midwest regions (Table 1). Within the Perth metropolitan region, the number of cases recorded (517) surpassed the long term average for all months of 2014-2015. During July to December 2014 this increase was significant. However, given the large population in this region, the disease rate (incidence per 100,000 people) was actually the lowest of all regions across the State (Table 1). The Crude Rate (CR) represents the number of RRV notifications per 100,000 population in each region and the Age Standardised Rate (ASR) adjusts for differences in the age distribution between the regions to enable direct comparison of the rates across regions.

The highest RRV ASR of 682.8 cases per 100,000 was recorded in the Gascoyne region, resulting from an outbreak around Carnarvon in April and May 2015. The Midwest and Kimberley regions had ASRs over 100 cases per 100,000 during 2014-2015.

A total of 368 cases were recorded from the Southwest region. Although most cases were reported during November to January period, numbers were below the long term monthly average. Similar to the Perth metropolitan region, July to November 2014 and May to June 2015 periods had significantly more cases than monthly long term averages.

Table 1: Serologically confirmed, doctor-notified, and laboratory reported cases of Ross River virus disease per month for each WA region from July 2014 to June 2015. CR = Crude rate per 100,000. ASR= Age standardised rate (age standardised to 2001 Australian standard population). * *Table may vary from previous or future version due to inclusion of additional surveillance data.*

Region	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total	CR	ASR
Kimberley	3	2	0	1	3	0	4	12	8	7	5	1	46	117.7	123.0
Pilbara	6	5	5	4	7	2	7	7	0	1	3	5	52	77.0	71.8
Gascoyne	0	0	1	0	0	0	0	0	0	23	32	12	68	682.8	655.6
Midwest	4	7	4	6	6	4	5	5	10	25	23	11	110	168.5	169.5
Wheatbelt	2	1	0	0	6	4	9	2	2	1	4	0	31	45.8	45.4
Metro	33	34	36	49	42	41	76	66	52	37	31	20	517	30.4	30.1
Southwest	15	16	22	25	62	56	44	36	37	16	18	21	368	85.8	
Peel	9	9	13	19	47	34	30	25	25	6	7	16	240	94.2	95.2
Leschenault	1	5	4	2	4	15	7	2	6	8	3	5	62	82.6	83.1
Geographe	4	2	4	3	8	4	6	5	6	1	6	0	49	93.1	98.7
Elsewhere SW	1	0	1	1	3	3	1	4	0	1	2	0	17	36.7	34.3
Great Southern	5	2	0	3	10	3	1	3	1	0	6	5	39	65.1	68.2
Goldfields-Esperance	1	4	1	2	1	4	2	2	0	0	1	1	19	31.0	30.3
WA undetermined	0	0	0	0	0	0	0	0	0	0	0	0	0		
Interstate	1	0	1	1	1	2	3	3	0	2	0	2	16		
WA Total (Does Not Include Interstate)	**69**	**71**	**69**	**90**	**137**	**114**	**148**	**133**	**110**	**110**	**123**	**76**	**1250**		

Midwest and Gascoyne Outbreak

Compared to the previous year, the number of RRV cases recorded in 2014-2015 in the Midwest and Gascoyne regions were significantly above the monthly average between April and June 2015. A total of 126 RRV cases were recorded during these three months, compared to only 5 cases during the same period in 2013-2014 (Figure 2). Moreover, the Gascoyne region recorded the highest crude rate for the year. This outbreak resulted from heavy rainfall associated with Cyclone Olwyn that crossed the WA coast between March 12 to 14 2014. Human cases of RRV disease were reported from throughout the Midwest region (Figure 3) and a cluster of cases were specifically associated with the Shire of Greater Geraldton (Figure 4).

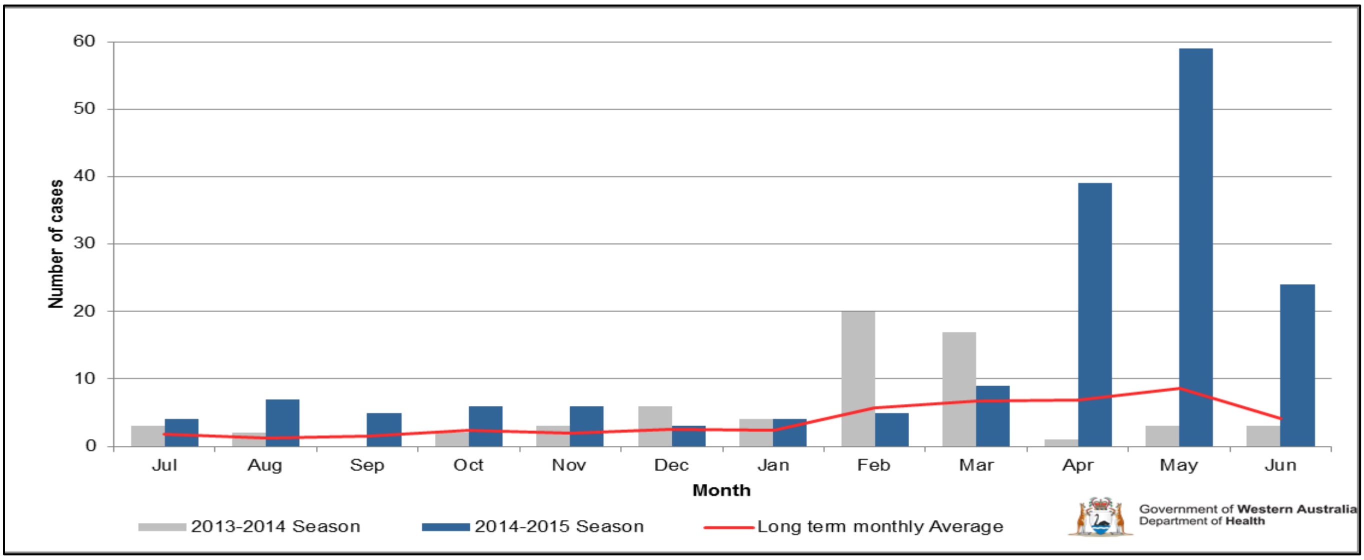


Figure 2: Difference in RRV cases recorded in 2013-2014 (grey) and 2014-2015 (blue) for the Midwest and Gascoyne regions. The red line indicates the long-term average number of notified human cases of RRV for the region by month.

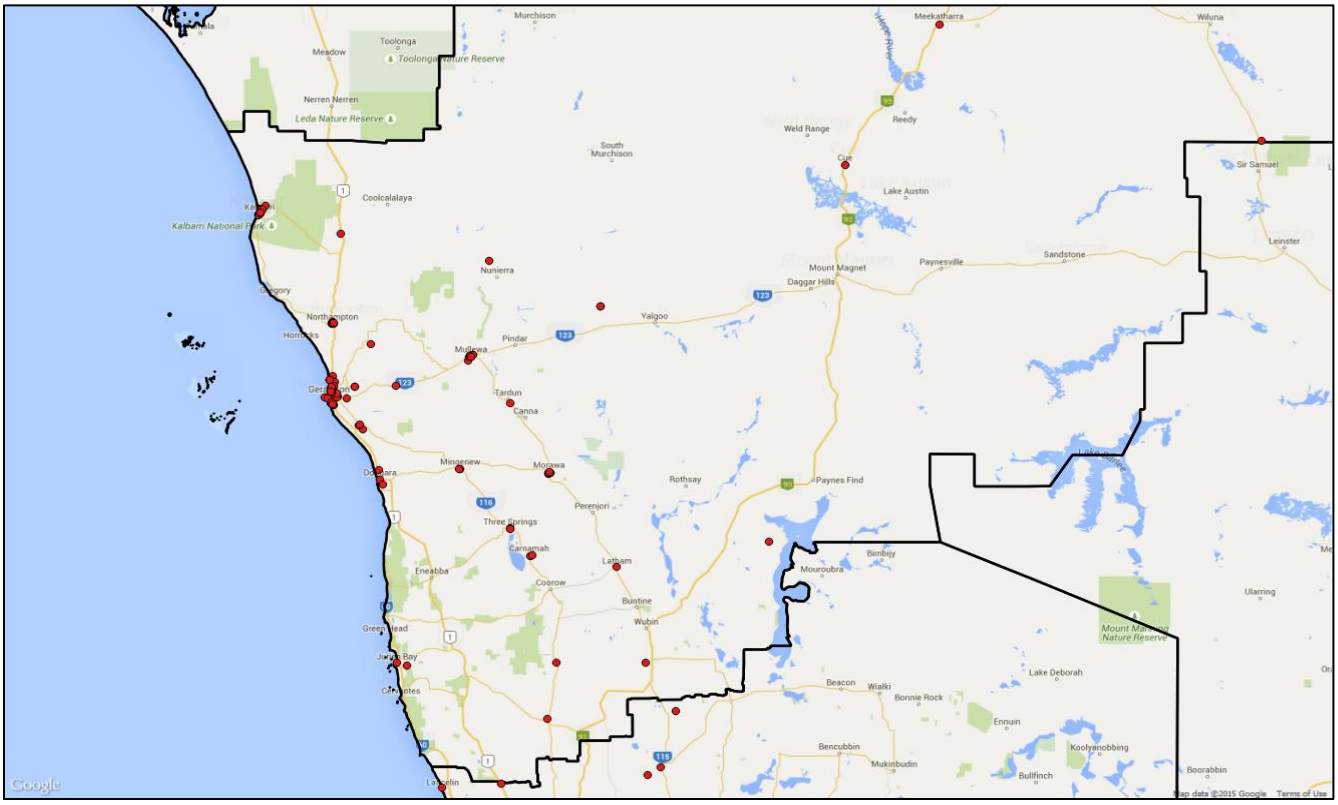


Figure 3: Map of WA showing RRV cases distribution in Midwest region. Red dots represent notified human cases of RRV from the region during 2014-2015.

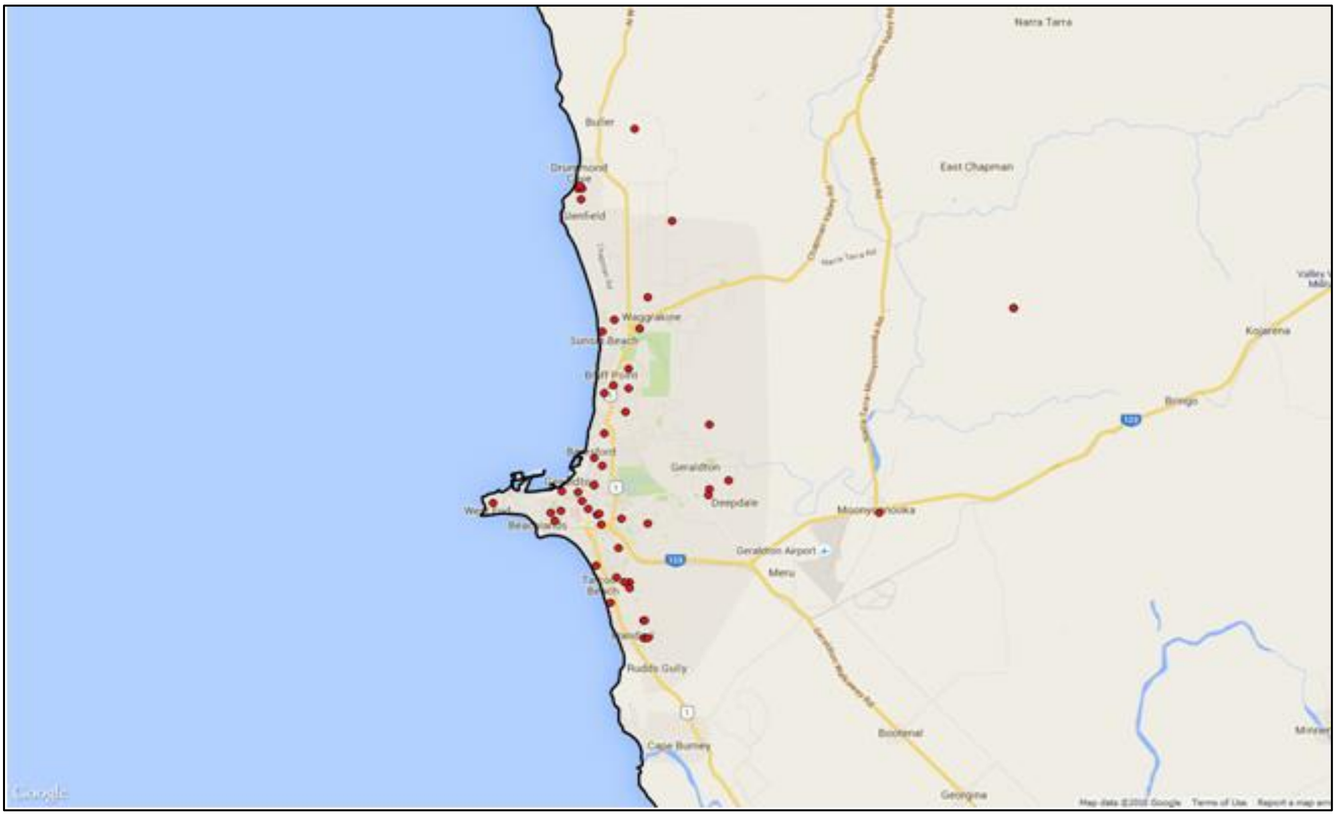


Figure 4: Map of WA showing RRV cases distribution in Geraldton area in the Midwest region. Red dots represent notified human cases of RRV from the region during 2014-2015.

During 2014-2015, most LG areas reported similar rates compared to the State average (Figure 5). Only 14 of 140 LGs had significantly higher rates of RRV disease compared to the State average (indicated by red shading), including northern LGs such as Broome and Wyndham/East Kimberley, parts of the Midwest and a few southern LG areas including Capel and Mandurah (Figure 5). Only LGs within the Perth metropolitan region reported significantly lower RRV rates compared to the State average.

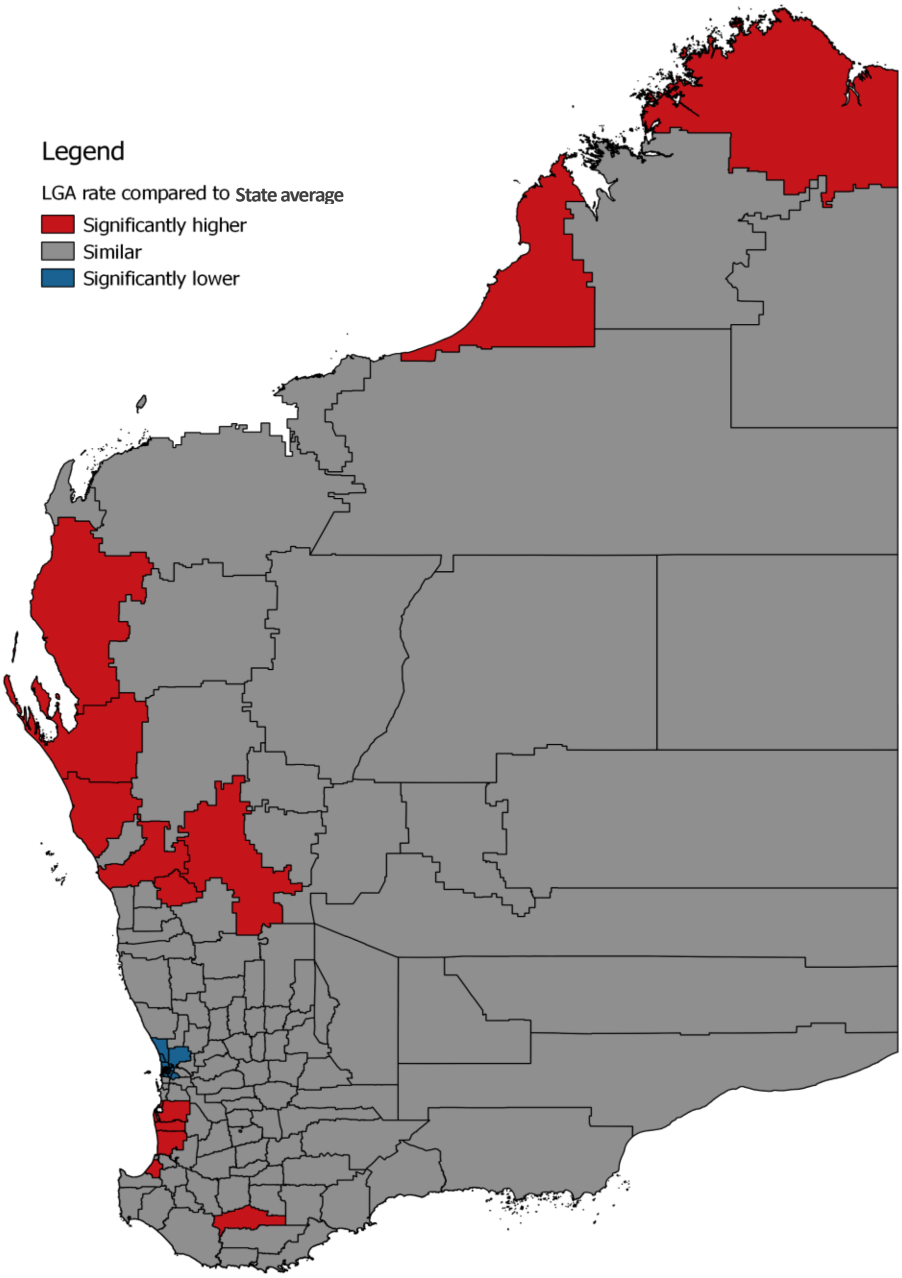


Figure 5: Map of WA showing Local Government areas indicating the rate of human cases of RRV per 100,000 population in 2014-2015 compared to the State average rate (red indicates rates higher than the State average, grey indicates rates similar to the State average and blue indicates rates below the State average).

Perth Metropolitan Summary

As is the case in most years, all of the Perth metropolitan region had RRV rates similar to or significantly lower than the State average (Figure 6).

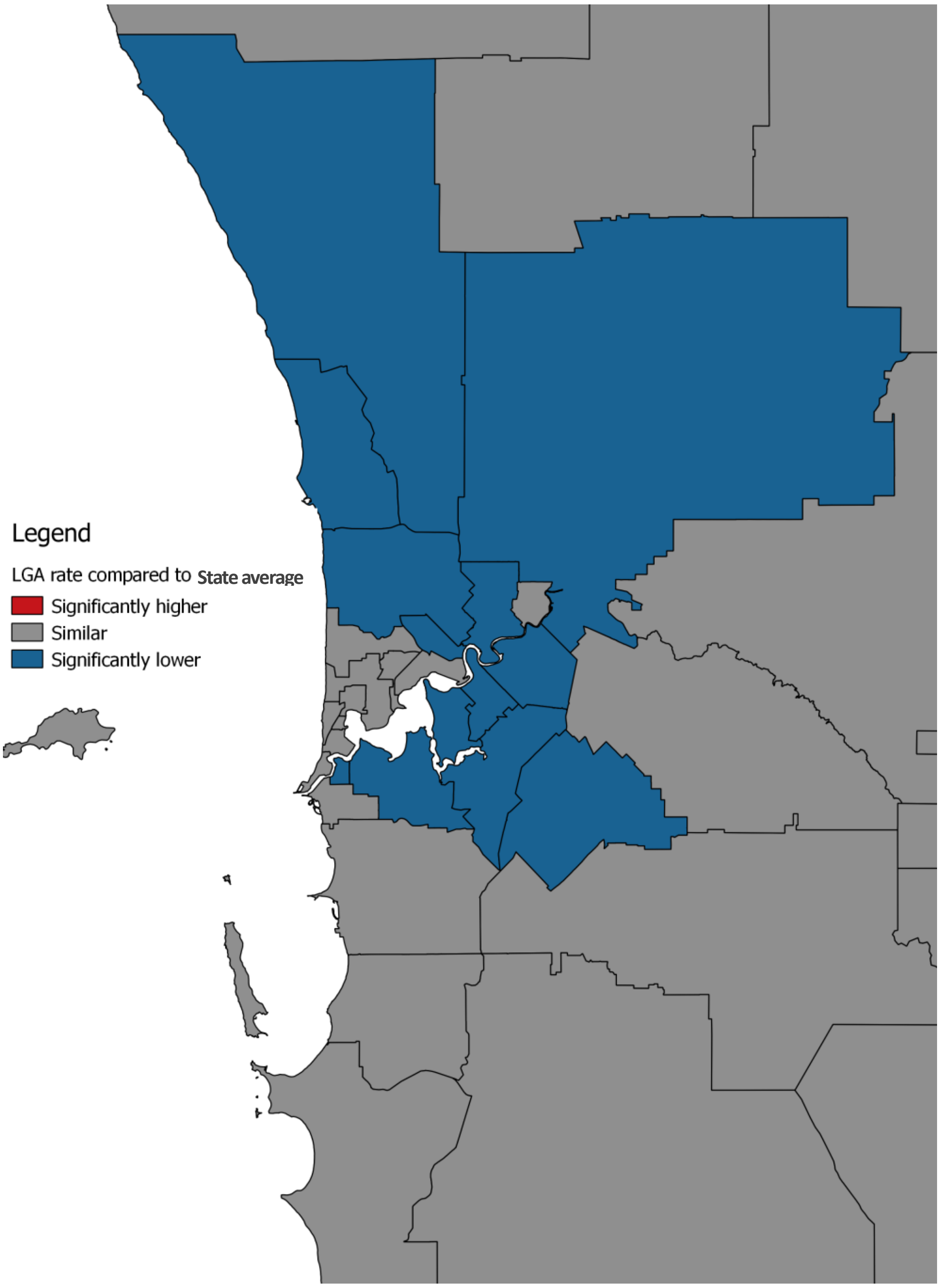


Figure 6: Map of the Perth metropolitan area showing Local Government areas shaded to indicate the rate of human cases of RRV per 100,000 population in 2014-2015 compared to the State average rate.

Barmah Forest virus (BFV)

BFV is the second most common arbovirus to cause human disease in WA. The virus is closely related to RRV and the symptoms of infection are similar. However, BFV is generally regarded as the milder of the two and typically rarer than RRV human cases. Symptoms experienced by BFV patients can be mistaken for RRV, thus serological testing is the only reliable way to correctly diagnose the causative virus.

Overview

A total 44 human cases of BFV were notified in WA for 2014-2015. The number of cases was similar to or significantly below the long term monthly average for all months except May 2015, during which time 9 cases were reported. This is significantly higher than the long term monthly average of 5 (Figure 7).

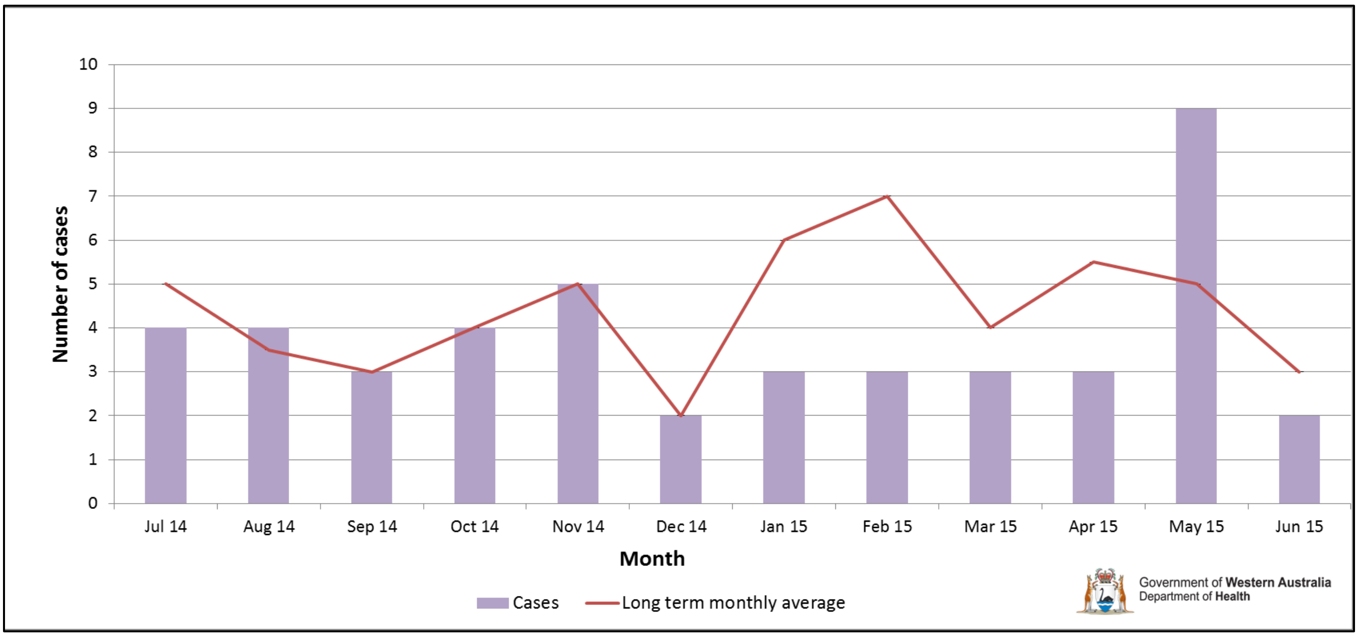


Figure 7: The total number of monthly notified human cases of BFV across WA from July 2014 to June 2015*.

**Based on enhanced notified human cases from the West Australian Notifiable Infectious Disease Database (WANIDD) and includes enhanced surveillance data from follow-up questionnaires.*

Numerous false positive BFV cases were notified from a faulty batch of test kits in mid-2012 to late 2013. Although this does not fall within this financial year, it is important to note that this period was omitted when calculating the long term average for each month.

Regional Summaries

The majority of notified cases of BFV disease occurred in the Southwest region while the Kimberley (15.3) and Gascoyne (20.1) had the highest age standardised rates of BFV disease per 100,000 (Table 2).

Table 2: Serologically confirmed, doctor-notified, and laboratory reported cases of Barmah Forest virus disease per month for each WA region from July 2014 to June 2015. CR = Crude rate per 100,000 population. ASR= Age standardised rate (standardised to 2001 Australian standard population). **Table may vary from previous or future version due to inclusion of additional surveillance data.*

Region	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total	CR	ASR
Kimberley	0	0	1	0	2	0	1	0	1	0	1	0	6	15.3	16.0
Pilbara	1	0	0	0	0	1	1	0	0	0	0	0	3	4.4	4.2
Gascoyne	0	0	0	0	0	0	0	0	0	0	1	1	2	20.1	19.6
Midwest	0	0	0	0	0	0	0	0	0	0	1	0	1	1.5	1.2
Wheatbelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Metro	1	0	0	0	1	1	0	0	2	1	1	0	7	0.4	0.4
Southwest	1	3	1	4	2	0	0	3	0	2	4	1	21	4.9	
Peel	1	1	0	2	0	0	0	0	0	0	3	0	8	3.1	3.1
Leschenault	0	2	0	2	0	0	0	0	0	1	0	1	6	8.0	7.9
Geographe	0	0	0	0	1	0	0	3	0	1	0	0	5	9.5	9.1
Elsewhere SW	0	0	1	0	1	0	0	0	0	0	0	0	2	4.3	3.2
Great Southern	1	0	1	0	0	0	0	0	0	0	1	0	3	5.0	5.7
Goldfields-Esperance	0	1	0	0	0	0	0	0	0	0	0	0	1	1.6	1.7
WA undetermined	0	0	0	0	0	0	0	0	0	0	0	0	0		
Interstate	0	0	0	0	0	0	1	0	0	0	0	0	1		
WA Total (Does Not Include Interstate)	**4**	**4**	**3**	**4**	**5**	**2**	**2**	**3**	**3**	**3**	**9**	**2**	**44**		

Murray Valley encephalitis (MVE) virus

The rare but potentially fatal MVE virus is endemic in the northern two thirds of WA (specifically the Kimberley region). It is occasionally active in other regions, such as the Gascoyne, Goldfields, and Midwest.

Approximately one person in a thousand will develop disease symptoms after being bitten by a MVE virus-carrying mosquito. The virus cannot be caught directly from people or birds. Symptoms of MVE in young children can include: fever, floppiness, irritability, excessive sleepiness and fits. In older children and adults, symptoms can include fever, drowsiness, confusion, headache, stiff neck, nausea, vomiting, dizziness, and muscle tremors. Patients with the severe form of MVE become ill very quickly with confusion, worsening headaches, increasing drowsiness and possible fits. Patients can slip into a coma, suffer permanent brain damage or die.

No human cases of MVE were notified to the DoH during 2014-2015 (Figure 8). The last notified case of MVE in WA occurred in May 2011. A high number of cases (9) were notified to the DoH during 2010-2011.

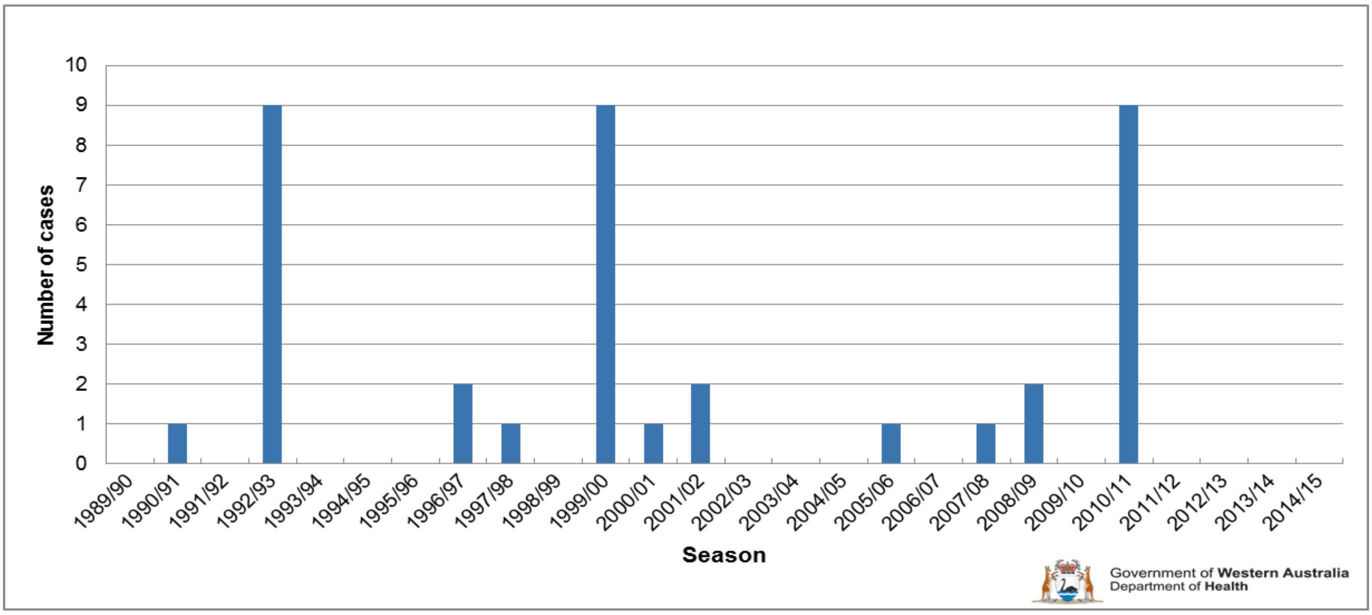


Figure 8: The number of notified human cases of MVE disease occurring in WA since 1989.

West Nile virus Kunjin strain (WNV_{KUN})

West Nile virus Kunjin strain is closely related to MVE virus. While Kunjin disease is much less common than MVE disease, the symptoms of the disease are very similar to, but generally milder than MVE disease. Kunjin disease can also be associated with joint pain.

No human cases of Kunjin disease were notified to the DoH in 2014-2015. The last known case of the Kunjin disease in Western Australia was reported in 2006 (Figure 9).

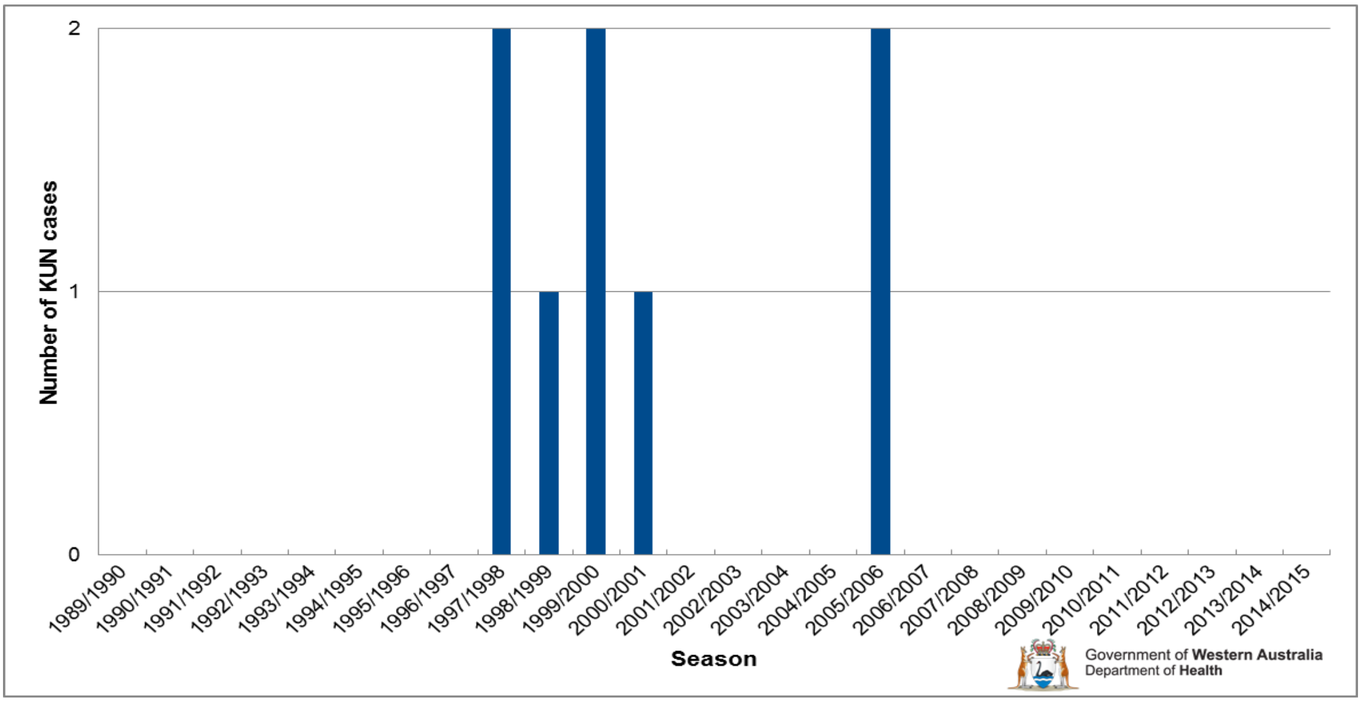


Figure 9: The number of notified human cases of Kunjin disease in WA since 1989.

Exotic Mosquito-Borne Diseases

A number of mosquito-borne diseases are currently being diagnosed in people returning home after international travel or in international visitors to WA. Due to the legislative requirements to notify infectious diseases to the WA Department of Health, these cases are also entered into the Western Australian Notifiable Infectious Disease Database (WANIDD), but are considered ‘exotic’ as they are not acquired in WA.

The most common exotic mosquito-borne diseases diagnosed in WA are dengue, malaria, chikungunya and Japanese encephalitis (JE). All infections are caused by a virus with the exception of malaria, whose aetiological agent is a protozoan parasite. All notified cases of exotic diseases are followed up with an enhanced questionnaire to ensure the patients acquired the disease overseas.

Dengue viruses

Five dengue virus serotypes are currently recognised. An initial infection with the virus will result in dengue fever, characterised by fever, headache, muscle and joint pain and skin rashes. A subsequent infection with a different strain can lead to a severe form of the illness known as dengue haemorrhagic fever. Dengue haemorrhagic fever results in bleeding from body orifices, blood spots on the skin, a weak pulse and may be fatal if not treated appropriately. There is currently no vaccine available. Dengue is spread only by the bite of infected *Aedes aegypti* or *Ae. albopictus* mosquitoes, both of which have not established in WA.

The total number of dengue cases notified in WA during 2014-2015 was 607. All cases reported during 2014-2015 were acquired overseas.

The number of dengue cases acquired from overseas has increased in recent years. This could be due to increasing travel to dengue endemic countries in south-east Asia, particularly Bali, as well as increasing dengue activity within those countries. As shown in Figure 10, the majority of cases of dengue were acquired in Bali, Indonesia.

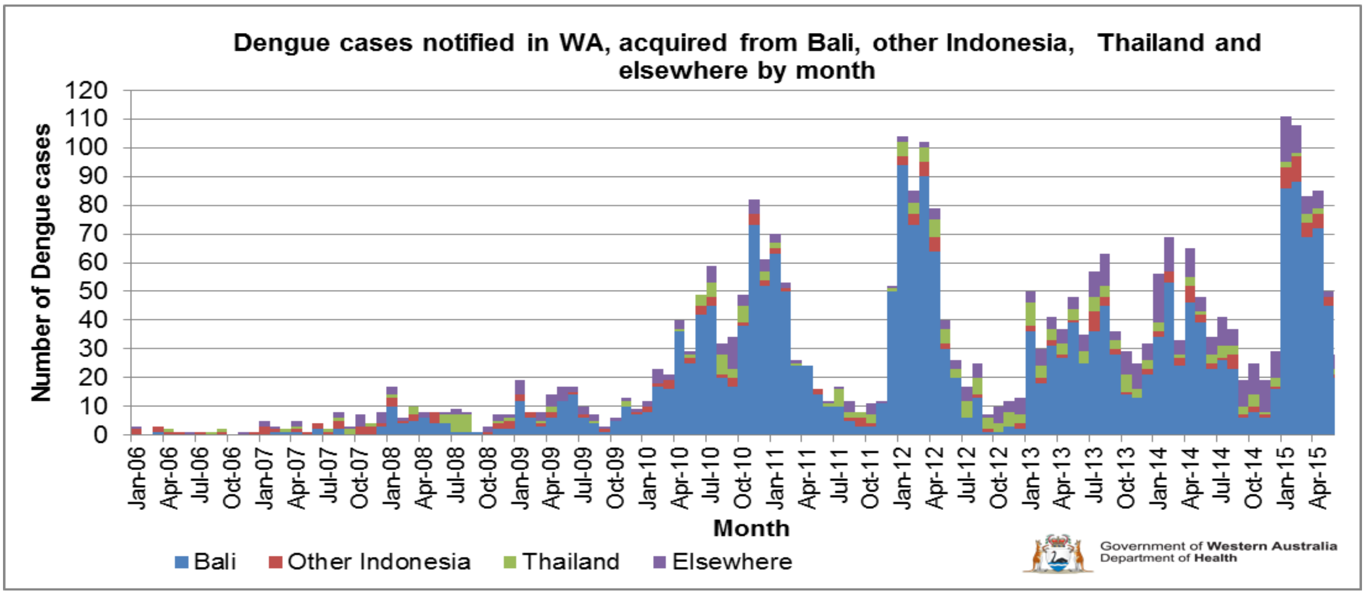


Figure 10: Monthly total number of notified cases of dengue reported in WA but acquired from overseas travel.

Chikungunya virus

The risk of infection with chikungunya virus has traditionally been highest in Africa and Asia. More recently, the disease has emerged in countries in the Pacific and Indian Ocean regions as well as south-east Asia and the Caribbean. It is not endemic to Australia and the known vectors of this disease are not present in WA, although it is suspected that some native WA mosquito species such as *Aedes vigilax, Ae. notoscriptus* and *Coquillettidia* species near *linealis* may be capable of transmitting this disease.

Symptoms of chikungunya infection include fever, chills, muscle aches, sudden headache, fatigue, nausea, vomiting and a flat rash on the limbs and torso. Many patients experience joint pain in peripheral joints such as the hands or feet. This joint inflammation can last for several weeks or months.

A total of 17 cases of chikungunya was notified in WA during 2014-2015 (Figure 11), which represents a decrease in cases entering WA from overseas locations compared to 2013-2014 and particularly 2012-2013. As with dengue infections, Bali appears to be the predominant location for chikungunya acquisition.

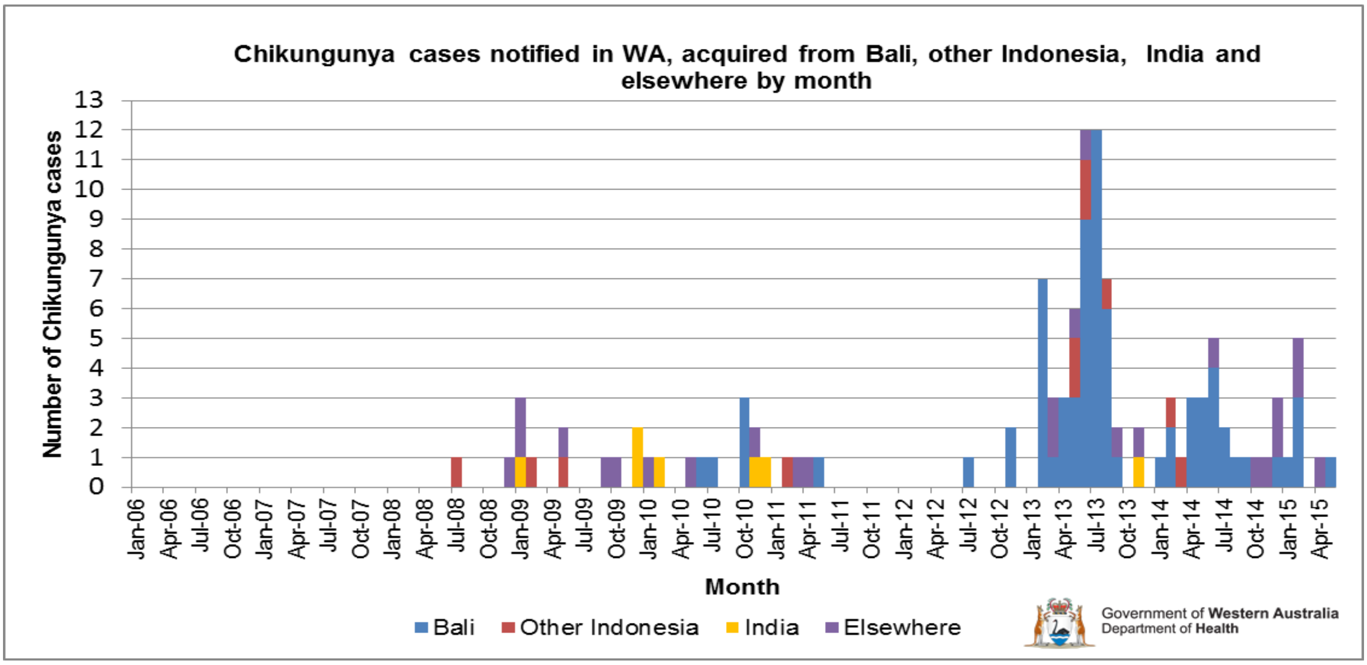


Figure 11: Monthly total number of human notifications of chikungunya reported in WA but acquired from overseas locations.

Malaria

Malaria is caused by infection with one of five species of the *Plasmodium* parasite: *Plasmodium falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi are* passed on by the bite of infected *Anopheles* mosquitoes. Travellers to tropical regions of Asia, Africa and Central or South America are most at risk of infection. Malaria caused by *P. falciparum* and *P. knowlesi* can be fatal if prompt medical treatment is not sought.

Malaria is characterised by fever, shivering, chills, headache and sweats but can also present as respiratory or gastrointestinal illness. Effective treatment relies on early diagnosis and specific anti-malarial medications.

Anti-malarial medication must be taken prior to and during travel to prevent infection. The most effective anti-malarial treatment will depend on the region of travel and the length of time away.

The total number of malaria cases diagnosed in WA during 2014-2015 was 43 (the majority infected with *P. falciparum*). Most of these cases were notified in travellers and refugees from

Africa. The monthly number of notified cases of malaria was lower between 2010 and present, compared to earlier years, 2006-2009 (Figure 12). Despite this trend, Africa remains the highest risk area for exposure to malaria.

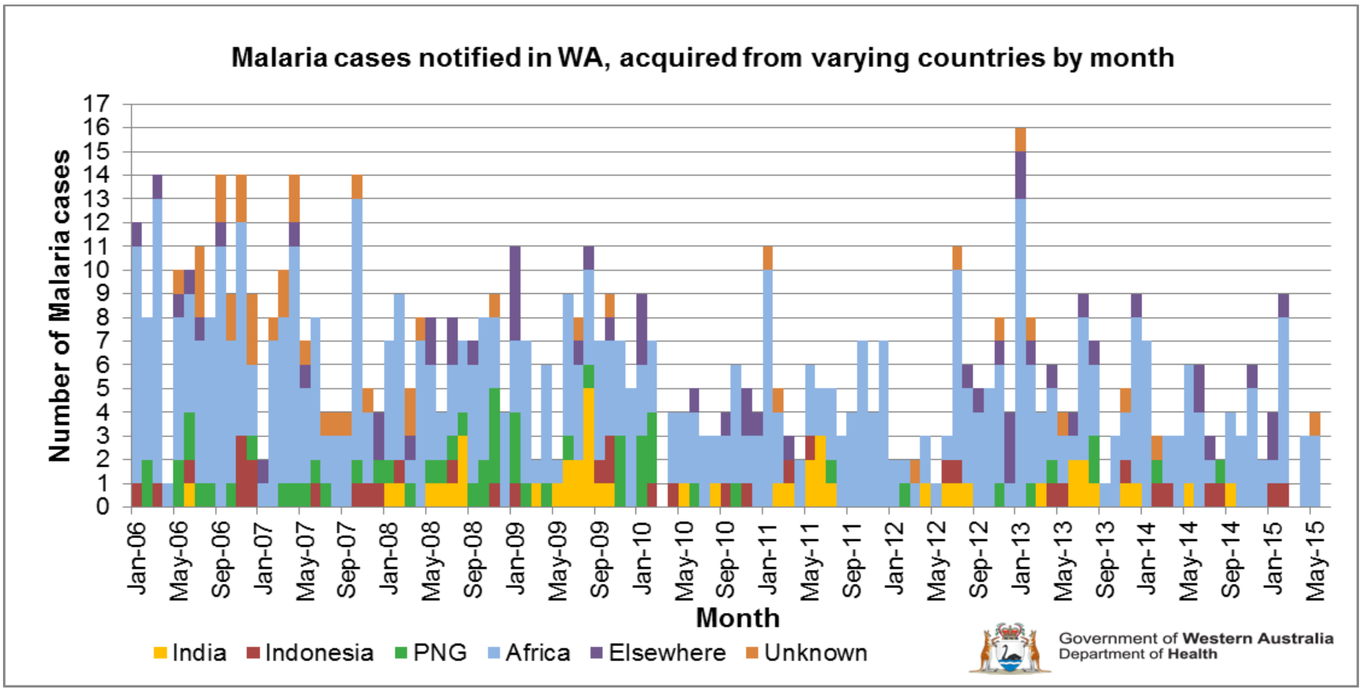


Figure 12: Monthly total number of notifications of Malaria reported in WA but acquired from overseas locations.

Japanese encephalitis

Japanese encephalitis (JE) is a viral infection transmitted by mosquitoes. Many individuals infected with JE virus will have very mild or no symptoms. However, in some cases JE can cause inflammation of the brain (encephalitis). Symptoms of this more severe form of infection include headache, high fever, convulsions and possible coma. The illness can be fatal or leave patients with permanent brain damage.

The risk of infection is highest in Asian countries, including several common travel destinations from Australia. Whilst rare outbreaks have occurred in the outer Torres Strait Islands, only one locally acquired infection has ever been reported in Australia (far north Queensland).

No cases of JE cases were notified to the Department of Health during 2014-2015.

Climatic Conditions 2014-2015

ENSO – El Niño, La Niña and Southern Oscillation

El Niño refers to extensive warming of the central and eastern tropical Pacific that leads to a major shift in weather patterns across the Pacific. Over much of Australia, El Niño events are associated with an increased probability of drier conditions and fewer high tides. El Niño conditions do not generally support large, persistent populations of mosquitoes in WA as rainfall and tidal driven mosquito breeding is less common under these environmental conditions.

La Niña refers to extensive cooling of the central and eastern tropical Pacific Ocean. It is sometimes considered the 'opposite of El Niño'. La Niña events are associated with increased probability of wetter conditions over much of Australia, and has been correlated with higher numbers of tropical cyclones during cyclone season. Importantly for WA, La Niña conditions translate to increased occurrence and magnitude of high tides (including an increased frequency of 'king' tides). This is particularly important in the Southwest region of WA, where the majority of mosquito egg-hatching is tidally driven. The absence of La Niña conditions during 2014-2015 was associated a reduction in mosquito breeding.

The consensus of ENSO prediction models indicate continuation of moderate El Niño conditions during the remainder of 2015 and lasting into early 2016 before returning to neutral conditions in the middle of the year. Thus dry conditions with lower and less frequent tides are expected in WA for most of 2015-2016 (Figure 13).

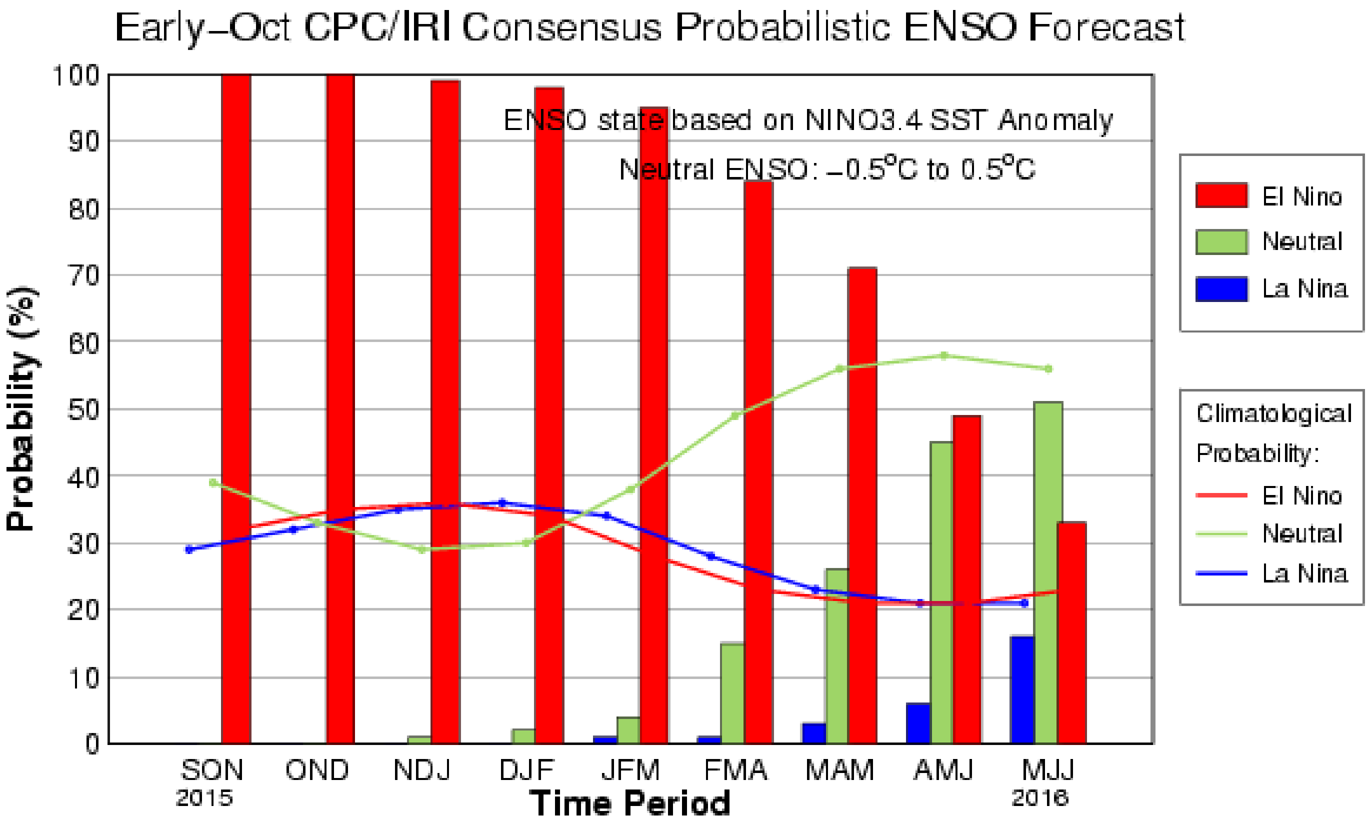
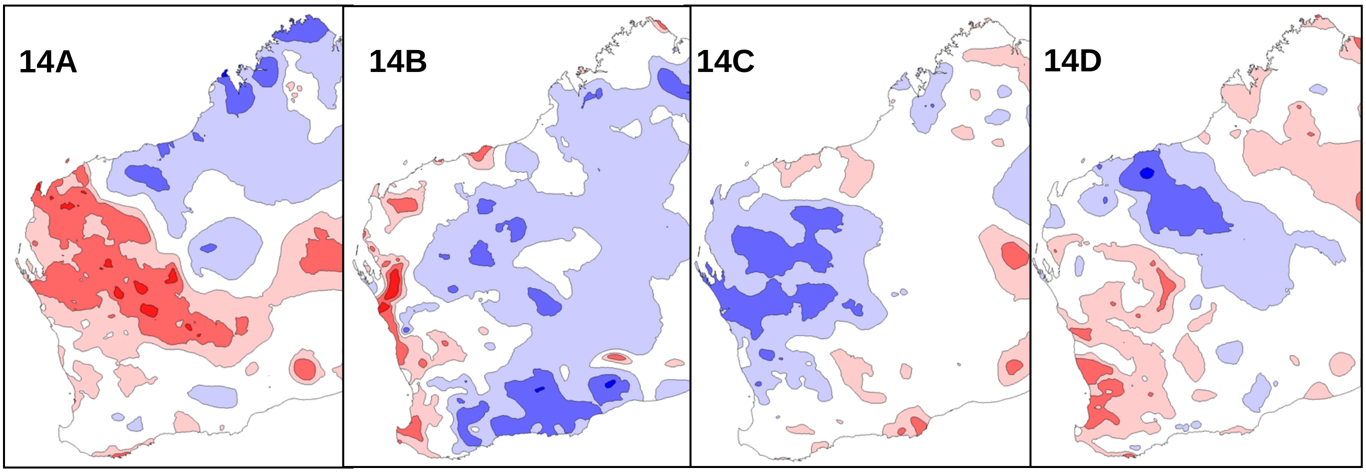
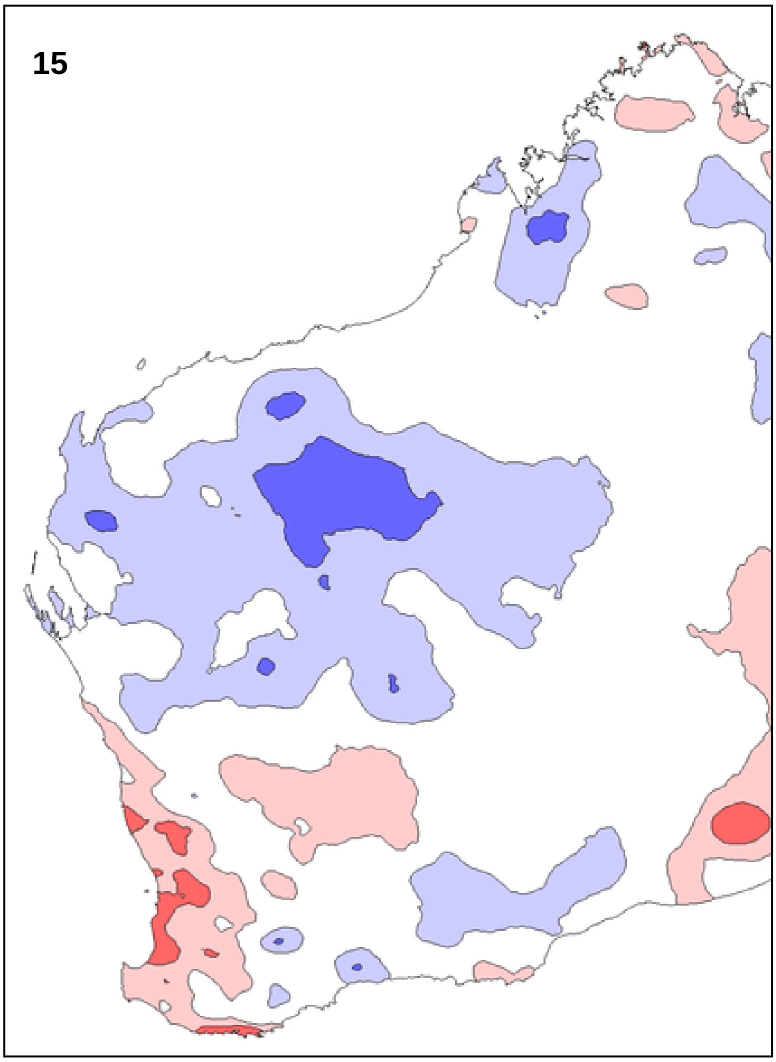


Figure 13: Probabilistic El Niño, La Niña and Southern Oscillation (ENSO) forecast for September 2015 to July 2016. Courtesy of International Research Institute for Climate and Society, Earth Institute, Columbia University, U.S.

Rainfall

Rainfall was average during 2014-2015 for the majority of the north and interior of WA (Figure 14 A-D), while mid-western parts received above or very much above average rainfall (Figure 15). However, south-western parts of WA received below or very much below average rainfall for 2014-2015.





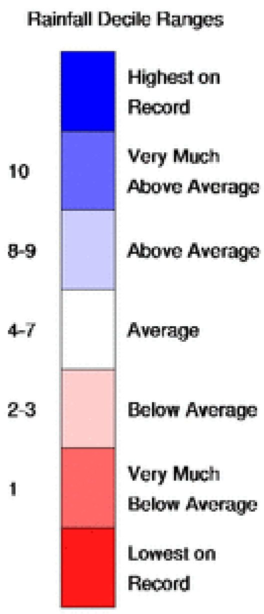


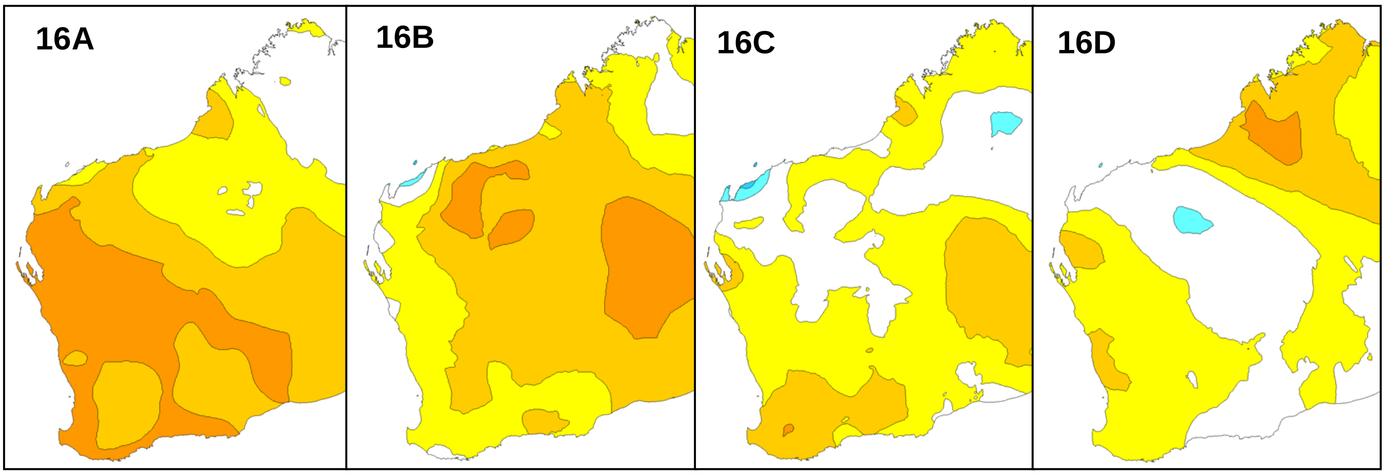
Figure 14 A-D: Three-monthly summary of Western Australian rainfall deciles. A: July-September 2014; B: October-December 2014; C: January-March 2015; D: April-June 2015 (source: Commonwealth Bureau of Meteorology).

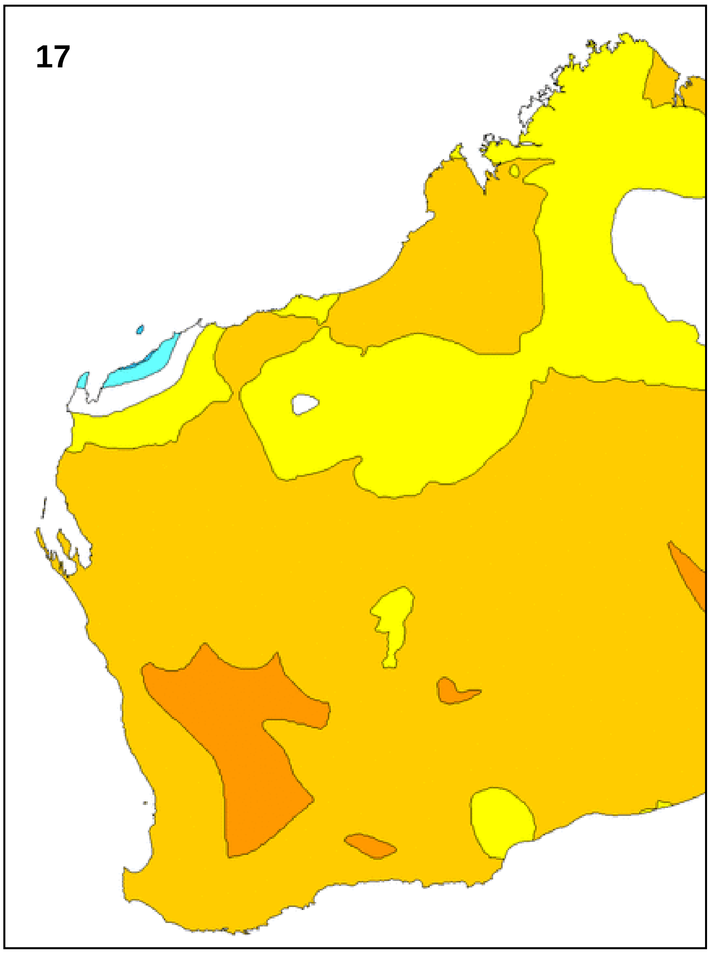
Figure 15: Western Australian Rainfall deciles for July 2014-June 2015 (source: Commonwealth Bureau of Meteorology).

Temperature

Maximum Temperature

The financial year started with above-average temperatures across most of WA, with the Bureau of Meteorology recording maximum temperature very much above average for the majority of WA during 2014-2015 (Figure 16 and 17). In some areas around the State, mosquito populations were likely to have decreased due to rapid evaporation of pooling surface water.





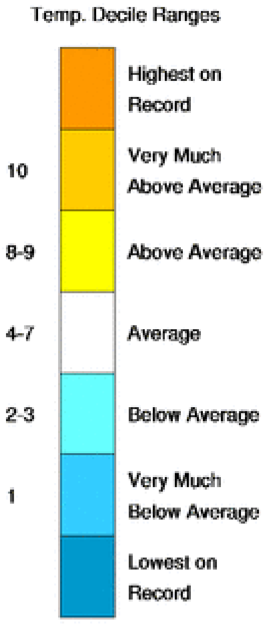


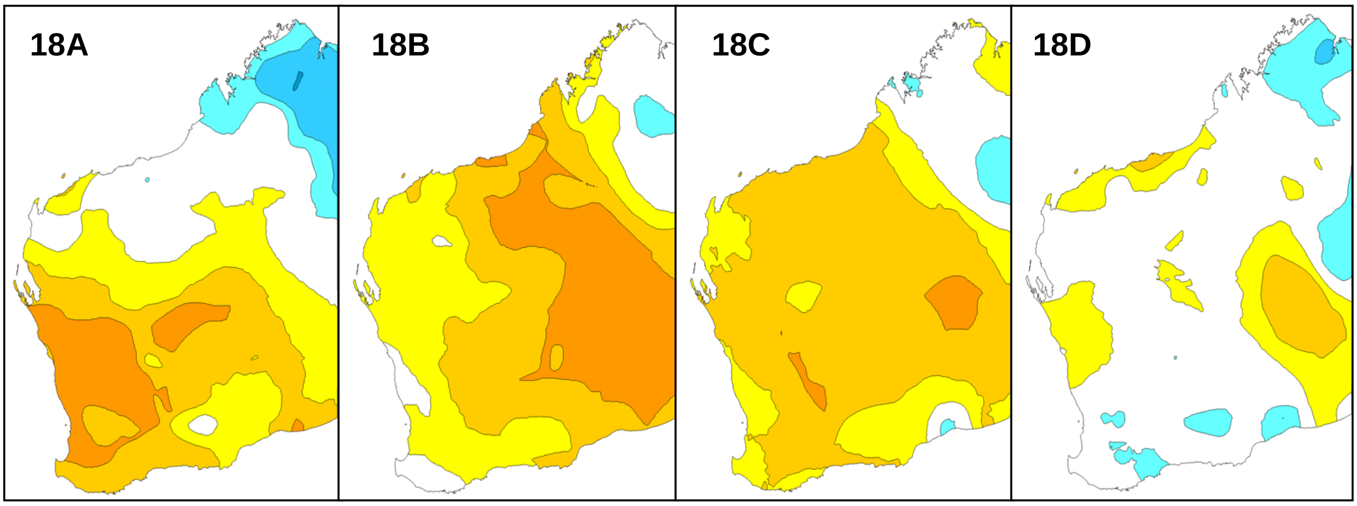
Figure 16 A-D: Three-monthly summaries of Western Australian maximum temperature deciles. A: July-September 2014; B: October-December 2014; C: January-March 2015; D: April-June 2015 (source: Commonwealth Bureau of Meteorology).

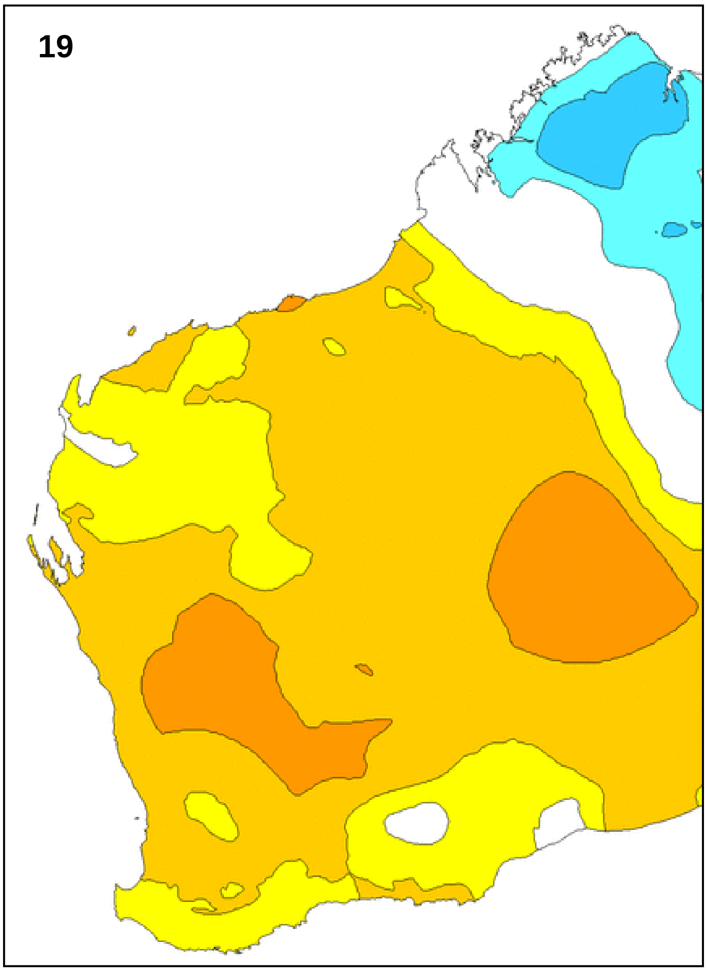
Figure 17: Western Australian maximum temperature deciles for July 2014-June 2015 (source: Commonwealth Bureau of Meteorology).

Minimum Temperature

Minimum temperatures were also very much above average across most of WA over 2014-2015. During September to November, the mean minimum temperature recorded was the second highest on record for WA and fourth highest on record for south-western parts of WA (Figure 18 and 19).

The increased minimum and maximum temperatures were likely to have contributed to increased water temperatures, which in turn promotes a more rapid progression through the life cycle of mosquito larvae. These3 environmental factors are also like to facilitate arbovirus replication in mosquito vectors until maximum temperatures become extreme.





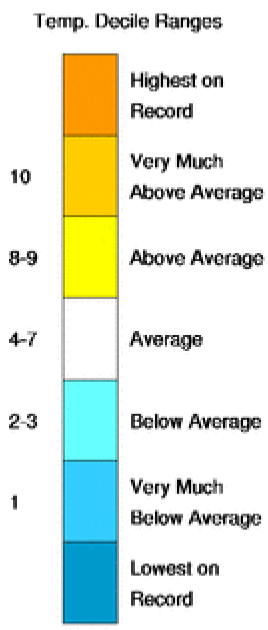


Figure 18 A-D: Three-monthly summaries of Western Australian minimum temperature deciles. A: July-September 2014; B: October-December 2014; C: January-March 2015; D: April-June 2015 (source: Commonwealth Bureau of Meteorology).

Figure 19: Western Australian minimum temperature deciles for July 2014-June 2015 (source: Commonwealth Bureau of Meteorology).

2014–2015 Australian Tropical Cyclone Season Summary

Three significant tropical cyclones had an impact on mosquito breeding and the potential for disease transmission in WA (mainly northern regions). These were:

- Tropical Cyclone Kate
- Tropical Cyclone Olwyn and
- Tropical Cyclone Quang

Tropical Cyclone Kate

Tropical Cyclone Kate was the first tropical cyclone to develop over Australian waters during 2014-2015. On 21 December 2014 a tropical low had developed Southeast of Sumatra, Indonesia. Over the next few days the system gradually developed further as it moved south-eastwards and then towards the southwest Cocos (Keeling) Islands during 23 December. Early next day, it intensified into Category 1 tropical cyclone Kate. The next day, Kate continued to intensify as an eye developed and reached peak intensity as a Category 4 severe tropical cyclone. On 30th December Kate had moved out of the Australian region (Figure 20). Tropical Cyclone Kate caused minor damage on Cocos Islands after passing to the north of the community. Flooding was reported from West Island, however, the impact on mosquito breeding was minimal. A number of trees were damaged and there was some property damage. Weather conditions improved during the evening as Kate moved away.

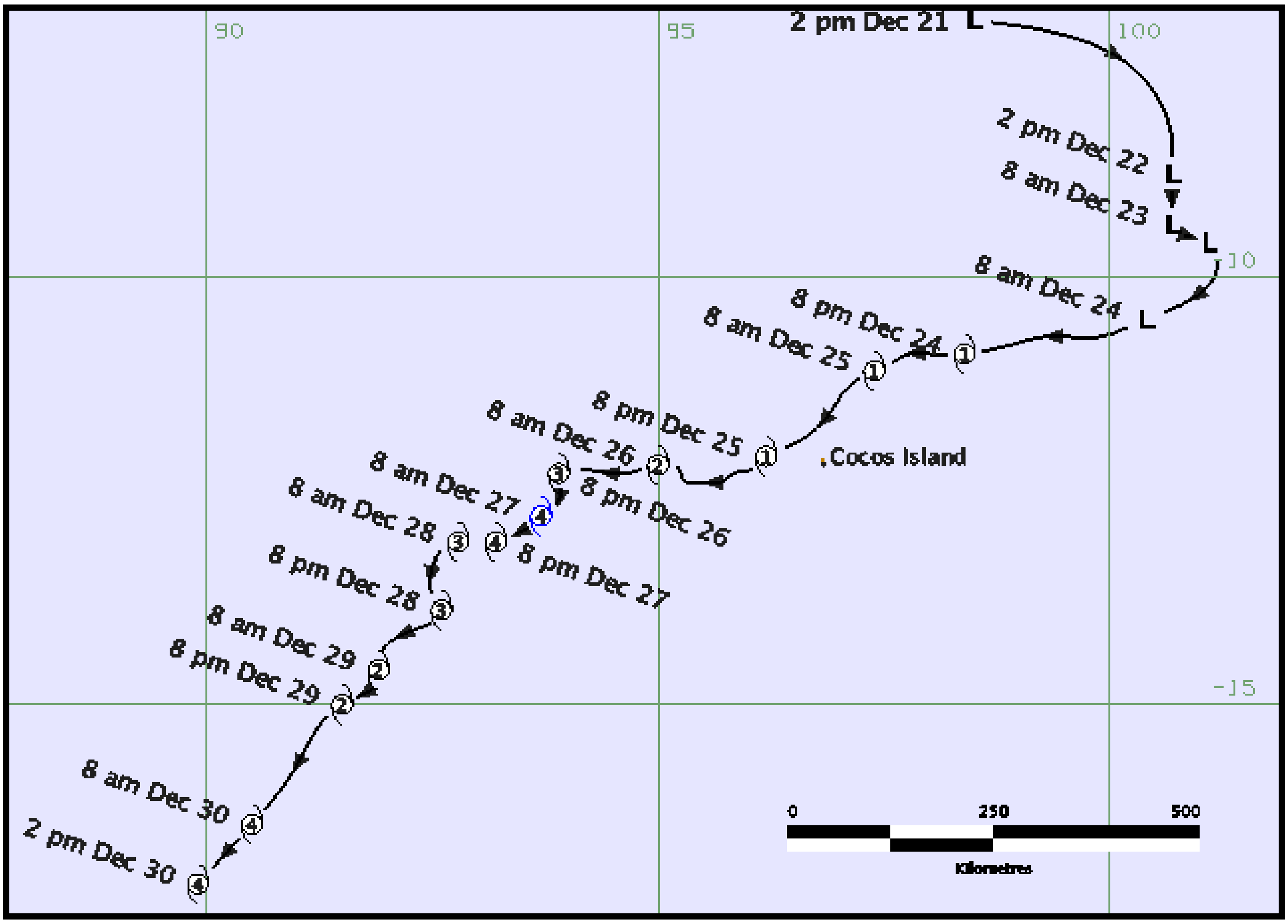


Figure 20: Documented path of Tropical Cyclone Kate National Climate Centre, Commonwealth of Australia, Bureau of Meteorology.

Tropical Cyclone Olwyn

On 8 March 2015 a weak tropical low developed over WA. Over the next few days it intensified to a category 1 tropical cyclone named Olwyn. Early on 13 March, Olwyn reached its peak strength to a category 3 cyclone. Olwyn was downgraded to category 1 after crossing land later on the same day (Figure 21).

Olwyn caused extensive damage along the coast of WA, from Onslow to Kalbarri. 128 km/h wind gusts and 141.6 mm of rain was recorded on Barrow Island. The Gascoyne River experienced its most severe flood since 2010 due to rains from Olwyn. Cases of RRV disease increased significantly from March to June in both the Gascoyne and Midwest regions due to the heavy rainfall and floods received from Cyclone Olwyn,

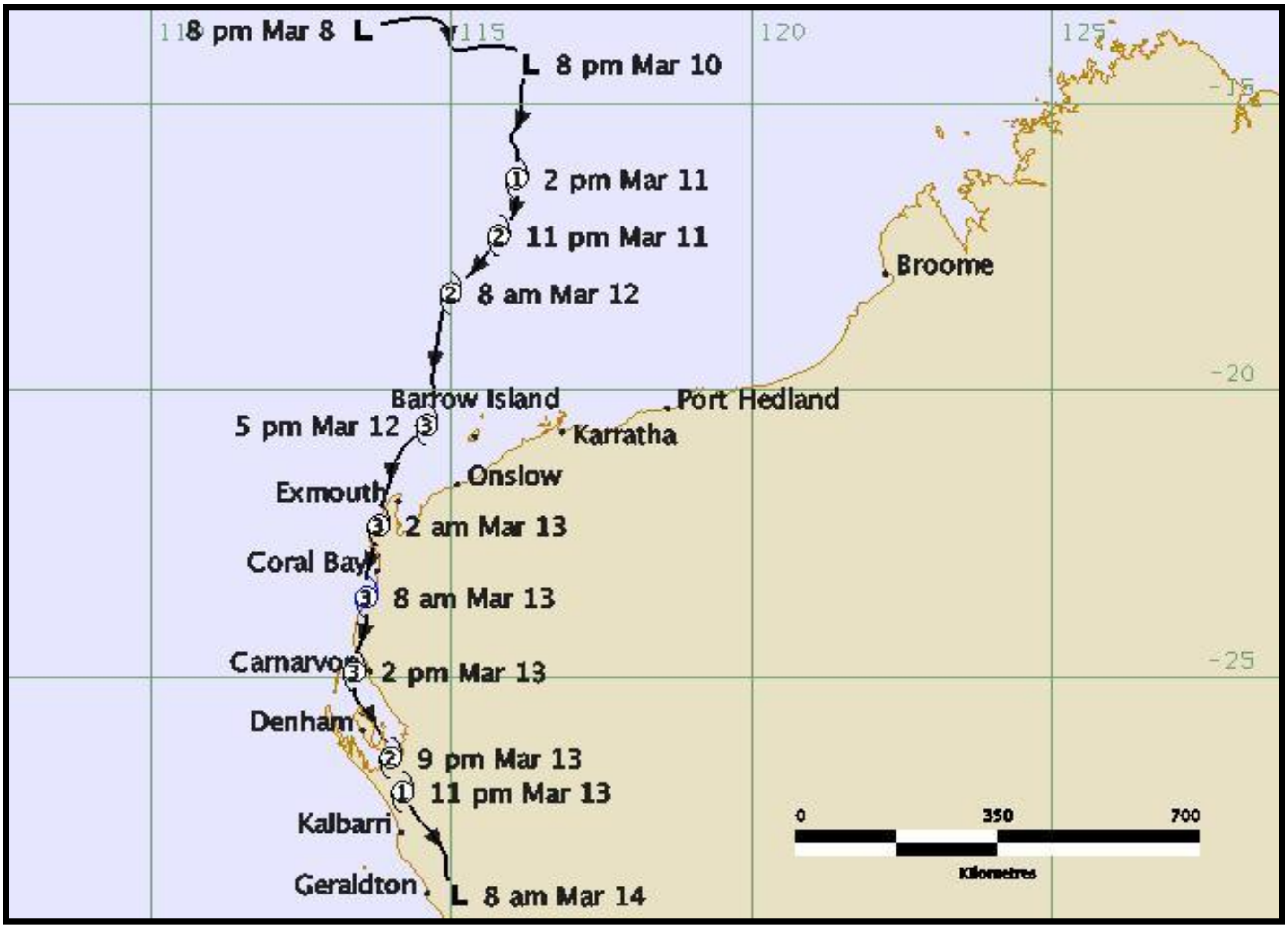


Figure 21: Path of Tropical Cyclone Olwyn National Climate Centre, Commonwealth of Australia, Bureau of Meteorology.

Tropical Cyclone Quang

On 27 April, a tropical low formed over WA. The next day, the system gradually intensified into Tropical Cyclone Quang. Quang developed rapidly during 29 April and much of 30 April, reaching a maximum intensity of Category 4 during the afternoon of 30 April, with estimated maximum wind gusts associated with the cyclone of 275 km/h. At this stage, Severe Tropical Cyclone Quang was about 600 kilometres northwest of the North West Cape region and on a south-easterly trajectory. Quang crossed the coast near Exmouth on the night of 1 May and quickly weakened to a tropical low (Figure 22). It was the final cyclone of 2014-2015. The cyclone did not affect the number of mosquito-borne disease cases reported in the region.

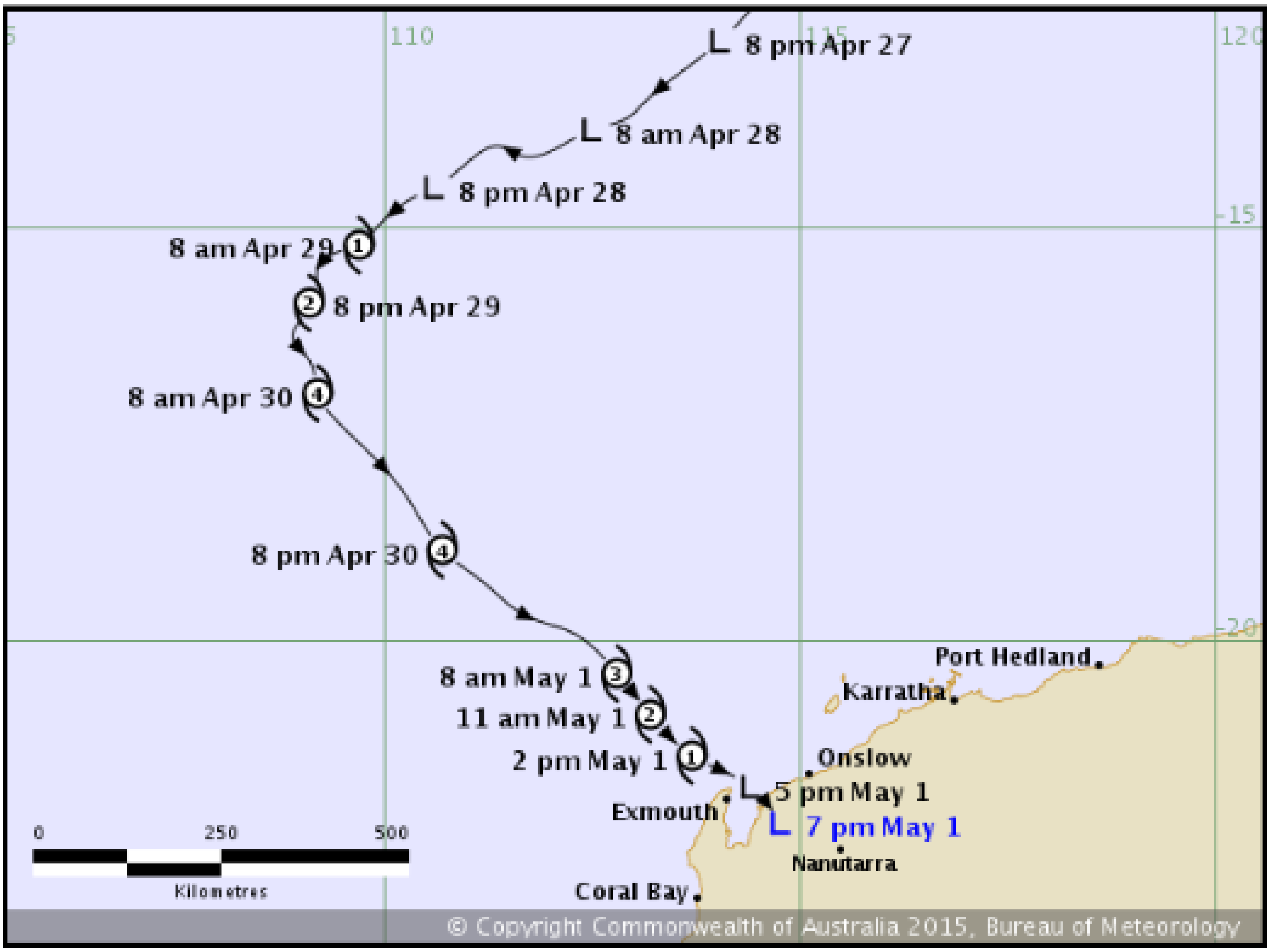


Figure 22: Path of Tropical Cyclone Quang National Climate Centre, Commonwealth of Australia, Bureau of Meteorology.

Mosquito-borne disease surveillance programs

Southwest Arbovirus Surveillance Program

Outbreaks of Ross River virus (RRV) and Barmah Forest virus (BFV) occur in the Southwest region every three to four years. The DoH undertakes regular RRV and BFV surveillance in the region to monitor disease activity and provide an early warning of increased disease risk. Monitoring of mosquitoes and mosquito-borne virus activity in the Southwest region commenced in 1987. The program was based at The University of Western Australia (UWA) until 2015 when it became a joint Medical Entomology and PathWest program.

El Niño conditions were recorded for the majority of 2014-2015. This resulted in below average to very much below average rainfall in the Southwest of WA, particularly during October to December 2014 (Figure 14), and warm maxima and minima (Figures 16 and 18). Reduced rainfall and warmer than usual temperatures impacted negatively on mosquito populations in most regions along the Swan Coastal Plain.

In summary, a total of 96,577 mosquitoes were collected in 443 traps (97% success rate). Of these, 69,534 (72.0%) were processed in 5,127 pools for virus detection. During the peak risk period, mosquito homogenates were tested in parallel by virus isolation and by PCR, with the support of FIMMWA funding. In total there were 16 detections of RRV, comprising 15 by PCR and 11 by virus isolation. A media release was issued in late October, reminding residents and travellers to take precautions against mosquito bites. No viruses were isolated from mosquitoes collected in the Southwest after October 2014.

Mosquito abundance at Peel Inlet trapsites was similar to the previous year (Figure 23). *Aedes camptorhynchus* was the most abundant species collected (Table 3). Targeted mosquito trapping by the City of Mandurah for container breeding mosquitoes in additional mosquito traps led to increased collections of *Ae. notoscriptus* during 2014-2015. *Aedes vigilax* populations were very low through the summer period. Two detections of RRV were made in Peel Inlet mosquitoes collected on 30 October 2015 (Table 4) approximately one month before the peak incidence of RRV disease in the Peel region (Table 1).

Mosquito abundance was lower than usual at Harvey Estuary mosquito collection sites (Figure 24). *Aedes camptorynchus* and *Anopheles annulipes* s.l. were the dominant species (Table 5). There were no arbovirus detections from mosquitoes collected at Harvey Estuary sites.

Mosquito abundance in the Leschenault region was lower than usual (Figure 25, Table 6). Peak mosquito abundance preceded a peak infection rate of 15.4 per 1000 mosquitoes on 28 October 2014 when there were 13 detections of RRV at Leschenault Inlet collection sites (Table 4), providing advanced warning of the increased risk of RRV disease in the area (Table 1).

Aedes camptorhynchus dominated collections at Capel forest sites (Table 7). Mosquito abundance peaked mid-October 2014, but was otherwise low for most of the year (Figure 26). There were no RRV or BFV detections in mosquitoes collected at these sites, reflecting the low incidence of human disease in the Geographe region (Tables 1 and 2). Similarly, mosquito collections were low at Busselton wetlands sites (Figure 27, Table 8), peaking in mid-October 2014 and declining to very low levels during the summer months. Like more northerly sites in the Geographe region, there were no detections of RRV or BFV in Busselton wetlands sites and a low incidence of RRV and BFV disease during 2014-2015.

Table 3: Details of mosquitoes collected and processed for virus isolation, Peel Inlet sites, southwest of Western Australia, 1 July 2014 to 30 June 2015.[1]

Species	Class	Total	(%)	Processed	Pools	Pinned	RRV	(MIR)
Ae. (Finlaya) alboannulatus	Female	504	(1.2)	422	107	0		
Ae. (Finlaya) notoscriptus	Bloodfed	4	(<0.1)	0	0	0		
Ae. (Finlaya) notoscriptus	Female	4025	(9.5)	3246	264	0		
Ae. (Finlaya) notoscriptus variant two spots on tergites	Female	1	(<0.1)	0	0	1		
Ae. (Ochlerotatus) camptorhynchus	Bloodfed	109	(0.3)	0	0	0		
Ae. (Ochlerotatus) camptorhynchus	Female	33405	(78.9)	22465	1190	0	2	(0.1)
Ae. (Ochlerotatus) camptorhynchus	Male/Female	1	(<0.1)	1	1	0		
Ae. (Ochlerotatus) camptorhynchus	Male	2	(<0.1)	2	2	0		
Ae. (Ochlerotatus) clelandi	Female	15	(<0.1)	8	7	0		
Ae. (Ochlerotatus) hesperonotius	Female	5	(<0.1)	3	3	0		
Ae. (Ochlerotatus) turneri	Female	4	(<0.1)	3	3	0		
Ae. (Ochlerotatus) vigilax	Bloodfed	4	(<0.1)	0	0	0		
Ae. (Ochlerotatus) vigilax	Female	649	(1.5)	621	88	0		
Ae. (Ochlerotatus) vigilax	Male	1	(<0.1)	1	1	0		
Ae. (Ochlerotatus) species near *explorator* (damaged)	Female	4	(<0.1)	2	0	2		
Ae. species (unidentified) - new or difficult to ID species	Male	13	(<0.1)	8	6	0		
An. (Cellia) annulipes s.l.	Bloodfed	1	(<0.1)	0	0	0		
An. (Cellia) annulipes s.l.	Female	248	(0.6)	214	42	0		
Cq. (Coquillettidia) species near *linealis*	Female	8	(<0.1)	8	6	0		
Cs. (Culicella) atra	Female	23	(0.1)	14	8	0		
Cx. (Culex) annulirostris	Female	127	(0.3)	126	41	0		
Cx. (Culex) australicus	Bloodfed	1	(<0.1)	0	0	0		
Cx. (Culex) australicus	Female	662	(1.6)	404	58	0		
Cx. (Culex) globocoxitus	Bloodfed	8	(<0.1)	0	0	0		
Cx. (Culex) globocoxitus	Female	1637	(3.9)	1286	129	0		
Cx. (Culex) globocoxitus	Male	2	(<0.1)	2	1	0		
Cx. (Culex) quinquefasciatus	Bloodfed	4	(<0.1)	0	0	0		
Cx. (Culex) quinquefasciatus	Female	689	(1.6)	584	102	1		
Cx. species (unidentified) - new or difficult to ID species	Male/Female	1	(<0.1)	0	0	0		
Cx. species (unidentified) - new or difficult to ID species	Male	104	(0.2)	96	20	0		
Tripteroides (Polylepidomyia) atripes	Female	5	(<0.1)	4	3	0		
Unidentifiable *Aedes* sp. (too damaged/features missing)	Female	48	(0.1)	33	3	0		
Unidentifiable *Culex* sp. (too damaged/features missing)	Bloodfed	3	(<0.1)	0	0	0		
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	8	(<0.1)	7	6	0		
Total		**42325**	**(100.0)**	**29560**	**2091**	**4**	**2**	**(0.1)**

[1]RRV is Ross River virus, MIR is minimum infection rate per 1000 mosquitoes (Chiang and Reeves 1962).

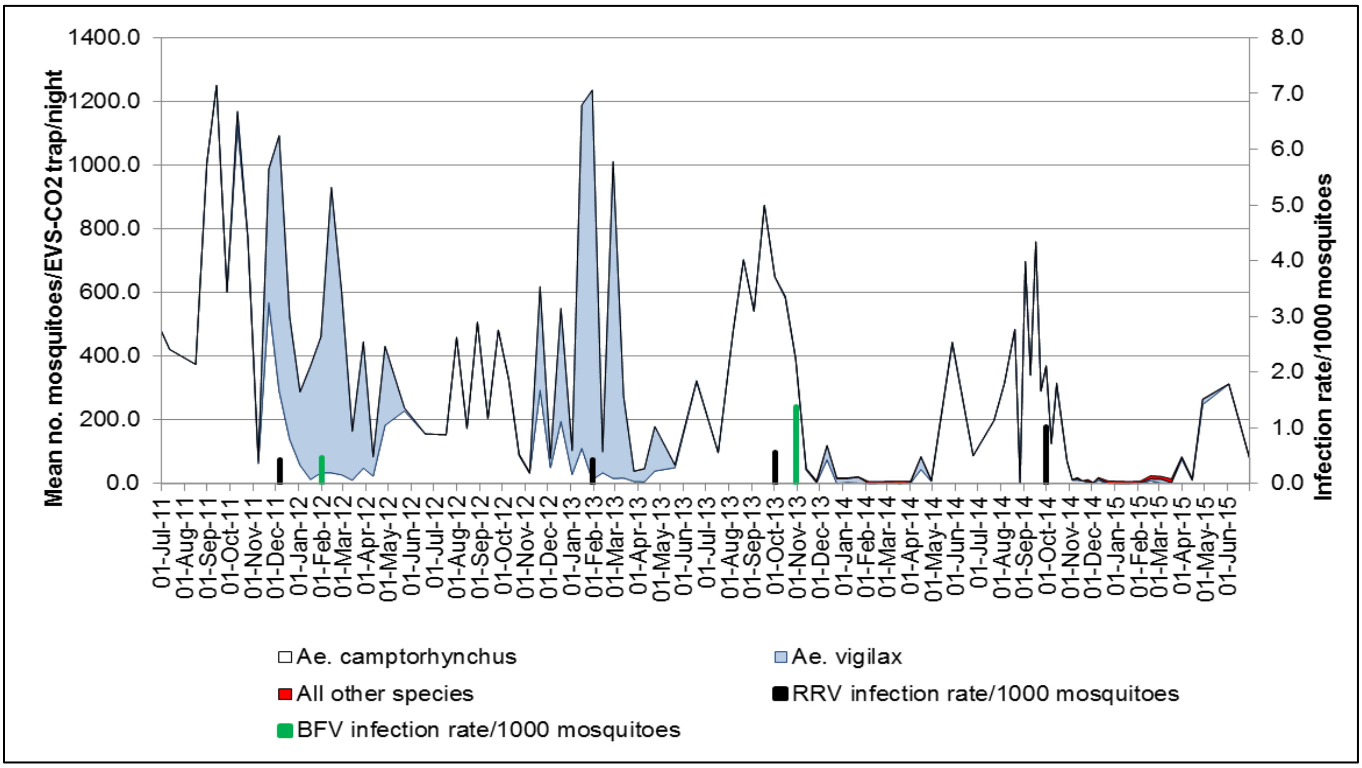


Figure 23: Abundance of adult mosquitoes and their infection rates (all species) with RRV and BFV, Peel Inlet sites, 1 July 2011 to 30 June 2015.

Table 4: Details of arbovirus detections in mosquitoes collected during the mosquito/arbovirus surveillance program on the Swan Coastal Plain, the Southwest of WA, 1 July 2014 to 30 June 2015.[1]

Region	Date	Isolate no.	Trap location	Species	Class	No. in Pool	Virus isolation	PCR[2]
Peel								
	30.09.14	DC59583	Riverside Gardens, Mandurah	*Ae. camptorhynchus*	Female	20	NE RRV	RRV
	"	DC59627	Riverview, Mandurah	"	"	20	NE RRV	
Leschenault								
	14.10.14	SW99116	Freshwater larval site, N end of Leschenault Inlet	"	"	20	NE RRV	RRV
	28.10.14	SW99334	Belvidere, W side of Leschenault Inlet	"	"	20	NE RRV	RRV
	"	SW99335	"	"	"	20	NE RRV	RRV
	"	SW99337	"	"	"	20	NE RRV	RRV
	"	SW99339	"	"	"	20		RRV
	"	SW99340	"	"	"	20	NE RRV	RRV
	"	SW99341	"	"	"	20		RRV
	"	SW99342	"	"	"	20	NE RRV	RRV
	"	SW99347	"	"	"	20		RRV
	"	SW99353	Freshwater larval site, N end of Leschenault Inlet	"	"	20		RRV
	"	SW99355	"	"	"	20	NE RRV	RRV
	"	SW99356	"	"	"	20	NE RRV	RRV
	"	SW99357	"	"	"	20		RRV
	"	SW99359	"	"	"	6	NE RRV	RRV

[1]RRV is Ross River virus; NE is the northern eastern phenotype of RRV.
[2]PCR is real-time reverse transcription-polymerase chain reaction.

Table 5: Details of mosquitoes collected and processed for virus isolation, Harvey Estuary sites, southwest of Western Australia, 1 July 2014 to 30 June 2015.

Species	Class	Total	(%)	Processed	Pools	Pinned
Ae. (Finlaya) alboannulatus	Bloodfed	2	(<0.1)	0	0	0
Ae. (Finlaya) alboannulatus	Female	176	(1.5)	154	26	0
Ae. (Finlaya) notoscriptus	Bloodfed	2	(<0.1)	0	0	0
Ae. (Finlaya) notoscriptus	Female	288	(2.5)	275	46	0
Ae. (Ochlerotatus) camptorhynchus	Bloodfed	137	(1.2)	0	0	0
Ae. (Ochlerotatus) camptorhynchus	Female	7977	(69.0)	6853	364	0
Ae. (Ochlerotatus) clelandi	Bloodfed	1	(<0.1)	0	0	0
Ae. (Ochlerotatus) clelandi	Female	47	(0.4)	38	12	0
Ae. (Ochlerotatus) hesperonotius	Female	10	(0.1)	10	5	0
Ae. (Ochlerotatus) ratcliffei	Female	58	(0.5)	56	13	0
Ae. (Ochlerotatus) turneri	Female	1	(<0.1)	1	1	0
Ae. (Ochlerotatus) vigilax	Bloodfed	1	(<0.1)	0	0	0
Ae. (Ochlerotatus) vigilax	Female	422	(3.7)	416	32	0
Ae. species (unidentified) - new or difficult to ID species	Male	2	(<0.1)	2	2	0
An. (Cellia) annulipes s.l.	Bloodfed	5	(<0.1)	0	0	0
An. (Cellia) annulipes s.l.	Female	1736	(15.0)	1670	108	0
An. (Cellia) annulipes s.l.	Male	7	(0.1)	7	2	0
An. species (unidentified) - new or difficult to ID species	Male	1	(<0.1)	1	1	0
Cq. (Coquillettidia) species near *linealis*	Female	29	(0.3)	29	11	0
Cs. (Culicella) atra	Female	10	(0.1)	10	3	0
Cx. (Culex) annulirostris	Bloodfed	1	(<0.1)	0	0	0
Cx. (Culex) annulirostris	Female	115	(1.0)	113	25	0
Cx. (Culex) australicus	Bloodfed	1	(<0.1)	0	0	0
Cx. (Culex) australicus	Female	193	(1.7)	168	22	0
Cx. (Culex) globocoxitus	Bloodfed	3	(<0.1)	0	0	0
Cx. (Culex) globocoxitus	Female	258	(2.2)	250	29	0
Cx. (Culex) globocoxitus	Male	3	(<0.1)	3	2	0
Cx. (Culex) quinquefasciatus	Female	21	(0.2)	21	9	0
Cx. species (unidentified) - new or difficult to ID species	Male	30	(0.3)	30	9	0
Unidentifiable *Aedes* sp. (too damaged/features missing)	Female	14	(0.1)	7	3	0
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	3	(<0.1)	3	2	0
Total		**11554**	**(100.0)**	**10117**	**727**	**0**

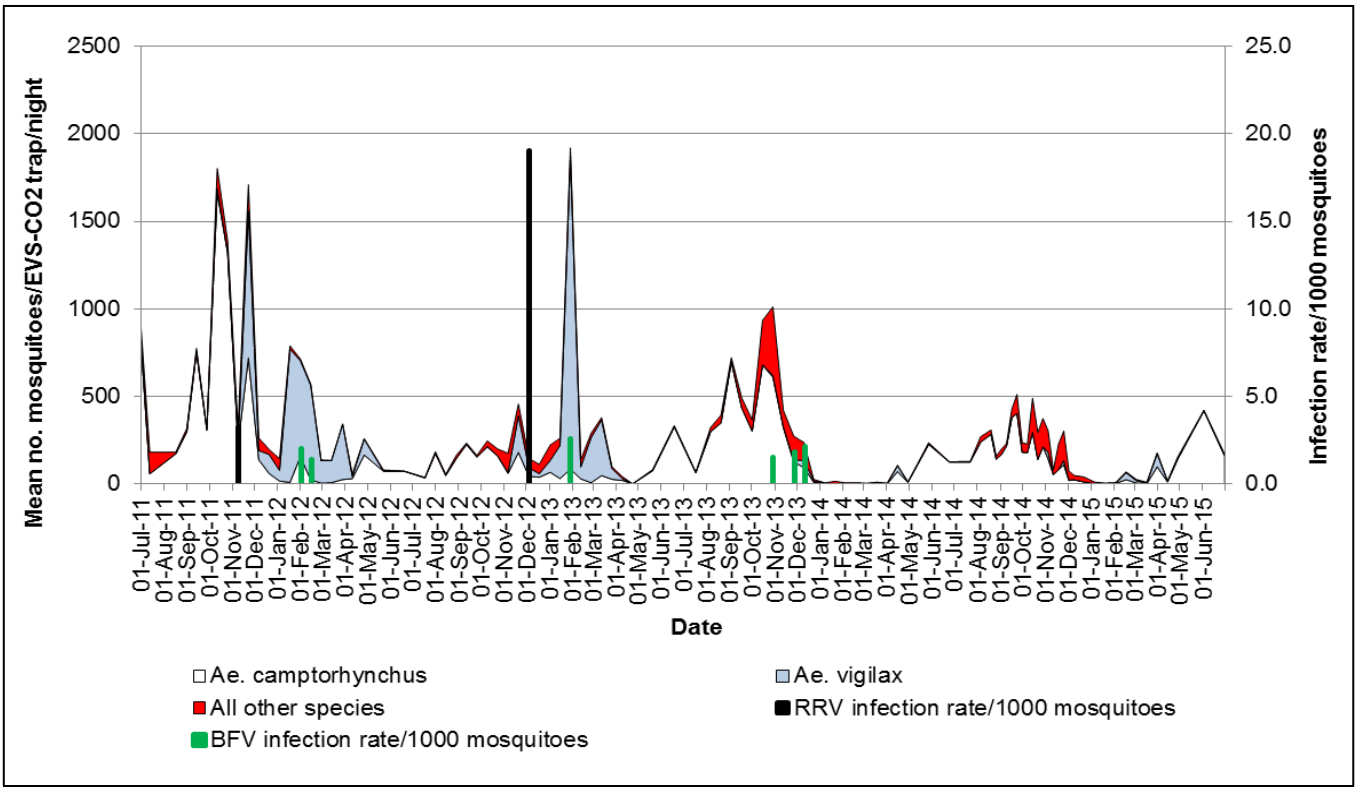


Figure 24: Abundance of adult mosquitoes and their infection rates (all species) with RRV and BFV, Harvey Estuary sites, 1 July 2011 - 30 June 2015.

Table 6: Details of mosquitoes collected and processed for virus isolation, Leschenault sites, southwest of Western Australia, 1 July 2014 to 30 June 2015.[1]

Species	Class	Total	(%)	Processed	Pools	Pinned	RRV	(MIR)
Ae. (Finlaya) alboannulatus	Bloodfed	5	(<0.1)	0	0	0		
Ae. (Finlaya) alboannulatus	Female	366	(1.9)	354	76	0		
Ae. (Finlaya) mallochi	Female	1	(0.0)	1	1	0		
Ae. (Finlaya) notoscriptus	Female	312	(1.6)	302	53	0		
Ae. (Macleaya) E.N. Marks' species No. 147	Female	1	(<0.1)	0	0	1		
Ae. (Ochlerotatus) camptorhynchus	Bloodfed	149	(0.8)	0	0	0		
Ae. (Ochlerotatus) camptorhynchus	Female	13023	(68.5)	10218	564	0	14	(1.4)
Ae. (Ochlerotatus) camptorhynchus	Male	2	(<0.1)	2	1	0		
Ae. (Ochlerotatus) clelandi	Bloodfed	4	(<0.1)	0	0	0		
Ae. (Ochlerotatus) clelandi	Female	477	(2.5)	351	35	0		
Ae. (Ochlerotatus) hesperonotius	Bloodfed	10	(0.1)	0	0	0		
Ae. (Ochlerotatus) hesperonotius	Female	1208	(6.4)	946	53	0		
Ae. (Ochlerotatus) nigrithorax	Bloodfed	3	(<0.1)	0	0	0		
Ae. (Ochlerotatus) nigrithorax	Female	17	(0.1)	11	5	0		
Ae. (Ochlerotatus) ratcliffei	Female	5	(<0.1)	5	3	0		
Ae. (Ochlerotatus) turneri	Female	8	(<0.1)	3	3	0		
Ae. (Ochlerotatus) vigilax	Bloodfed	2	(<0.1)	0	0	0		
Ae. (Ochlerotatus) vigilax	Female	965	(5.1)	965	70	0		
Ae. (Ochlerotatus) vigilax	Male	1	(<0.1)	1	1	0		
Ae. species (unidentified) - new or difficult to ID species	Male	29	(0.2)	11	5	0		
An. (Anopheles) atratipes	Female	4	(<0.1)	4	4	0		
An. (Cellia) annulipes s.l.	Female	183	(1.0)	143	42	0		
An. (Cellia) annulipes s.l.	Male	1	(<0.1)	1	1	0		
Cq. (Coquillettidia) species near *linealis*	Bloodfed	4	(<0.1)	0	0	0		
Cq. (Coquillettidia) species near *linealis*	Female	324	(1.7)	321	42	0		
Cs. (Culicella) atra	Female	69	(0.4)	68	22	0		
Cx. (Culex) annulirostris	Bloodfed	3	(<0.1)	0	0	0		
Cx. (Culex) annulirostris	Female	149	(0.8)	148	35	0		
Cx. (Culex) australicus	Bloodfed	1	(<0.1)	0	0	0		
Cx. (Culex) australicus	Female	562	(3.0)	519	72	0		
Cx. (Culex) australicus variant	Female	1	(<0.1)	0	0	1		
Cx. (Culex) globocoxitus	Bloodfed	4	(<0.1)	0	0	0		
Cx. (Culex) globocoxitus	Female	937	(4.9)	805	91	0		
Cx. (Culex) globocoxitus	Male	1	(<0.1)	1	1	0		
Cx. (Culex) quinquefasciatus	Female	86	(0.5)	86	33	0		
Cx. species (unidentified) - new or difficult to ID species	Male	58	(0.3)	25	9	0		
Unidentifiable (too damaged/features missing)	Female	15	(0.1)	15	2	0		
Unidentifiable *Aedes* sp. (too damaged/features missing)	Female	6	(<0.1)	6	1	0		
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	5	(<0.1)	5	2	0		
Total		**19001**	**(100.0)**	**15317**	**1227**	**2**	**14**	**(0.9)**

[1]RRV is Ross River virus, MIR is minimum infection rate per 1000 mosquitoes (Chiang and Reeves 1962).

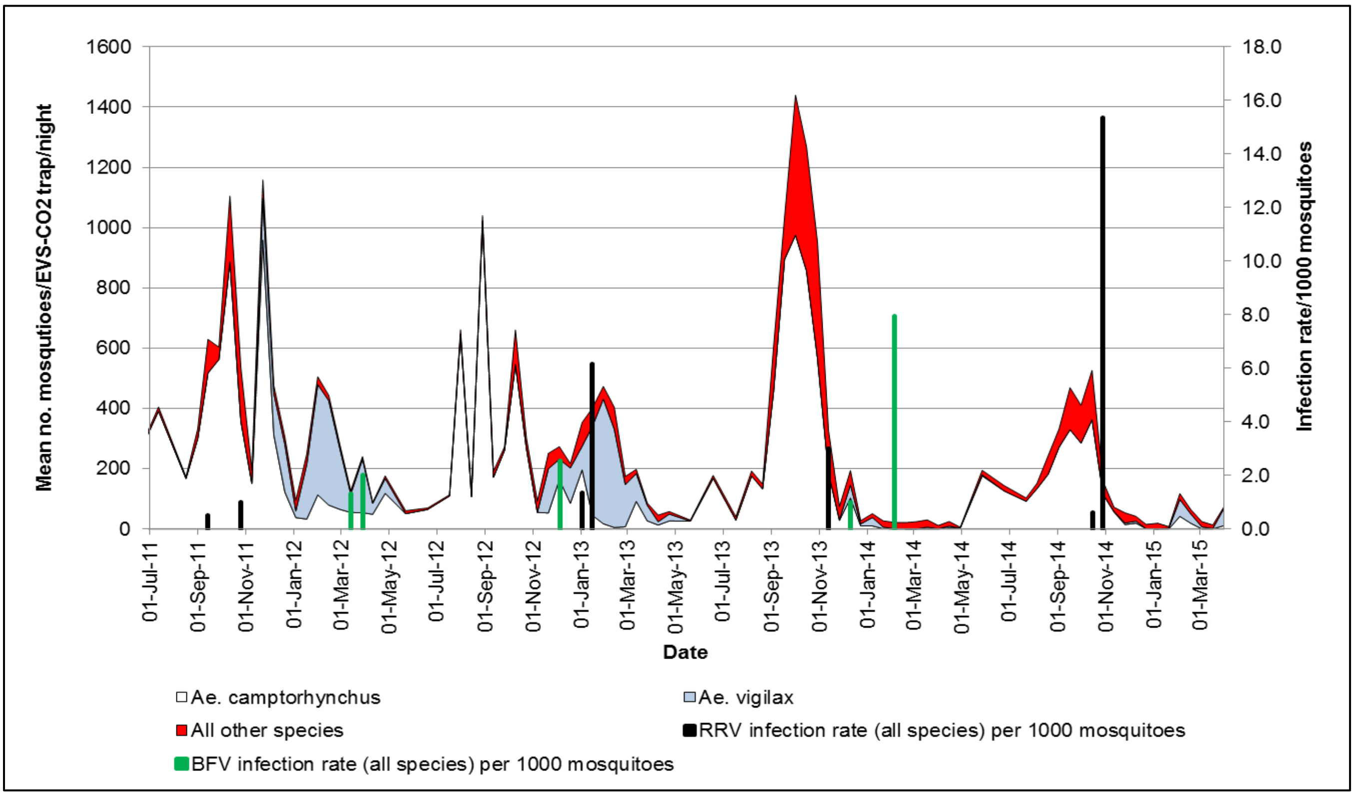


Figure 25: Abundance of adult mosquitoes and their infection rates (all species) with RRV and BFV, Leschenault Inlet sites, 1 July 2011 - 30 June 2015.

Table 7: Details of mosquitoes collected and processed for virus isolation, Capel forest sites, southwest of Western Australia, 1 July 2014 to 30 June 2015.

Species	Class	Total	(%)	Processed	Pools	Pinned
Ae. (Finlaya) alboannulatus	Bloodfed	1	(<0.1)	0	0	0
Ae. (Finlaya) alboannulatus	Female	177	(1.0)	151	38	0
Ae. (Finlaya) notoscriptus	Female	76	(0.4)	69	20	0
Ae. (Ochlerotatus) camptorhynchus	Bloodfed	181	(1.0)	0	0	0
Ae. (Ochlerotatus) camptorhynchus	Female	15718	(90.2)	8091	419	0
Ae. (Ochlerotatus) camptorhynchus variant	Female	1	(<0.1)	0	0	1
Ae. (Ochlerotatus) clelandi	Female	6	(<0.1)	5	4	0
Ae. (Ochlerotatus) hesperonotius	Female	2	(<0.1)	1	1	0
Ae. (Ochlerotatus) ratcliffei	Female	254	(1.5)	78	8	0
Ae. (Ochlerotatus) turneri	Female	2	(<0.1)	1	1	0
Ae. species (unidentified) - new or difficult to ID species	Male	3	(<0.1)	2	2	0
An. (Cellia) annulipes s.l.	Female	317	(1.8)	205	33	0
An. (Cellia) annulipes s.l.	Male	3	(<0.1)	3	2	0
Cq. (Coquillettidia) species near *linealis*	Female	28	(0.2)	24	13	0
Cs. (Culicella) atra	Female	6	(<0.1)	5	2	0
Cx. (Culex) annulirostris	Bloodfed	1	(<0.1)	0	0	0
Cx. (Culex) annulirostris	Female	106	(0.6)	106	18	0
Cx. (Culex) annulirostris	Male	2	(<0.1)	2	1	0
Cx. (Culex) australicus	Female	71	(0.4)	41	19	0
Cx. (Culex) globocoxitus	Female	445	(2.6)	285	47	0
Cx. (Culex) globocoxitus	Male	1	(<0.1)	1	1	0
Cx. species (unidentified) - new or difficult to ID species	Male	23	(0.1)	15	3	0
Total		**17424**	**(100.0)**	**9085**	**632**	**1**

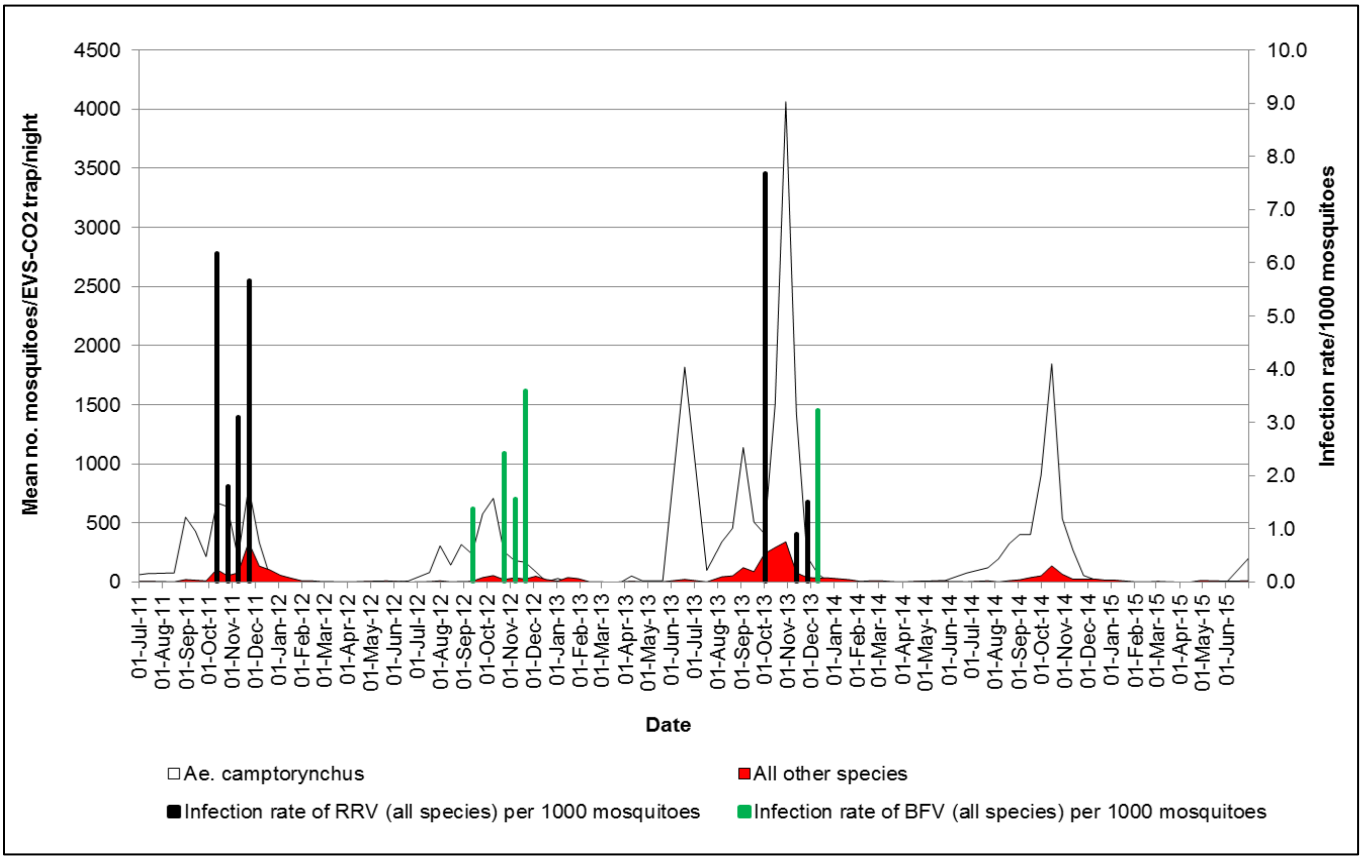


Figure 26: Abundance of adult mosquitoes and their infection rate (all species) with RRV and BFV, Capel forest sites, 01 July 2011 - 30 June 2015.

Table 8: Details of mosquitoes collected and processed for virus isolation, Busselton wetlands sites, southwest of Western Australia, 1 July 2014 to 30 June 2015.

Species	Class	Total	(%)	Processed	Pools	Pinned
Ae. (Finlaya) alboannulatus	Bloodfed	20	(0.3)	0	0	0
Ae. (Finlaya) alboannulatus	Female	308	(4.9)	306	43	0
Ae. (Finlaya) notoscriptus	Bloodfed	1	(<0.1)	0	0	0
Ae. (Finlaya) notoscriptus	Female	61	(1.0)	56	18	0
Ae. (Halaedes) ashworthi	Female	1	(<0.1)	1	1	0
Ae. (Ochlerotatus) camptorhynchus	Bloodfed	35	(0.6)	0	0	0
Ae. (Ochlerotatus) camptorhynchus	Female	2677	(42.7)	2313	138	0
Ae. (Ochlerotatus) clelandi	Bloodfed	6	(0.1)	0	0	0
Ae. (Ochlerotatus) clelandi	Female	182	(2.9)	181	18	0
Ae. (Ochlerotatus) hesperonotius	Bloodfed	1	(<0.1)	0	0	0
Ae. (Ochlerotatus) hesperonotius	Female	108	(1.7)	107	9	0
Ae. (Ochlerotatus) ratcliffei	Female	3	(<0.1)	3	2	0
Ae. (Ochlerotatus) species near *explorator*[1]	Female	1	(<0.1)	0	0	1
Ae. (Ochlerotatus) turneri	Female	8	(0.1)	7	1	0
Ae. (Ochlerotatus) vigilax	Female	8	(0.1)	8	4	0
Ae. species (unidentified) - new or difficult to ID species	Male	3	(0.0)	3	3	0
An. (Cellia) annulipes s.l.	Female	657	(10.5)	621	52	0
An. (Cellia) annulipes s.l.	Male	4	(0.1)	4	1	0
Cq. (Coquillettidia) species near *linealis*	Female	1	(<0.1)	1	1	0
Cs. (Culicella) atra	Female	16	(0.3)	16	8	0
Cx. (Culex) annulirostris	Bloodfed	2	(<0.1)	0	0	0
Cx. (Culex) annulirostris	Female	106	(1.7)	103	25	0
Cx. (Culex) australicus	Bloodfed	1	(<0.1)	0	0	0
Cx. (Culex) australicus	Female	236	(3.8)	218	37	0
Cx. (Culex) globocoxitus	Bloodfed	8	(0.1)	0	0	0
Cx. (Culex) globocoxitus	Female	1585	(25.3)	1276	96	0
Cx. (Culex) globocoxitus	Male	3	(<0.1)	3	2	0
Cx. (Culex) quinquefasciatus	Female	38	(0.6)	38	16	0
Cx. species (unidentified) - new or difficult to ID species	Male	182	(2.9)	180	16	0
Unidentifiable *Aedes* sp. (too damaged/features missing)	Female	6	(0.1)	6	2	0
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	5	(0.1)	3	2	0
Total		**6273**	**(100.0)**	**5454**	**495**	**1**

[1]Identification confirmed by Mr Peter Whelan (retired Northern Territory Medical Entomologist) and Ms Jane Carter (NT Dept of Health and Families).

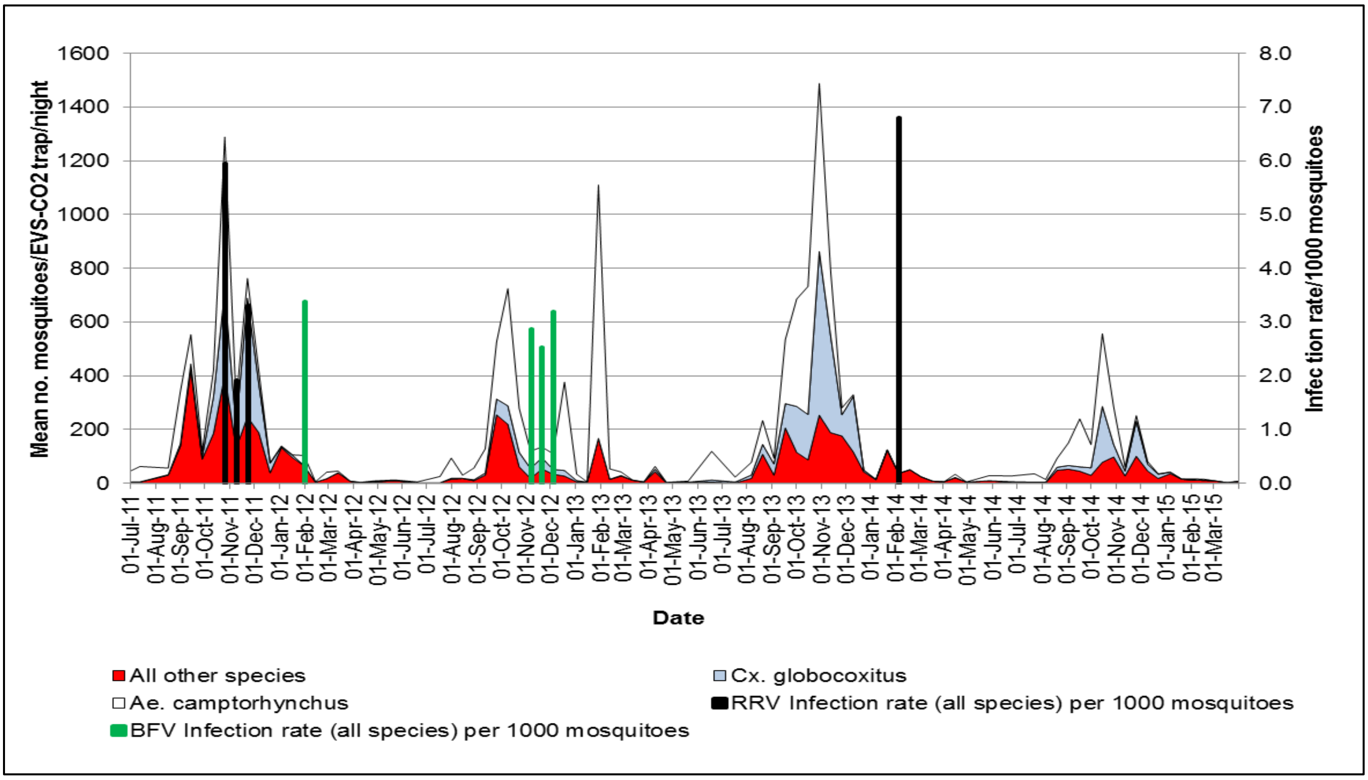


Figure 27: Abundance of adult mosquitoes and their infection rate (all species) with RRV and BFV, Busselton wetland sites, 01 July 2011 - 30 June 2015.

During 2014-2015, below to very much below average rainfall in the Southwest of WA contributed to well below average mosquito abundance from mid-October 2014 until June 2015 (Figure 28).

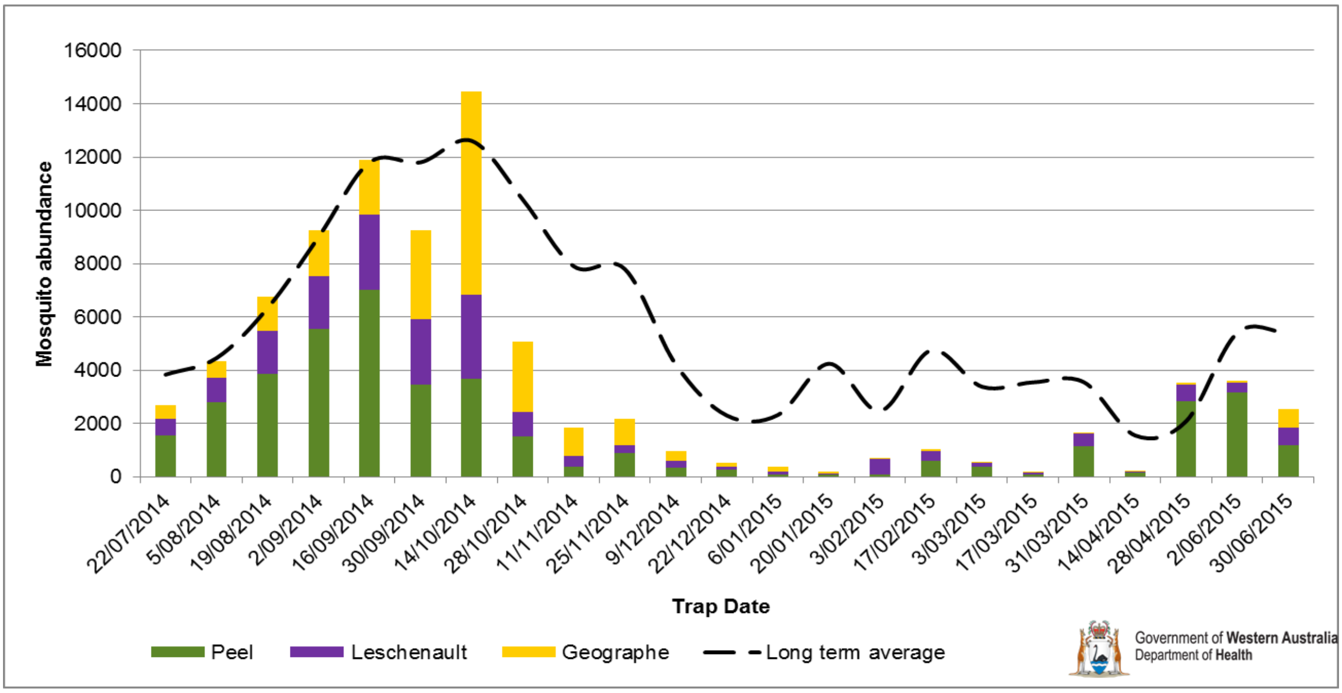


Figure 28: Mosquito abundance in Peel, Leschenault and Geographe in Southwest region of WA from July 2014 to June 2015.

Mosquito collections and arbovirus isolations from the Northeast Kimberley region, 2014

A total of 53 adult mosquito traps were set at Wyndham (including Parry's Creek) and Kununurra in the Northeast Kimberley region between 15 and 17 April, 2014, with one trap failure. Mosquito abundance at Parry's Creek was moderate, where *Culex annulirostris* was the most abundant species (62%) (Table 9). Arbovirus isolates included three KUNV, three SINV and one non-alpha/non-flavivirus, and most of these were from *Cx. annulirostris*. Mosquito abundance was low at Wyndham Six Mile (Table 10), Three Mile (Table 11) and Port (Table 12).

Mosquito abundance was also low at Kununurra Irrigation area (Table 13), Town and environs (Table 14) and Packsaddle Plains (Table 15). The most abundant species collected was *Cx. annulirostris*, and only non-alphavirus/non-flaviviruses were isolated from mosquitoes collected at these locations.

Notable mosquito species collected in the northeast Kimberley region included the first specimen of Hodgesia E.N.M. species number 157 in WA, and *Aedes phaecasiatus* at Kununurra. A single specimen of *Culex gelidus* was collected at Kununurra (township) in 2014.

In total, 23 arbovirus isolates were obtained from mosquitoes collected in the Northeast Kimberley region in 2014, comprising three KUNV, two SINV and 18 non-alphavirus/non-flavivirus isolates (Table16). The low number of flavivirus detections in mosquitoes reflects the low number of flavivirus seroconversions in sentinel chickens in WA during the 2013-14 wet season (data not shown).

Table 9: Mosquito collections and virus isolations from Wyndham (Parry's Creek) in April 2014 (9 traps, 1 failure)

Species	Class	Total	(%)	Processed	Pools	Pinned	Virus isolates[1]
Ad. (Aedeomyia) catasticta	Female	1	(<0.1)	1	1	0	
Ae. (Finlaya) notoscriptus	Female	3	(0.1)	3	2	0	
Ae. (Macleaya) E.N. Marks' species No. 147	Female	1	(<0.1)	1	1	0	
Ae. (Macleaya) species	Female	1	(<0.1)	1	1	0	
Ae. (Neomellanoconion) lineatopennis	Female	3	(0.1)	3	2	0	
Ae. (Ochlerotatus) normanensis	Bloodfed	1	(<0.1)	0	0	0	
Ae. (Ochlerotatus) normanensis	Female	141	(2.8)	141	10	0	
An. (Anopheles) bancroftii	Female	262	(5.1)	262	13	0	
An. (Cellia) amictus	Bloodfed	1	(<0.1)	0	0	0	
An. (Cellia) amictus	Female	139	(2.7)	139	9	0	
An. (Cellia) annulipes s.l.	Female	243	(4.7)	243	13	0	
An. (Cellia) hilli	Female	6	(0.1)	6	3	0	
An. (Cellia) meraukensis	Female	470	(9.2)	470	24	0	
Cq. (Coquillettidia) xanthogaster	Bloodfed	2	(<0.1)	0	0	0	
Cq. (Coquillettidia) xanthogaster	Female	74	(1.4)	74	8	0	
Cq. (Coquillettidia) xanthogaster	Male	1	(<0.1)	1	1	0	
Cx. (Culex) annulirostris	Bloodfed	82	(1.6)	0	0	0	
Cx. (Culex) annulirostris	Female	3178	(62.0)	3178	133	0	3 KUNV, 1 SINV, 2 Non A/F
Cx. (Culex) annulirostris variant	Female	1	(<0.1)	0	0	1	
Cx. (Culex) bitaeniorhynchus	Female	1	(<0.1)	1	1	0	
Cx. (Culex) crinicauda	Female	9	(0.2)	9	5	0	
Cx. (Culex) palpalis	Bloodfed	7	(0.1)	0	0	0	
Cx. (Culex) palpalis	Female	305	(6.0)	303	16	2	
Cx. (Culex) sitiens	Bloodfed	1	(<0.1)	0	0	0	
Cx. (Culex) sitiens	Female	1	(<0.1)	1	1	0	
Cx. (Culex) starckeae	Bloodfed	2	(<0.1)	0	0	0	
Cx. (Culex) starckeae	Female	8	(0.2)	8	4	0	1 SINV
Cx. (Culiciomyia) pullus	Female	40	(0.8)	40	6	0	
Ma. (Mansonioides) uniformis	Female	41	(0.8)	41	6	0	
Unidentifiable *Anopheles* sp. (too damaged/features missing)	Female	27	(0.5)	27	4	0	
Unidentifiable *Culex* sp. (too damaged/features missing)	Bloodfed	9	(0.2)	0	0	0	
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	60	(1.2)	60	7	0	
Ve. (Verrallina) reesi	Female	1	(<0.1)	1	1	0	
Total		**5122**	**(100.0)**	**5014**	**272**	**3**	**3 KUNV, 2 SINV, 2 Non A/F**

[1]KUNV is Kunjin virus, SINV is Sindbis virus, Non A/F is not a recognised Australian alphavirus or flavivirus.

Table 10: Mosquito collections and virus isolations from Wyndham (Six Mile) in April 2014 (4 traps, no failures)

Species	Class	Total	(%)	Processed	Pools	Pinned
Ad. (Aedeomyia) catasticta	Female	1	(0.2)	1	1	0
Ae. (Finlaya) notoscriptus	Female	3	(0.6)	3	1	0
Ae. (Macleaya) species	Female	12	(2.4)	12	1	0
Ae. (Macleaya) species	Male	23	(4.5)	23	1	0
Ae. (Mucidus) alternans	Female	1	(0.2)	1	1	0
Ae. (Neomellanoconion) lineatopennis	Female	1	(0.2)	1	1	0
Ae. (Ochlerotatus) normanensis	Female	10	(2.0)	10	3	0
Ae. (Ochlerotatus) vigilax	Female	11	(2.2)	11	3	0
An. (Anopheles) bancroftii	Female	7	(1.4)	7	2	0
An. (Cellia) amictus	Female	19	(3.7)	19	3	0
An. (Cellia) annulipes s.l.	Female	15	(3.0)	15	3	0
An. (Cellia) hilli	Female	5	(1.0)	5	2	0
An. (Cellia) meraukensis	Female	5	(1.0)	5	1	0
Cq. (Coquillettidia) xanthogaster	Bloodfed	1	(0.2)	0	0	0
Cq. (Coquillettidia) xanthogaster	Female	42	(8.3)	42	4	0
Cq. (Coquillettidia) xanthogaster	Male	4	(0.8)	4	1	0
Cx. (Culex) annulirostris	Bloodfed	4	(0.8)	0	0	0
Cx. (Culex) annulirostris	Female	266	(52.5)	266	12	0
Cx. (Culex) bitaeniorhynchus	Female	1	(0.2)	1	1	0
Cx. (Culex) crinicauda	Female	1	(0.2)	1	1	0
Cx. (Culex) palpalis	Female	56	(11.0)	56	4	0
Cx. (Culex) quinquefasciatus	Female	6	(1.2)	6	2	0
Cx. (Culex) starckeae	Female	1	(0.2)	1	1	0
Cx. (Culiciomyia) pullus	Female	5	(1.0)	5	3	0
Unidentifiable *Aedes* sp. (too damaged/features missing)	Female	1	(0.2)	1	1	0
Unidentifiable *Culex* sp. (too damaged/features missing)	Bloodfed	1	(0.2)	0	0	0
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	4	(0.8)	3	1	1
Ve. (Verrallina) reesi	Female	1	(0.2)	1	1	0
Total		**507**	**(100.0)**	**500**	**55**	**1**

Table 11: Mosquito collections and virus isolations from Wyndham (Three Mile) in April 2014 (3 traps, no failures)[1]

Species	Class	Total	(%)	Processed	Pools	Pinned	Virus isolates[2]
Ae. (Finlaya) notoscriptus	Female	1	(0.4)	1	1	0	
Ae. (Macleaya) species	Female	6	(2.6)	4	3	0	
Ae. (Macleaya) species	Male	6	(2.6)	6	3	0	
Ae. (Ochlerotatus) normanensis	Female	24	(10.6)	24	4	0	
Ae. (Ochlerotatus) vigilax	Female	18	(7.9)	18	2	0	
An. (Cellia) amictus	Female	13	(5.7)	13	2	0	
An. (Cellia) annulipes s.l.	Female	2	(0.9)	2	2	0	
An. (Cellia) hilli	Female	5	(2.2)	5	2	0	
Cq. (Coquillettidia) xanthogaster	Female	6	(2.6)	6	3	0	
Cq. (Coquillettidia) xanthogaster	Male	4	(1.8)	4	1	0	
Cx. (Culex) annulirostris	Bloodfed	1	(0.4)	0	0	0	
Cx. (Culex) annulirostris	Female	108	(47.6)	108	6	0	2 Non A/F
Cx. (Culex) palpalis	Female	18	(7.9)	18	3	0	1 Non A/F
Cx. (Culex) quinquefasciatus	Female	6	(2.6)	6	1	0	
Cx. (Culex) starckeae	Female	4	(1.8)	4	1	0	
Cx. (Culiciomyia) pullus	Female	3	(1.3)	3	2	0	
Cx. (Lophoceraomyia) species	Hermaphrodite	1	(0.4)	0	0	1	
Unidentifiable *Anopheles* sp. (too damaged/features missing)	Female	1	(0.4)	1	1	0	
Total		**227**	**(100.0)**	**223**	**37**	**1**	**3 Non A/F**

[1]In addition, approx. 400 Ceratopogonidae (*Culicoides*) were collected and processed for virus isolation.

[2]Non A/F is not a recognised Australian alphavirus or flavivirus.

Table 12: Mosquito collections and virus isolations from Wyndham (Port) in April 2014 (1 traps, no failure)

Species	Class	Total	(%)	Processed	Pools	Pinned
Ae. (Macleaya) E.N. Marks' species No. 76	Female	1	(1.4)	1	1	0
Ae. (Macleaya) species	Female	19	(26.0)	19	1	0
An. (Cellia) amictus	Female	2	(2.7)	2	1	0
An. (Cellia) hilli	Female	1	(1.4)	1	1	0
Cq. (Coquillettidia) xanthogaster	Female	1	(1.4)	1	1	0
Cx. (Culex) annulirostris	Female	11	(15.1)	11	1	0
Cx. (Culex) sitiens	Female	36	(49.3)	36	2	0
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	2	(2.7)	2	1	0
Total		**73**	**(100.0)**	**73**	**9**	**0**

Table 13: Mosquito collections and virus isolations from Kununurra (Irrigation area) in April 2014 (13 traps, no failures)

Species	Class	Total	(%)	Processed	Pools	Pinned	Virus isolates[1]
Ad. (Aedeomyia) catasticta	Female	2	(0.1)	2	1	0	
Ae. (Aedimorphus) alboscutellatus	Female	1	(0.1)	0	0	0	
Ae. (Chaetocruiomyia) calabyi	Female	1	(0.1)	0	0	1	
Ae. (Finlaya) britteni	Female	1	(0.1)	1	1	0	
Ae. (Finlaya) notoscriptus	Female	23	(1.2)	23	5	0	
Ae. (Macleaya) E.N. Marks' species No. 125	Female	3	(0.2)	3	2	0	
Ae. (Macleaya) species	Female	16	(0.9)	16	5	0	
Ae. (Macleaya) species	Male	4	(0.2)	4	4	0	
Ae. (Mucidus) alternans	Female	7	(0.4)	7	3	0	
Ae. (Neomellanoconion) lineatopennis	Female	22	(1.2)	22	3	0	
Ae. (Ochlerotatus) normanensis	Bloodfed	3	(0.2)	0	0	0	
Ae. (Ochlerotatus) normanensis	Female	90	(4.8)	90	11	0	
Ae. (Ochlerotatus) pseudonormanensis	Female	1	(0.1)	1	1	0	
An. (Anopheles) bancroftii	Female	6	(0.3)	6	6	0	
An. (Cellia) amictus	Female	82	(4.4)	82	12	0	
An. (Cellia) annulipes s.l.	Female	112	(6.0)	112	13	0	1 Non A/F
An. (Cellia) meraukensis	Female	3	(0.2)	3	1	0	
An. (Cellia) novaguinensis	Female	1	(0.1)	1	1	0	
Cq. (Coquillettidia) xanthogaster	Bloodfed	1	(0.1)	0	0	0	
Cq. (Coquillettidia) xanthogaster	Female	37	(2.0)	37	4	0	
Cx. (Culex) annulirostris	Bloodfed	25	(1.3)	0	0	0	
Cx. (Culex) annulirostris	Female	1177	(63.3)	1177	53	0	6 Non A/F
Cx. (Culex) bitaeniorhynchus	Female	5	(0.3)	5	2	0	
Cx. (Culex) crinicauda	Female	2	(0.1)	2	2	0	
Cx. (Culex) palpalis	Female	20	(1.1)	20	5	0	
Cx. (Culex) quinquefasciatus	Female	8	(0.4)	8	4	0	
Cx. (Culex) starckeae	Female	27	(1.5)	27	7	0	
Cx. (Culiciomyia) pullus	Female	134	(7.2)	134	11	0	
Ma. (Mansonioides) uniformis	Female	3	(0.2)	3	2	0	
Tripteroides (Polylepidomyia) punctolateralis	Female	4	(0.2)	4	4	0	
Unidentifiable *Anopheles* sp. (too damaged/features missing)	Female	2	(0.1)	2	2	0	
Unidentifiable *Culex* sp. (too damaged/features missing)	Bloodfed	1	(0.1)	0	0	0	
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	31	(1.7)	31	4	0	
Ve. (Verrallina) reesi	Female	3	(0.2)	3	2	0	
Total		**1858**	**(100.0)**	**1826**	**171**	**1**	**7 Non A/F**

[1]Non A/F is not a recognised Australian alphavirus or flavivirus.

Table 14: Mosquito collections and virus isolations from Kununurra (Town and environs) in April 2014 (16 traps, no failures)

Species	Class	Total	(%)	Processed	Pools	Pinned	Virus isolates[1]
Ad. (Aedeomyia) catasticta	Female	6	(0.3)	6	4	0	
Ae. (Finlaya) britteni	Female	1	(<0.1)	1	1	0	
Ae. (Finlaya) notoscriptus	Female	63	(2.6)	63	8	0	
Ae. (Macleaya) species	Female	53	(2.2)	53	7	0	
Ae. (Macleaya) species	Male	23	(1.0)	23	4	0	
Ae. (Mucidus) alternans	Female	4	(0.2)	4	3	0	
Ae. (Neomellanoconion) lineatopennis	Female	2	(0.1)	2	2	0	
Ae. (Ochlerotatus) normanensis	Female	84	(3.5)	84	12	0	
Ae. (Ochlerotatus) pseudonormanensis	Bloodfed	1	(<0.1)	0	0	0	
Ae. (Ochlerotatus) pseudonormanensis	Female	48	(2.0)	38	2	0	
Ae. species (unidentified) - new or difficult to ID species	Male	1	(<0.1)	1	1	0	
An. (Anopheles) bancroftii	Female	186	(7.8)	186	14	0	
An. (Cellia) amictus	Female	88	(3.7)	88	12	0	
An. (Cellia) annulipes s.l.	Female	133	(5.6)	133	14	0	1 Non A/F
An. (Cellia) annulipes species B	Female	1	(<0.1)	1	1	0	
An. (Cellia) farauti	Female	7	(0.3)	7	3	0	
An. (Cellia) meraukensis	Bloodfed	1	(<0.1)	0	0	0	
An. (Cellia) meraukensis	Female	14	(0.6)	14	6	0	
An. (Cellia) novaguinensis	Female	1	(<0.1)	1	1	0	
Cq. (Coquillettidia) xanthogaster	Bloodfed	4	(0.2)	0	0	0	
Cq. (Coquillettidia) xanthogaster	Female	281	(11.8)	281	20	0	
Cq. (Coquillettidia) xanthogaster	Male	25	(1.0)	25	7	0	
Cx. (Culex) annulirostris	Bloodfed	29	(1.2)	0	0	0	
Cx. (Culex) annulirostris	Female	942	(39.5)	942	44	0	
Cx. (Culex) bitaeniorhynchus	Female	21	(0.9)	21	4	0	
Cx. (Culex) crinicauda	Female	25	(1.0)	25	8	0	
Cx. (Culex) edwardsi	Female	7	(0.3)	6	1	1	
Cx. (Culex) gelidus	Female	1	(<0.1)	1	1	0	
Cx. (Culex) palpalis	Female	5	(0.2)	5	4	0	
Cx. (Culex) quinquefasciatus	Female	15	(0.6)	15	3	0	
Cx. (Culex) starckeae	Female	7	(0.3)	7	5	0	
Cx. (Culiciomyia) pullus	Female	148	(6.2)	148	16	0	
Cx. (Lophoceraomyia) cubiculi	Female	60	(2.5)	60	5	0	
Cx. (Lophoceraomyia) hilli	Female	1	(<0.1)	1	1	0	
Cx. (Lophoceraomyia) species	Female	6	(0.3)	6	3	0	
Hodgesia E. N. Marks' species No. 157	Female	1	(<0.1)	0	0	1	
Ma. (Mansonioides) uniformis	Female	52	(2.2)	52	5	0	
Tripteroides (Polylepidomyia) punctolateralis	Female	2	(0.1)	2	1	0	
Unidentifiable Anopheles sp. (too damaged/features missing)	Female	2	(0.1)	2	2	0	
Unidentifiable *Culex* sp. (too damaged/features missing)	Bloodfed	1	(<0.1)	0	0	0	
Unidentifiable *Uranotaenia* sp. (too damaged/features missing)	Female	1	(<0.1)	1	1	0	
Ur. (Uranotaenia) albescens	Female	20	(0.8)	20	2	0	
Ve. (Verrallina) reesi	Female	12	(0.5)	12	4	0	
Total		**2385**	**(100.0)**	**2337**	**232**	**2**	**1 Non A/F**

[1]Non A/F is not a recognised Australian alphavirus or flavivirus.

Table 15: Mosquito collections and virus isolations from Kununurra (Packsaddle Plain) in April 2014 (7 traps, no failures)

Species	Class	Total	(%)	Processed	Pools	Pinned	Virus isolates[1]
Ad. (Aedeomyia) catasticta	Female	13	(0.3)	13	4	0	
Ae. (Aedimorphus) alboscutellatus	Female	1	(<0.1)	1	1	0	
Ae. (Finlaya) notoscriptus	Female	1	(<0.1)	1	1	0	
Ae. (Macleaya) species	Female	6	(0.1)	6	3	0	
Ae. (Macleaya) species	Male	1	(<0.1)	1	1	0	
Ae. (Macleaya) tremulus	Female	2	(<0.1)	2	1	0	
Ae. (Mucidus) alternans	Female	18	(0.4)	18	6	0	
Ae. (Neomellanoconion) lineatopennis	Female	83	(1.8)	83	8	0	
Ae. (Ochlerotatus) E.N. Marks' species No. 85	Female	2	(<0.1)	2	1	0	
Ae. (Ochlerotatus) normanensis	Bloodfed	3	(0.1)	0	0	0	
Ae. (Ochlerotatus) normanensis	Female	226	(5.0)	226	13	0	
Ae. (Ochlerotatus) phaecasiatus	Female	2	(<0.1)	2	2	0	
Ae. (Ochlerotatus) vigilax	Female	2	(<0.1)	2	1	0	
An. (Anopheles) bancroftii	Female	600	(13.2)	600	27	0	
An. (Cellia) amictus	Female	87	(1.9)	87	9	0	1 Non A/F
An. (Cellia) annulipes s.l.	Bloodfed	1	(<0.1)	0	0	0	
An. (Cellia) annulipes s.l.	Female	258	(5.7)	258	15	0	
An. (Cellia) farauti	Female	129	(2.8)	128	9	1	
An. (Cellia) meraukensis	Female	100	(2.2)	91	9	0	1 Non A/F
An. (Cellia) novaguinensis	Female	26	(0.6)	26	1	0	
Cq. (Coquillettidia) xanthogaster	Bloodfed	3	(0.1)	0	0	0	
Cq. (Coquillettidia) xanthogaster	Female	1010	(22.2)	1010	43	0	1 Non A/F
Cq. (Coquillettidia) xanthogaster	Male	53	(1.2)	53	5	0	
Cx. (Culex) annulirostris	Bloodfed	12	(0.3)	0	0	0	
Cx. (Culex) annulirostris	Female	1420	(31.1)	1420	59	0	2 Non A/F
Cx. (Culex) bitaeniorhynchus	Female	1	(<0.1)	1	1	0	
Cx. (Culex) crinicauda	Female	54	(1.2)	54	4	0	
Cx. (Culex) palpalis	Female	19	(0.4)	19	4	0	
Cx. (Culex) quinquefasciatus	Female	5	(0.1)	5	1	0	
Cx. (Culex) sitiens	Female	1	(<0.1)	1	1	0	
Cx. (Culex) starckeae	Bloodfed	1	(<0.1)	0	0	0	
Cx. (Culex) starckeae	Female	23	(0.5)	23	6	0	
Cx. (Culiciomyia) pullus	Female	123	(2.7)	123	10	0	
Cx. (Lophoceraomyia) cubiculi	Female	24	(0.5)	24	1	0	
Cx. (Lophoceraomyia) fraudatrix	Female	1	(<0.1)	0	0	1	
Cx. (Lophoceraomyia) hilli	Female	26	(0.6)	26	2	0	
Cx. (Lophoceraomyia) species	Female	11	(0.2)	11	2	0	
Ma. (Mansonioides) uniformis	Bloodfed	1	(<0.1)	0	0	0	
Ma. (Mansonioides) uniformis	Female	37	(0.8)	37	8	0	
Unidentifiable *Aedes* sp. (too damaged/features missing)	Female	2	(<0.1)	2	1	0	
Unidentifiable *Anopheles* sp. (too damaged/features missing)	Female	23	(0.5)	23	3	0	
Unidentifiable *Culex* sp. (too damaged/features missing)	Female	69	(1.5)	69	5	0	
Unidentifiable *Uranotaenia* sp. (too damaged/features missing)	Female	1	(<0.1)	1	1	0	
Ve. (Verrallina) reesi	Female	78	(1.7)	78	6	0	
Total		**4559**	**(100.0)**	**4527**	**275**	**2**	**5 Non A/F**

[1]Non A/F is not a recognised Australian alphavirus or flavivirus.

Table 16: Virus isolations from mosquitoes collected in the Kimberley region during the 2014 wet season.

Locality	Code	Species	Collection site	Date	Virus[1]
Parry's Creek	K80850	*Culex annulirostris*	Old Halls Creek Road turnoff	15-Apr-14	Non A/F
Wyndham (Three Mile)	K80969	*Culex palpalis*	Wyndham Community Centre	"	Non A/F
"	K80981	*Cx. annulirostris*	Wyndham sewage lagoon	"	Non A/F
"	K80982	"	"	"	Non A/F
Wyndham (Parry's Creek)	K81136	"	Jogalong Billabong	"	KUNV
"	K81142	"	"	"	KUNV
"	K81170	"	Parry's Creek Crossing	"	Non A/F
"	K81201	"	Parry's Creek Farm	"	SINV
"	K81204	"	"	"	KUNV
"	K81212	*Culex starckeae*	"	"	SINV
Kununurra (Irrigation area)	K81228	*Cx. annulirostris*	Kununurra sewage lagoon	16-Apr-14	Non A/F
"	K81232	"	"	"	Non A/F
"	K81284	*Anopheles annulipes* s.l.	Agricultural Experimental Farm main drain	"	Non A/F
"	K81286	*Cx. annulirostris*	"	"	Non A/F
"	K81302	"	KRS cattle block 8F	"	Non A/F
"	K81344	"	3.5 km N of north end of irrigation area	"	Non A/F
"	K81345	"	"	"	Non A/F
Kununurra (Town and environs)	K81438	*An. annulipes* s.l.	Kelly's Knob	"	Non A/F
Kununurra (Packsaddle Plain)	K81705	*Coquillettidia xanthogaster*	2.0 km along Swamp Road	17-Apr-14	Non A/F
"	K81810	*Anopheles amictus*	Wither's Jetty	"	Non A/F
"	K81857	*Anopheles meraukensis*	Abattoir	"	Non A/F
"	K81863	*Cx. annulirostris*	"	"	Non A/F
"	K81866	"	"	"	Non A/F

[1]KUNV is Kunjin virus, SINV is Sindbis virus, Non A/F is not a recognised Australian alphavirus or flavivirus.

Sentinel Chicken Surveillance Program

MVE and WNV_{KUN} viruses are maintained in a bird – mosquito – bird cycle throughout the north of WA. The Department of Health manages a sentinel chicken program, which provides an early warning for MVE and WNV_{KUN} virus activity across northern WA.

When a chicken is bitten by an infected mosquito, they develop antibodies to the virus but do not become sick. Chickens do not develop high levels of the virus in their body so do not contribute to the spread of the virus to mosquitoes or humans.

Chickens are bled by trained environmental health officers or volunteers and the blood samples are sent to PathWest laboratories to be tested for antibodies to the viruses. When antibodies to MVE and WNV_{KUN} viruses are detected the information is used by the DoH to issue media releases, warning residents and travellers to the affected regions of the increased risk of severe mosquito-borne diseases and the need to take precautions against being bitten by mosquitoes.

In 2014-2015, 28 sentinel chicken flocks were located in major towns and communities in the Kimberley, Pilbara, Gascoyne, Midwest, Wheatbelt and Goldfields regions of WA (Figure 29).

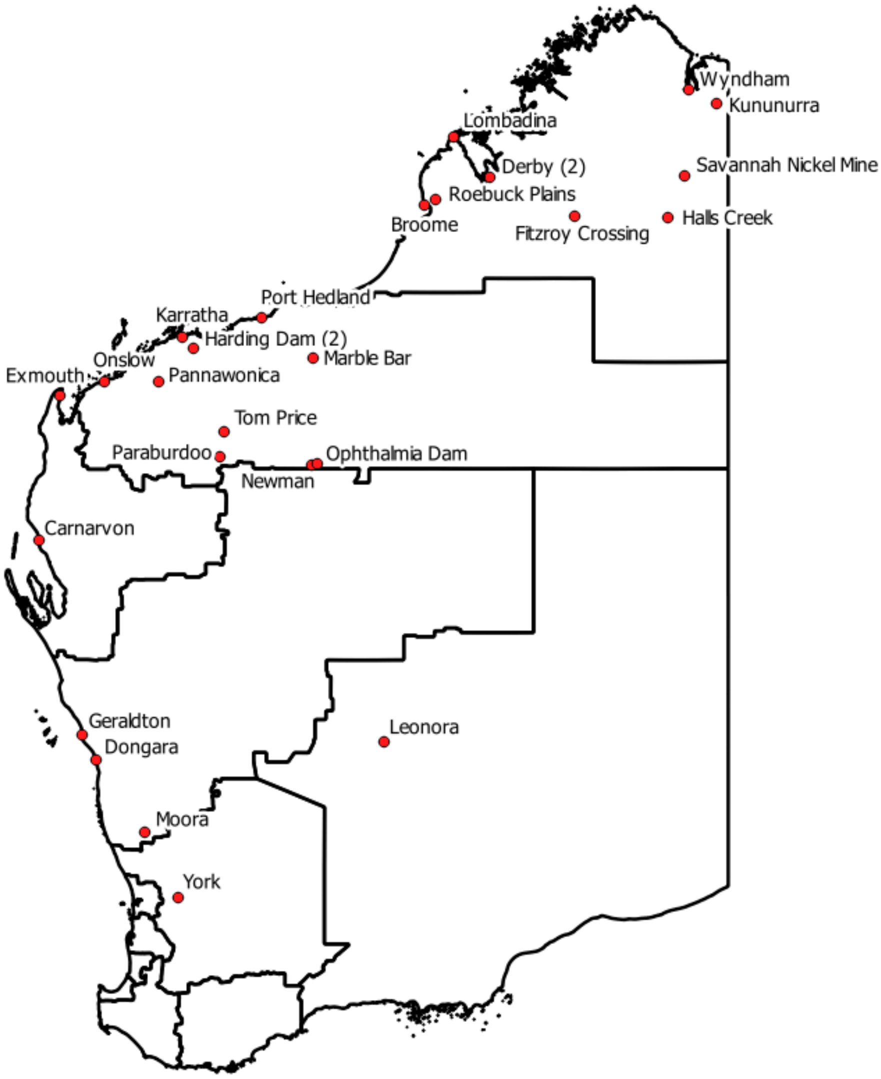


Figure 29: Locations of the sentinel chicken flocks in WA.

The level of flavivirus activity in sentinel chickens in northern WA in 2014-2015 was moderate, with the Kimberley region experiencing the most activity (Table 17). Seroconversions were detected in 39 of the 4744 samples tested (0.82%), which was higher than the previous two years, but still relatively low.

Seroconversions in the Kimberley and Pilbara regions during July and August 2014 were associated with the previous year but did prompt a media release to be issued by the WA DoH in September, reminding travellers and residents to take precautions against mosquito bites.

The first seroconversions of 2015 occurred in early March, when MVEV was detected at Derby. In the same month, MVEV was also detected at Kununurra and Roebuck Plains, and WNV_{KUN} was detected at Kununurra, Halls Creek and Derby. These results triggered the release of a second media alert by the DoH in late March. Ongoing detections of MVEV at Kununurra and Savannah Nickel Mine as well as WNV_{KUN} at Kununurra, Fitzroy Crossing and Derby resulted in a third media release targeting the Kimberley region in mid-April. A seroconversion to WNV_{KUN} at Newman, in the Pilbara, and the ongoing detections of MVEV and WNV_{KUN} across the Kimberley resulted in a media release to warn residents and travellers to both the Pilbara and Kimberley regions to take precautions against mosquito bites. Late detections in Kununurra and Lombadina in May/June resulted in a fifth media release for 2014-15, targeting the Kimberley region.

Table 17: Number of sentinel chickens positive for flaviviruses during 2014- 2015.

Regions	Town/Site	Virus*	Number of chickens flavivirus positive	Month(s) positive
Kimberley	**Kununurra**	MVEV	6	March - May 2015
		WNV_{KUN}	5	March - May 2015
		Undetermined flavivirus	1	June 2015
	Halls Creek	WNV_{KUN}	3	March 2015
	Savannah Nickel Mine	WNV_{KUN}	1	September 2014
		MVEV	2	April 2015
	Fitzroy Crossing	MVEV	1	July 2014
		WNV_{KUN}	6	April and May 2015
	Derby Site 2	MVEV	2	March 2015
		WNV_{KUN}	5	March and April 2015
	Lombadina	WNV_{KUN}	3	May and June 2015
	Broome	WNV_{KUN}	1	July 2014
	Roebuck Plains	MVEV	1	March 2015
Pilbara	**Marble Bar**	WNV_{KUN}	1	August 2014
	Ophthalmia Dam	WNV_{KUN}	1	July 2014
	Newman	WNV_{KUN}	1	April 2015

*Where MVEV = Murray Valley encephalitis virus; WNV_{KUN} = West Nile virus (Kunjin strain).

Aerial Larviciding Program across the Southwest of WA

The Department of Health funds the use of a helicopter for aerial application of mosquito larvicide in high mosquito-borne disease risk areas in the southwest of the WA. The aerial larviciding program is an important preventative Public Health activity.

The coastal southwest region experiences annual RRV and BFV activity, which in some years can lead to significant outbreaks of disease among local residents and visitors. By controlling vector mosquito populations, the program aims to reduce the number of cases of both diseases.

Mosquito breeding, and hence the need for control, is determined by environmental and meteorological factors such as rainfall and tidal activity. Local Government staff monitor mosquito breeding habitat in their jurisdictions and submit a pre-treatment form to the Department of Health when a treatment is required.

The Department then reviews the data and notifies the helicopter contractor of the proposed treatment date. Local Government staff then record details of the treatment and conduct a post-treatment survey after the treatment has been undertaken to determine if it was effective.

A total of 29 aerial larvicide treatments covering over 3000 hectares were undertaken during the 2014-2015 financial year. Table 18 shows the number of treatments and total area treated by helicopter across the three regions.

Table 18: Number of aerial treatments and area treated by region during 2014-2015.

Regions	Treatments	Area treated (ha)
Geographe	6	1023.4
Leschenault	6	233
Peel	17	2173.5
Total	**29**	**3429.9**

The most commonly used larvicides were granulated forms of S-methoprene and *Bacillus thuringiensis israelensis* (Bti).This is the second year during which aerial treatments have been carried out year round with the intention of ensuring larval numbers are controlled over winter and do not increase as quickly during the peak mosquito breeding months in spring in early summer.

Medical Entomology Funding for Mosquito Management

Contiguous Local Authorities Group (CLAG) Funding Scheme

CLAGs are comprised of one or more (contiguous) Local Governments (LG's) that share a common mosquito problem, usually natural or man-made mosquito-breeding habitat that subsequently impacts on surrounding communities.

The State Government funded CLAG scheme was endorsed by Cabinet in 1990. Since that time, the scheme has provided funding to CLAGs across the State.

The scheme provides funding assistance for larvicides (and adulticides only where larvicides are less effective), based on logistical and environmental considerations specific to each LG. Helicopter costs associated with aerial application of larvicides in high risk areas for RRV in the Southwest of the State are also funded.

As well as assistance with funding, CLAG members also benefit from the CLAG scheme through working in partnership with other LG's and the DoH to share knowledge, experience and logistics to achieve enhanced mosquito management programs.

There are currently 14 active CLAGs in WA:

- Ashburton (Shire of Ashburton);
- Broome (Shire of Broome);
- Carnarvon (Shire of Carnarvon);
- Derby-West Kimberley (Shire of Derby-West Kimberley);
- East Swan River (Towns of Bassendean and Victoria Park and Cities of Bayswater, Belmont and Swan);
- Geographe (City of Busselton and Shire of Capel);
- Leschenault (City of Bunbury and Shires of Dardanup and Harvey);
- Nedlands-Subiaco (Cities of Nedlands and Subiaco);
- Peel (Cities of Mandurah and Rockingham and Shires of Murray and Waroona);
- Port Hedland (Town of Port Hedland);
- Roebourne (City of Karratha); and
- Swan-Canning Rivers (City of South Perth, City of Canning, City of Melville and City of Perth).

Two new CLAGs joined late in the 2015 year, but were not active until the following year 2015-2016 including the:

- East Pilbara (Shire of East Pilbara); and
- Wyndham/East Kimberley (Shire of Wyndham East Kimberley).

DoH provided funding to the amount of $198,594.43 to the above-mentioned CLAGs to assist with mosquito control in 2014-15. The amount each CLAG received was dependent on their unique requirements.

Funding Initiative for Mosquito Management in Western Australia (FIMMWA)

The Funding Initiative for Mosquito Management in Western Australia (FIMMWA) was established in 2013-2014 following a directive by the Minister for Health to provide an additional $1 million a year for four years (total $4 million) to be spent on the enhancement of mosquito management across WA. The additional funding was allocated between LG grants (approximately $300-400,000 per year), research grants (total of $200,000 a year) and Capability Building Projects to encourage enhanced mosquito management into the future (approximately $300-400,000 per year).

FIMMWA Additional Funding to Local Government Grants

The additional funding to LG provided funds for the purchase of goods/services outside the scope of the standard CLAG funding arrangement, including (but not limited to):

- equipment for mosquito management and breeding site assessment;
- health promotion material;
- external review of existing management programs;
- external audit of the mosquito fauna, breeding sites and public health risks;
- additional staff for mosquito management;
- staff attendance at mosquito management conferences/training courses; and
- purchase of IT for field based documentation of mosquito populations.

During the 2014-2015 round, requests from seven CLAGs and one LG (City of Kwinana) were received and reviewed by the Mosquito Control Advisory Committee (MCAC). The MCAC approved budgets totaling $148,434.66. This amount included additional purchases of a dry ice machine and calibration catch trays by DoH to further enhance mosquito management within LG. Funding was approved in August 2014 and all funds have since been distributed to the CLAG applicants.

FIMMWA Competitive Research Grants

The Competitive Research Grants aim to support (but are not limited to) projects whose research priorities involve:

- the design, implementation and/or evaluation of biological, chemical or physical mosquito control methods;
- mosquito control solutions for areas where large-scale mosquito control is logistically challenging or environmentally unacceptable;
- minimising reliance on pesticide use and/or the disruption of natural environments in mosquito control;
- increasing knowledge of mosquito-borne disease risks, vectors and/or host populations;
- understanding the relationship between environmental variables and mosquito-borne disease incidence; and
- understanding the impact of man-made infrastructure on vector mosquito populations and associated implications for planning and land-use management in WA.

Twelve applications (totaling $326,488.00) were received and reviewed by a panel comprising of the MCAC and the previous WA Chief Scientist (Prof. Lyn Beazely). The review panel supported six applications for funding which were subsequently endorsed by the Director of Environmental Health in July 2014, totaling $166,800.00. The University of Western Australia (3 grants), PathWest (2 grants) and the University of Tasmania (1 grant) were the successful recipients of FIMMWA Competitive Research Grants.

As $200,000 was initially available, a substantial sum remained after all grants were reviewed. The MCAC, with the support of Chief Scientist Professor Lyn Beazley, felt it would be most beneficial to use the remaining funds to target a number of research projects. Funding was used to undertake a randomized phone survey to determine the practices of individuals in relation to mosquito repellent application. The results will inform standardised guidelines surrounding the correct application of mosquito repellent products, as part of the “Fight the Bite” communication campaign. The Survey Research Centre (SRC) at Edith Cowan University was contracted to undertake the survey, on behalf of the Department of Health. The survey was completed in May 2015.

During the 2014-2015 financial year, following research projects were successful in receiving FIMMMWA research grants:

1. **Comparing virus isolation and PCR for detecting Ross River and Barmah Forest viruses in mosquitoes from the southwest of Western Australia.**

   During 2013-2014 the Arbovirus Surveillance and Research Laboratory undertook a trial to compare traditional virus isolation with multiplex real-time PCR for detection of RRV and BFV in field-caught mosquitoes.

   During two seasons, 7211 mosquito homogenates from mosquitoes collected during surveillance of mosquitoes and arboviruses were processed in parallel by virus isolation and by RNA extraction and real-time RT-PCR. A total of 43 (0.6%) homogenates were positive for RRV or BFV by virus isolation and/or PCR and PCR proved superior for detection of these viruses. Of the 43 positive homogenates, 37 (88%) were positive by PCR, 31 (72%) were positive by virus isolation, 12 (28%) were only positive by PCR and 6 (14%) were only positive by virus isolation.

   The RRV PCR had an initial sensitivity of 85% that increased to 97% on repeat testing, compared with 68% and 79%, respectively, for virus isolation. The BFV PCR and virus isolation were equally sensitive for detection of BFV in mosquitoes, although a limit of detection analysis showed the BFV real-time RT-PCR was more than 100-fold more sensitive.

   This study showed that detection of RRV and BFV can occur in just 2-3 days, compared with 8-13 days with virus isolation. Rapid detection of virus-infected mosquitoes improves the capacity of the WA Department of Health and Local Government authorities to manage and minimise the impact of arboviral diseases. As a result of this work the laboratory now uses real-time RT-PCR as the primary method for RRV and BFV detection in the southwest of WA.

   This project was funded in part through the Department of Health FIMMWA funding initiative. It involved a collaboration between UWA (Dr Cheryl Johansen, Dr Jay Nicholson, Shani Wong, Sarah Power and Michael Burley) and PathWest (Dr Glenys Chidlow and Clinical Professor David Smith).

2. **Assessment of honey-baited FTA® cards in mosquitoes for arbovirus surveillance in the southwest of Western Australia.**

This research project compared the use of a "mosquito-free" arbovirus detection system with current routine surveillance techniques including virus culture and molecular amplification from mosquito homogenates.

This enabled an assessment of the feasibility of using this system for detecting RRV and BFV activity in WA.

A total of 87 honey-baited FTA card traps were set between August and December 2014, comprising 348 FTA® cards for testing by real-time RT-PCR. Honey applied to the FTA® cards was coloured with blue food dye to assess feeding rates.

On average 26% of mosquitoes collected in the honey-baited FTA® card traps had probed the cards, evidenced by the presence of blue honey in their bodies. However it proved difficult to assess the number of mosquitoes with blue honey in their bodies due to desiccation and the dark integument of their bodies; the proportion of mosquitoes that probed is likely to be greater than 26%.

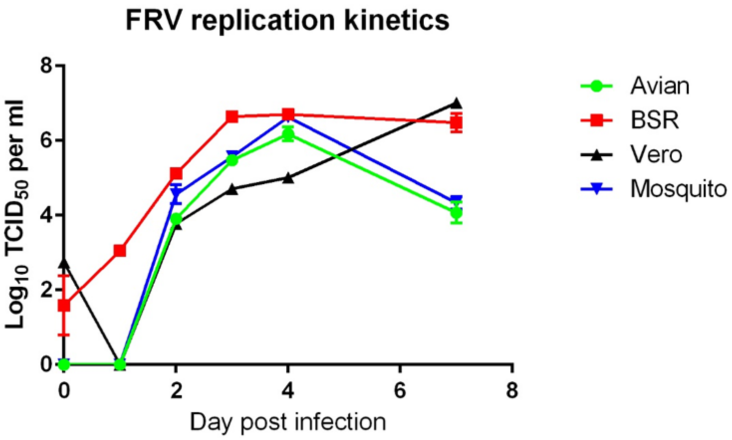
A total of 46 cards were positive in two tests (13.2%), compared with 11/2752 (0.4%) mosquito homogenates positive for RRV by virus culture and 15/2752 (0.5%) homogenates positive for RRV by real-time RT-PCR during the same period. RRV was detected in honey-baited FTA® card traps 7/17 weeks of the study compared with RRV virus isolation or real-time RT-PCR positive homogenates in 3/17 weeks. No BFV was detected in FTA® cards or in mosquito homogenates tested by virus isolation or real-time RT-PCR. The RRV detections in FTA® cards generally matched detections in mosquito homogenates, however FTA® cards were positive for RRV one week prior and approx. six weeks later than mosquito homogenates. Most PCR amplification scores were weak, with just nine positive cards scoring strong positive scores in duplicate tests.

Overall the honey-baited FTA® card system shows promise for improved detection of RRV and BFV in the southwest of WA. This project was funded in part through the Department of Health FIMMWA funding initiative. It was a collaborative effort between UWA (Dr Cheryl Johansen, Dr Jay Nicholson, Michael Burley, Shani Wong and Sarah Power) and PathWest (Dr Glenys Chidlow and Clinical Professor David Smith).

3. Virulence and host range of Fitzroy River virus, a novel mosquito-borne flavivirus in northern Australia.

A serological survey of antibodies to Fitzroy River virus (FRV) in humans, domestic animals (cattle, horses, chickens) and marsupials in northern WA and the Northern Territory revealed evidence of infection. Exposure to FRV was greatest in horses and cattle, however infection was not associated with overt clinical disease. Three human infections with FRV were also detected from the West Kimberley region. It is not known if FRV was the cause of any illness.

FRV replicated in four different cell lines, including mosquito, mammalian and avian cells. However virus replicated to much higher levels in mammalian BSR cells (a clone of Baby Hamster Kidney cells) than the other three cell lines examined (C6/36, Vero and DF-1). The level of virus present in the cells did not reflect the low level cytopathic effect observed during microscopic examination of infected cells.



In vivo studies in a mouse model showed that the virus was able to infect weanling mice, as evidenced by the production of detectable antibodies in serum from 85% of the animals. Other than mild eye symptoms in one mouse, animals inoculated with two different doses of FRV intra-peritoneally did not develop clinical signs. Three mice inoculated with FRV intra-cranially (ie bypassing the blood-brain barrier) developed only mild clinical disease and the remaining mice stayed healthy. Interestingly, all three mice with mild symptoms had evidence of meningoencephalitis after pathological examination of post-mortem brain tissues.

These results indicate that FRV can infect a range of vertebrates, including horses, cattle and rarely humans and birds. However severe clinical disease appears to be unlikely unless the health of the animal host is compromised.

This work received financial support from the Department of Health FIMMWA initiative. It involved a collaboration between UWA (Dr Cheryl Johansen), PathWest (Clinical Professor David Smith), The University of Queensland (Prof. Roy Hall, Dr Natalie Prow and Dr Helle Bjelefeldt-Ohmann) and the Northern Territory Department of Primary Industries and Fisheries (Dr Lorna Melville).

FIMMWA Capability Building Projects

A proportion of FIMMWA funding is set aside each year to building capacity within Local Governments for the future and to ensure systems that are in place for the management of mosquitoes over the long-term. During the 2014-2015 financial year, four Capability Building Projects were implemented or improved including:

1. **Environmental Health Atlas**: The Department of Health partnered with Gaia Resources and the Cooperative Research Centre for Spatial Information to develop an online portal for the collection of Environmental Health Hazards (EHH) data (mosquito abundance, species composition and disease occurrence) by Local Government Environmental Health Officers, PathWest and the Department of Health. Stage 1 was completed in 2013-2014 and Stage 2 is currently underway, which will include the ability to log human case data, public complaint data and reporting systems for the documentation of Local Government Mosquito Management Plans.

   The overall aim of the Environmental Health Hazards (EHH) data portal will allow:

   - storage of EHH data (mosquito abundance, species composition and disease occurrence) via a username and password allowing the Local Government to maintain their own data records and allow long-term storage of data over decades;
   - provision of a central repository for EHH data across all levels of Government;
   - provision of a long term, electronic store of EHH data to ease transition between staff moving across or between local Governments; and
   - to enable desktop visualisation and analysis of spatio-temporal EHH data and risks across WA (Figure 30).

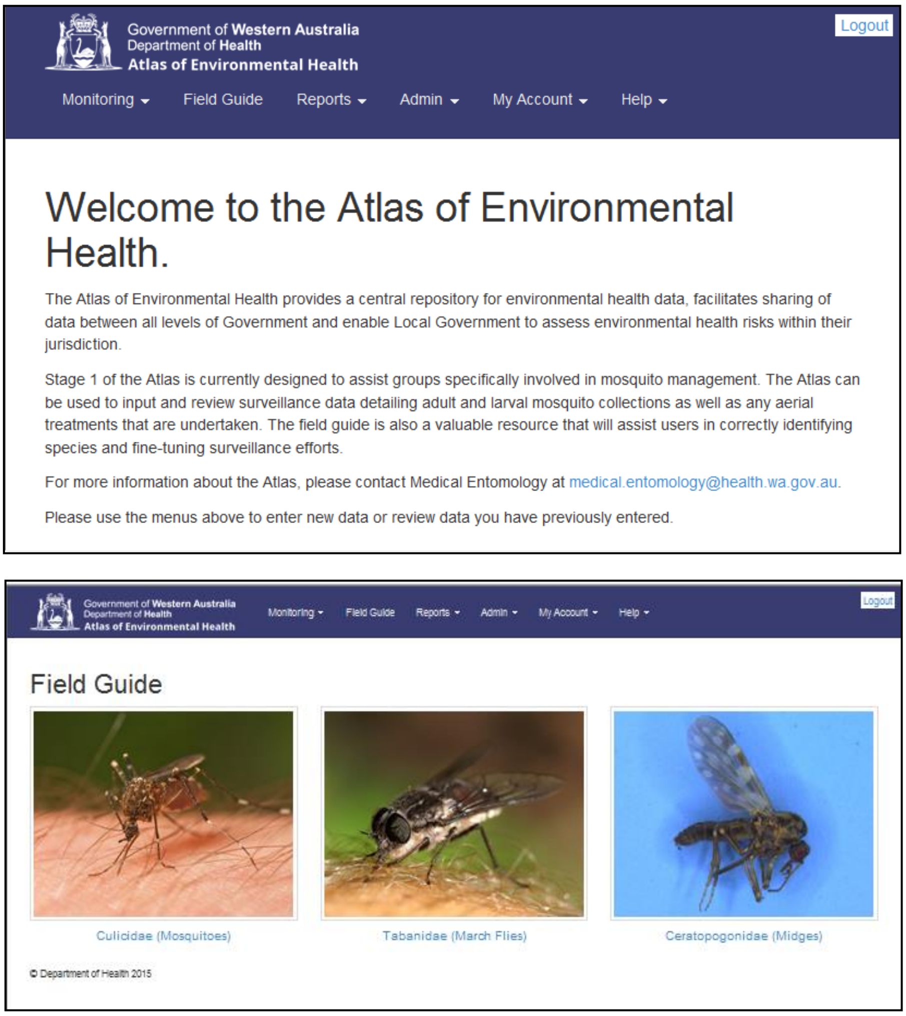


Figure 30: Screen snapshot of the newly developed online Environmental Health Atlas.

The Health Atlas has been built over two years, with the first phase released before December 2014 allowing Local Governments to initiate the collection and analysis of data. The second phase will provide reporting tools for Local Governments to be able to compile data over consecutive years and is aimed to be rolled out in 2015.

2. **Photographic Microscopy Project:** A Leica M205C Stereomicroscope with 8 megapixel Camera and Imaging Software together with a Leica DM1000 Compound Microscope were purchased to capture and collate a photographic database of mosquitoes in WA. The images are being incorporated into an electronic field guide within the Environmental Health Atlas to provide images and resources for local Governments to assist in mosquito identification. Additionally, 5 microscopes were purchased to further assist in training individuals in the correct identification of mosquitoes and mosquito larvae.

3. **Feasibility of Aerial larviciding treatments along the Swan and Canning Rivers:** A feasibility study has been carried out by the Department of Health in conjunction with Local Governments and other interested parties to determine the potential for aerial larviciding treatments along the Swan and Canning Rivers. The final report is due to be released in early 2016.

   Recently, Perth (and the Southwest) experienced La Niña weather patterns during consecutive years. These weather patterns caused extreme and constantly fluctuating high tides. This resulted in continual large breed-outs of *Aedes camptorhynchus* and *Ae. vigilax* despite LGs best efforts to control the mosquitoes.

   An aerial program in the Perth area could potentially alleviate;

   - occupational Health and Safety concerns for those sites that are dangerous or difficult to access on foot;
   - allow improved and more consistent treatment of these sites.
   - assistance to LGs in "bad years" where weather conditions make mosquito management very difficult and very resource intensive.

   The aerial image below shows a saltmarsh wetland that currently can only be treated by hand (Figure 31). This site cannot be accessed by vehicles such as quad bikes due to its thick vegetation and boggy mud. The same area could be treated by helicopter in as little as 10 minutes by helicopter.

   For aerial larviciding to be deemed feasible it needs to be:

   1) supported by LG and the community;
   2) cost effective;
   3) able to comply with all necessary regulations; and
   4) able to deliver appropriate mosquito control products at label rates across the vast majority of identified breeding sites.

Figure 31: Ashfield Flats in the Town of Bassendean.

To ascertain if these parameters are achievable, consultation with LG, Environmental agencies and other State Government agencies, the current aerial larviciding service provider and the community has taken place. Along with these parameters, other key considerations including the budgetary implications for DoH and LGs and the impact a Perth aerial larviciding program could have on the southwest program if there is only one service provider available.

Through the course of this consultation it has been determined that aerial larviciding could certainly be considered a feasible option for managing mosquitoes breeding in Perth's Swan and Canning River wetlands. Such a program could however cost approximately $100,000 in a "bad year" and $30,000 in an "average year".

It is important to note that aerial larviciding in the metropolitan region is intended to complement existing mosquito management programs. There will be seasons when, due to environmental conditions, aerial treatments will not be a feasible option as the areas requiring treatment will be small and will be easily managed using ground based methods. It is also important that DoH, LG and the public recognise the significant impact environmental conditions can have on any type of control program (aerial or ground based methods). While a helicopter may provide a great resource to assist LGs in mosquito management in difficult years, there will be times when even the best aerial program is not effective due to the prevailing environmental conditions.

4. ***Fight the Bite* Communication Campaign**: *Fight the Bite* is WA Health's first innovative, communication campaign that partners with LGs to actively raise awareness of mosquito-borne disease. An assessment of the current communication strategy utilised by the Medical Entomology team was initiated in February 2014. A telephone survey of 2,500 households across 12 regions in WA highlighted significant gaps in the knowledge, attitudes and practices (KAP) individuals held in relation to mosquitoes and mosquito-borne disease. It also highlighted the need for a more active communication campaign targeting at risk demographic groups within the community.

   After evaluating existing mosquito communication strategies, South Australia Health's *Fight the Bite* campaign was identified as a visually appealing, highly effective campaign that maintained scientific and medical integrity through simple messaging. Tailoring *Fight the Bite* to WA was considered the most desirable outcome in the development of a campaign to be introduced locally. Following the signing of a MoU between WA Health and SA Health to use the artwork in WA, approval was received from both the Executive Director (Public Health Division) and the Government Media Office (GMO) to tailor the campaign to WA and roll it out during 2015-2016.

   A toolkit of *Fight the Bite* education resources has been developed to support the campaign. Resources include, but are not limited to, pamphlets (At Home, On Holiday in Australia & On Holiday Overseas), posters and website material (Figure 32). A range of other *Fight the Bite* materials targeting at risk groups within the community will also be investigated. The toolkit will be available to LG to tailor to their region. The aim is to work in partnership with LG to support and complement existing communication efforts whilst increasing the reach of this state-wide campaign.

   Whilst WA Health and LG play an integral role in managing mosquito populations throughout the state, individuals should recognise the importance of reducing backyard breeding and ensuring personal protection. *Fight the Bite* resources specifically target the individual, providing information on how best to protect themselves at home, on holiday in Australia and on holiday overseas. The KAP survey data will be used to provide a baseline against which to evaluate the impact of the *Fight the Bite* campaign following a pilot period of 18-24 months.

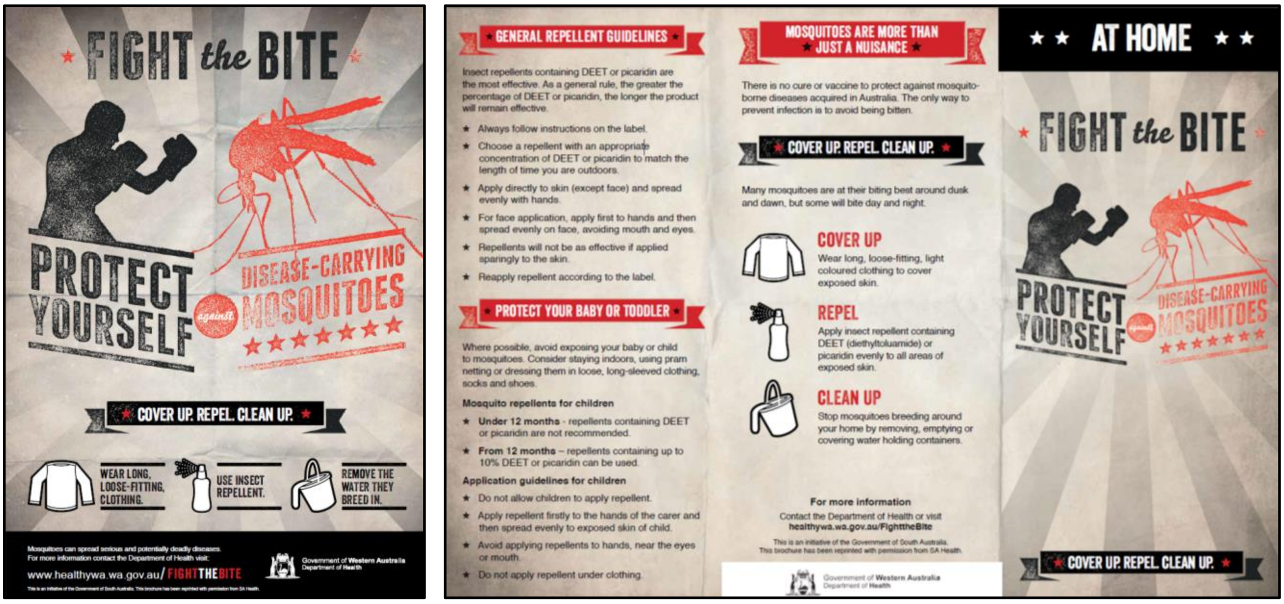


Figure 32: Fight the Bite educational materials.

Other notable events

Exotic Incursions at Perth International Airport

The exotic mosquito surveillance program employed by the Commonwealth Department of Agriculture and Water Resources (DAWR) Science Support Program successfully detected several importations of exotic mosquito species at the Perth International Airport between February 2014 and February 2015. The Department of Health confirmed the identifications of *Aedes aegypti* (the Yellow Fever Mosquito), *Aedes albopictus* (Asian Tiger Mosquito) and *Culex gelidus* specimens collected in DoA monitoring traps. The Department of Health's Medical Entomology team provided technical advice and direction on mosquito control treatments and ongoing monitoring, which were carried out by DAWR and Perth Airport personnel, with some assistance from the ME team (Figure 33).

Uncapped water-filled traffic bollards were found to provide a suitable breeding site for the exotic *Aedes* species in outdoor areas around the development site of the new Perth International Terminal. Additionally, the use of wheelie bins to collect water from cut water pipes within the terminal building were found to be breeding mosquitoes. Fogging, residual sprays and thousands of S-methoprene briquettes were used throughout the Perth International airport site to ensure the exotic mosquitoes did not establish.

Figure 33: Department of Health officers inspecting water accumulated containers for exotic mosquito larvae in Perth construction site of Perth International Airport.

The Medical Entomology team also conducted mosquito surveillance with the use of EVS CO_2 traps and Sticky Ovi Traps around the perimeter of both Perth domestic and international terminals. No exotic mosquitoes were collected outside the 400m exclusion zone controlled by the Department of Agriculture.

DoH Training Workshops

1) Mosquito Identification Workshop

After receiving several requests for assistance with mosquito identification, the Medical Entomology team developed a one day workshop for Local Government Environmental Health Officers (EHOs) to hone their mosquito identification skills.

Two workshops were offered, one on 28 October 2014 at Peppermint Grove Beach Community Centre in Shire of Capel which was attended by 17 regional EHOs. The second workshop ran on 31 October 2014 at Grace Vaughan House, Shenton Park in Perth which was attended by 27 Metropolitan EHOs.

The workshops covered basic information on mosquito biology, the need for adult trapping and the importance of adult mosquito identification. The remainder of the workshop was dedicated to practical mosquito identification. The Medical Entomology team also developed a pictorial mosquito identification key for participants to use as a resource.

Participant feedback indicated that the workshop was highly valued as a good opportunity to refresh identification skills and particularly to spend the time in front of a microscope. Almost all participants indicated that they would be interested to attend similar workshops in the future.

2) Equipment Calibration Workshop

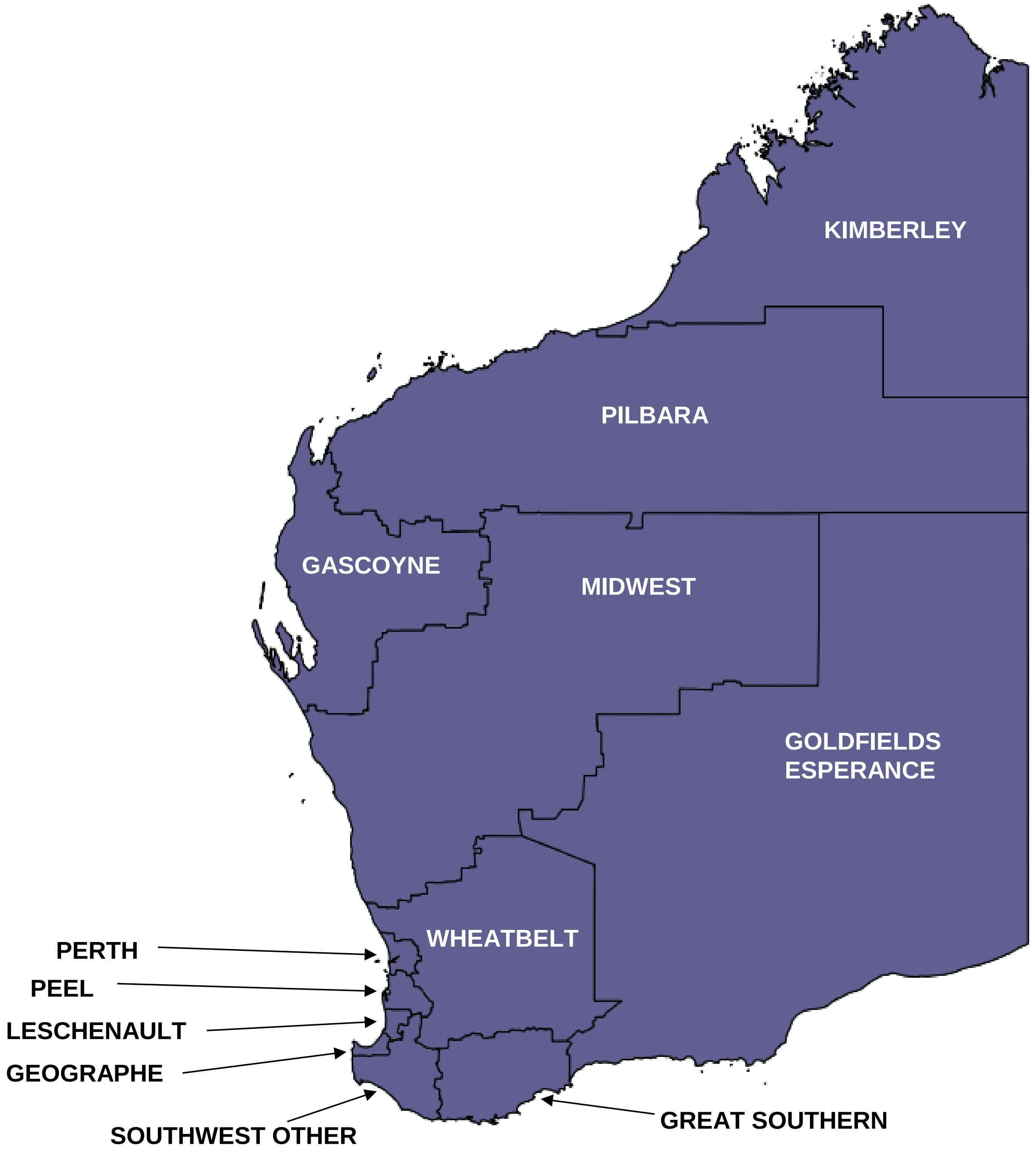
The Medical Entomology program utilised a portion of FIMMWA funding to deliver a free mosquito control equipment calibration workshop to internal DoH Officers and Local Government Environmental Health Staff involved in mosquito management.

The main content of the workshop was aimed at the use and calibration of certain types of handheld and backpack chemical applicator equipment typically used to apply both liquid and granule mosquito control chemicals, such as S-methoprene and *Bacillus thuringiensis israelensis* (Bti) products including Prosand and Vectobac.

David Walker, Managing Director of Pacific Biologics, presented two workshops on 26 and 27 May 2015. The first workshop was attended by 12 staff from the Medical Entomology team and DoH officers involved in the EHDERT (Environmental Health Directorate Emergency Response Team) program. The second workshop was attended by 26 EHOs and other staff involved in Local Government mosquito management programs.

Participant feedback indicated that the workshop was a valuable training session with good balance between theory of chemical application and practice with the various pieces of equipment. Some participants even suggested that it be repeated on a regular basis for newcomers and as a refresher session for others.

Appendix 1: Map of WA State regions



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