Government of **Western Australia**
Department of **Health**

# Medical Entomology

# 2015/2016
# Annual Report

**Environmental Health Hazards Unit**
**Environmental Health Directorate**
**Public Health Division**
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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 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 Environmental Health Directorate;
- the Communicable Disease Control Directorate;
- PathWest; and
- Communications Directorate.

The Pathwest laboratory 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 undertake mosquito control activities 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 by area.

# Contents

# Executive Summary

This annual report summarises the mosquito-borne disease case data and associated significant events for 2015/16 (1 July 2015 to 30 June 2016).

## Mosquito-borne disease case data:

**Ross River virus (RRV):** The total number of notified human cases of RRV infections for WA in 2015/16 was 503. The number of reported cases was lower than monthly five year moving average in all months apart from July to September 2015 and was significantly lower from November 2015 onwards.

**Barmah Forest virus (BFV):** A total of 29 human cases of BFV were notified in WA for 2015/16. The number of cases reported during July, October and December were greater than the long term average while the number of reported cases for all other months were below the long term average.

**Murray Valley encephalitis (MVE) virus:** No human cases of MVE were notified to the Department of Health during 2015/16.

**West Nile virus Kunjin strain ($WNV_{KUN}$):** No human cases of Kunjin disease were notified to the Department of Health during 2015/16.

## Climatic Conditions:

Rainfall was average to above average for the majority of the interior parts of WA. However, south-western and northern coastal parts of WA received below or very much below average rainfall. Minimum temperatures were significantly above average across most of WA. Maximum temperatures were above average for the southern coastal third of the State; very much above average in the Pilbara and interior and highest on record for the Kimberley and north of the State. Tropical Cyclone Stan was the only cyclone to develop over WA waters during 2015/16.

## Mosquito-Borne Disease Surveillance

**Southwest Arbovirus Surveillance Program:** A total of 39,691 mosquitoes were collected, but RRV was only detected at one of 21 routine surveillance sites, with ten detections of RRV from mosquitoes collected at Point Douro on the 4$^{th}$ April 2016. No BFV was detected from any of the routine surveillance sites in the Southwest during 2015/16.

### MVE virus and $WNV_{KUN}$ Surveillance

**Northern mosquito surveillance:** In 2015/16, mosquito surveillance was undertaken in the Kimberley region of WA between 15$^{th}$ March to 15$^{th}$ April 2016. The mosquitoes will be identified to species level in the laboratory and tested for arobviruses during 2016/17.

**Sentinel Chicken Program**: A total of 34 flavivirus detections were reported from sentinel chicken serum samples including seven MVEV and 22 $WNV_{KUN}$ detections.

## Aerial Larviciding Program:

The Department of Health spent $99,545.98 in the provision of aerial larviciding treatments through procurement of helicopter services in the Southwest region. A total of 25 aerial treatments were performed in the Southwest Region.

## Medical Entomology Funding for Mosquito Management

**Contiguous Local Authorities Groups (CLAGs):** The Department of Health provided funding to the amount of $250,801.65 to Local Governments (LGs) within CLAGs to assist with the management of mosquitoes and mosquito-borne diseases during 2015/16.

**Funding Initiative for Mosquito Management in Western Australia (FIMMWA):**
Through FIMMWA, funding was distributed as follows:

- $298,963.33 was directly provided to LG to assist with mosquito management, resources and capacity building;
- $153,682.18 was distributed to research institutions and other bodies for successful research grant applications; and
- $545,000.00 was spent on capability projects across the State to build long-term capacity within LG for the management of mosquitoes.

# Introduction

There are 300 different species of mosquitoes in Australia, of which approximately 100 are known to occur in WA. Of these, viruses have been isolated from over 30 species across Australia and many species have not been tested for their ability to transmit these 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;
3) Japanese encephalitis;
4) Chikungunya; and
5) Zika.

## 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 for 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)

Ross River virus 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, years.

### Overview

The total number of notified human cases of RRV infections for WA in 2015/16 was 503. At the start of the financial year, there was no significant difference in the number of RRV cases notified to the Department of Health (July to October 2015) – Figure 1. However, the number of notified human cases of RRV was significantly below the long term five year rolling average for all other months. There are two main reasons for the decline in the number of human cases. Firstly, the predominant weather patterns were not conducive to mosquito breeding for much of 2015-16 leading to lower mosquito abundance across much of the State and thus, a reduced incidence of transmission of disease. Secondly, and perhaps more importantly, the case definition for Ross River virus was reviewed nationally and new case definitions applied across all jurisdictions in Australia starting on 1 January 2016. Key changes from the previous definition include:

- Laboratory definitive evidence will only include detection by PCR and demonstrated serconversions. A single IgM will no longer be included in this category.
- Laboratory suggestive evidence will require an IgM in the presence of IgG on the same specimen.
- Single IgM positive results will no longer meet the confirmed or probable case definition.

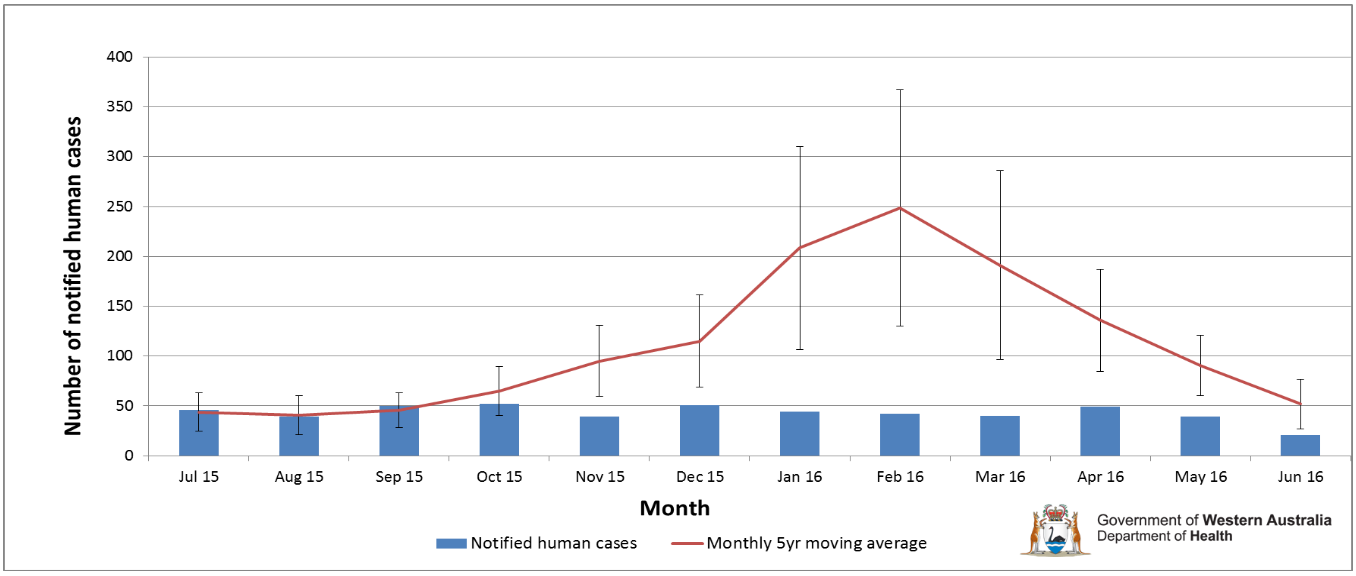



**Figure 1:** The total number of notified human cases of RRV per month across WA from July 2015 to June 2016*.

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

## Age and sex distribution

Ross River virus was most frequently reported in middle aged adults (median 47 years, range 0 – 94 years). Age and sex specific case numbers were highest among males aged 50 – 54 years, females aged 30 – 34 and 45 - 49 years (Figure 2).

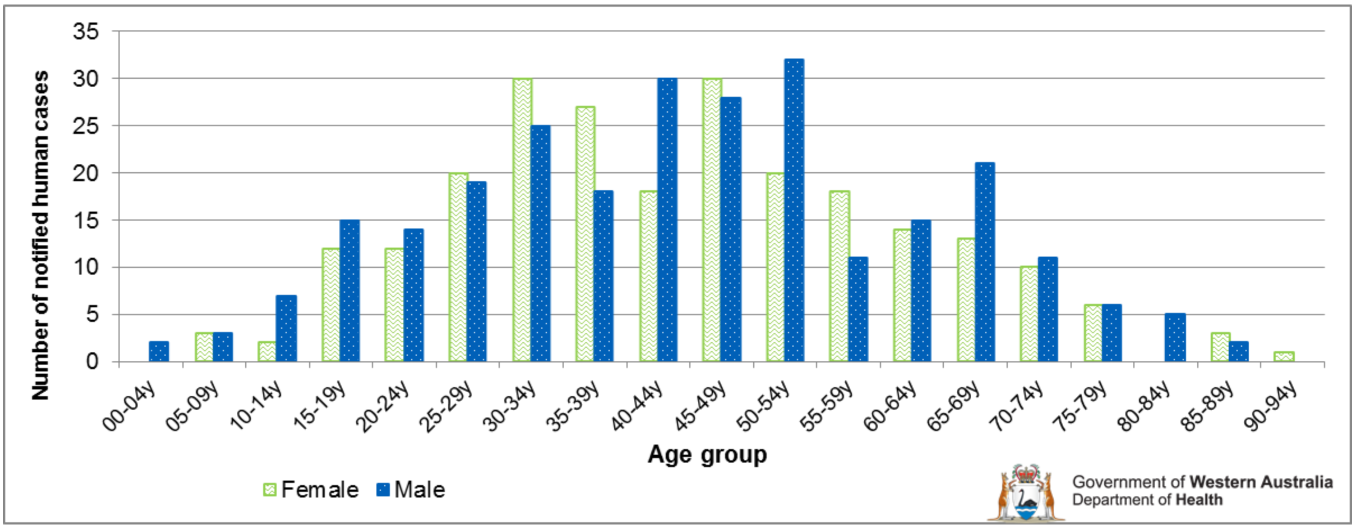



**Figure 2:** The total number of notified human cases of RRV across WA, by age group and sex from July 2015 to June 2016.

**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 and Southwest (Table 1). Within the Perth metropolitan region, the number of cases recorded was 187. Except July and August 2015 the number of cases reported was below the long term average (Figure 3). Although the numbers were high, given the large population in the Metro region, the disease rate (incidence per 100,000 people) was actually the lowest of all regions across the State (Table 1).

A total of 155 cases were recorded from the Southwest region. The number of cases reported were below the monthly five year moving average, with the exception of September 2015, which was slightly above the long term average (Figure 3).

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 CR of 90.4 and ASR of 95.8 were recorded from the Gascoyne region for the 2015/16 financial year.

**Table 1:** Serologically confirmed, doctor-notified, and laboratory reported cases of Ross River virus disease per month for each WA region from July 2015 to June 2016. 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 | 0 | 0 | 2 | 1 | 1 | 3 | 4 | 7 | 4 | 1 | 1 | 2 | 26 | 66.5 | 64.9 |
| Pilbara | 5 | 2 | 6 | 5 | 3 | 0 | 2 | 3 | 3 | 0 | 1 | 0 | 30 | 44.4 | 40.6 |
| Gascoyne | 3 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 9 | 90.4 | 95.8 |
| Midwest | 4 | 3 | 3 | 2 | 4 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 19 | 29.1 | 29.4 |
| Wheatbelt | 1 | 1 | 2 | 0 | 1 | 1 | 4 | 1 | 8 | 0 | 2 | 4 | 25 | 36.9 | 33.8 |
| Metro | 19 | 20 | 14 | 22 | 16 | 15 | 11 | 16 | 15 | 19 | 16 | 5 | 188 | 11.1 | 11.0 |
| Southwest | 12 | 9 | 17 | 16 | 6 | 18 | 17 | 12 | 9 | 20 | 13 | 5 | 154 | 35.9 | |
| *Peel* | 8 | 6 | 13 | 9 | 3 | 14 | 12 | 7 | 5 | 9 | 1 | 2 | 89 | 34.9 | 34.9 |
| *Leschenault* | 2 | 1 | 1 | 4 | 2 | 1 | 1 | 4 | 2 | 4 | 7 | 1 | 30 | 40.0 | 38.4 |
| *Geographe* | 2 | 2 | 3 | 2 | 1 | 3 | 1 | 1 | 2 | 4 | 1 | 1 | 23 | 43.7 | 44.2 |
| *Elsewhere SW* | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 3 | 4 | 1 | 12 | 25.9 | 25.9 |
| Great Southern | 1 | 3 | 1 | 1 | 4 | 3 | 2 | 1 | 0 | 3 | 3 | 3 | 25 | 41.7 | 40.0 |
| Goldfields-Esperance | 1 | 0 | 2 | 3 | 3 | 7 | 1 | 1 | 0 | 3 | 3 | 2 | 26 | 42.4 | 41.9 |
| WA undetermined | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Interstate | 0 | 0 | 2 | 2 | 0 | 2 | 3 | 0 | 0 | 1 | 0 | 0 | 10 | | |
| **WA Total (Does Not Include Interstate)** | **46** | **39** | **48** | **50** | **39** | **49** | **41** | **42** | **40** | **48** | **39** | **21** | **502** | | |

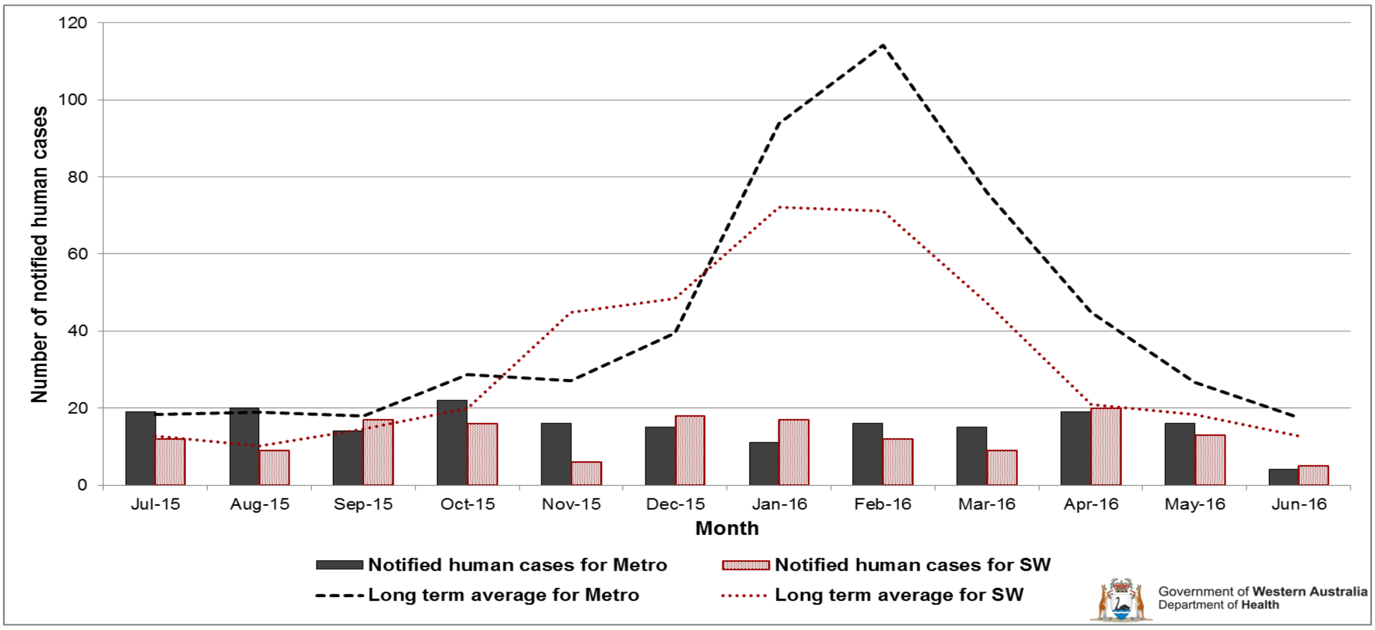



**Figure 3:** The total number of notified human cases of RRV per month across Metro (Grey) and Southwest (SW-Red) regions from July 2015 to June 2016*.

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

During 2015/16, most LGs reported similar rates of RRV disease compared to the State average (Figure 4). Only 17 of 140 LGs had significantly higher rates compared to the State average, including northern LGs such as Broome, Wyndham/East Kimberley, parts of the Midwest and a few southern LG areas including Capel and Mandurah (Figure 4). Only LGs within the Perth metropolitan region reported significantly lower RRV rates compared to the State average.

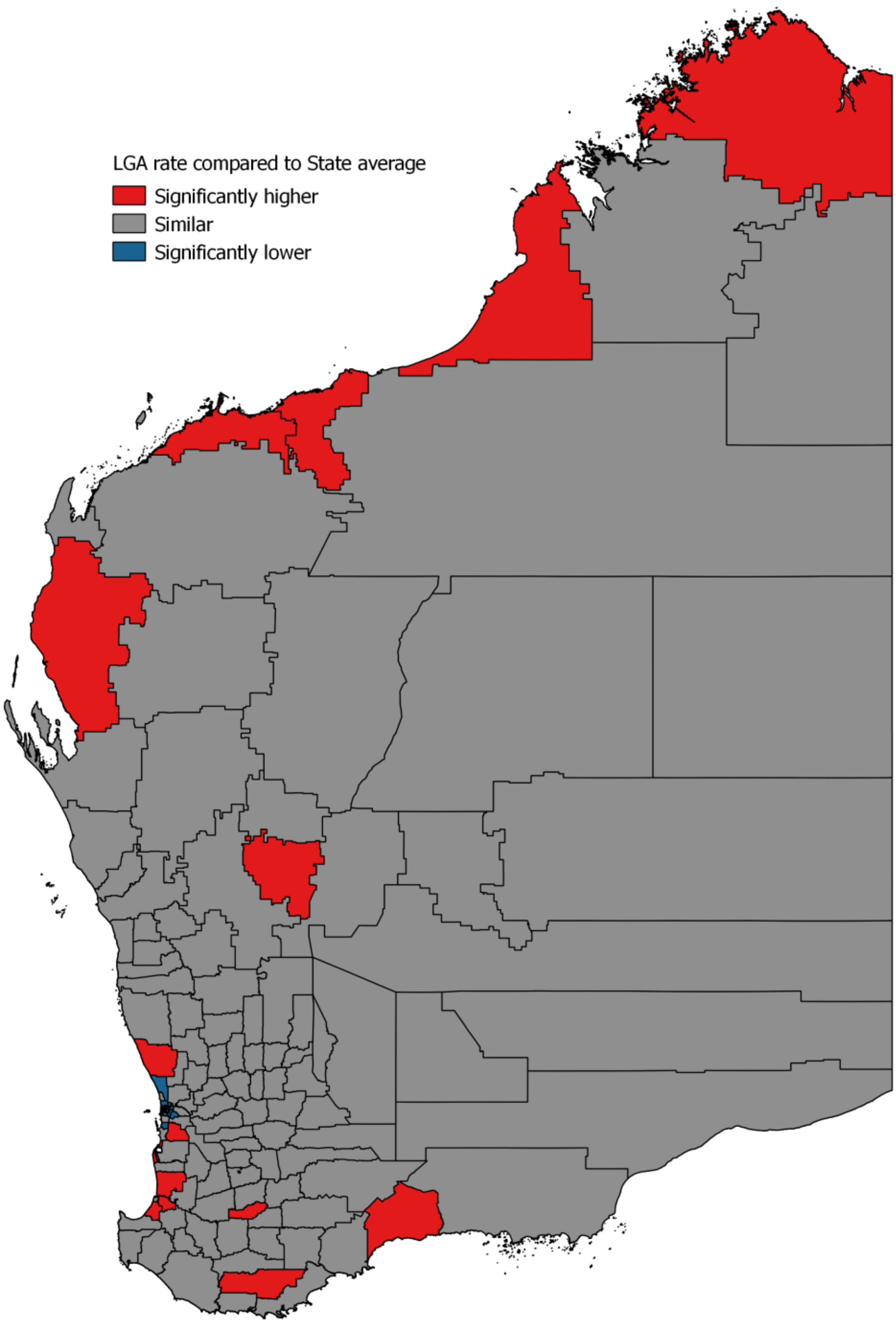



**Figure 4:** Map of WA showing Local Government areas indicating the rate of human cases of RRV per 100,000 population in 2015/16 compared to the State average rate.

### 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 5).

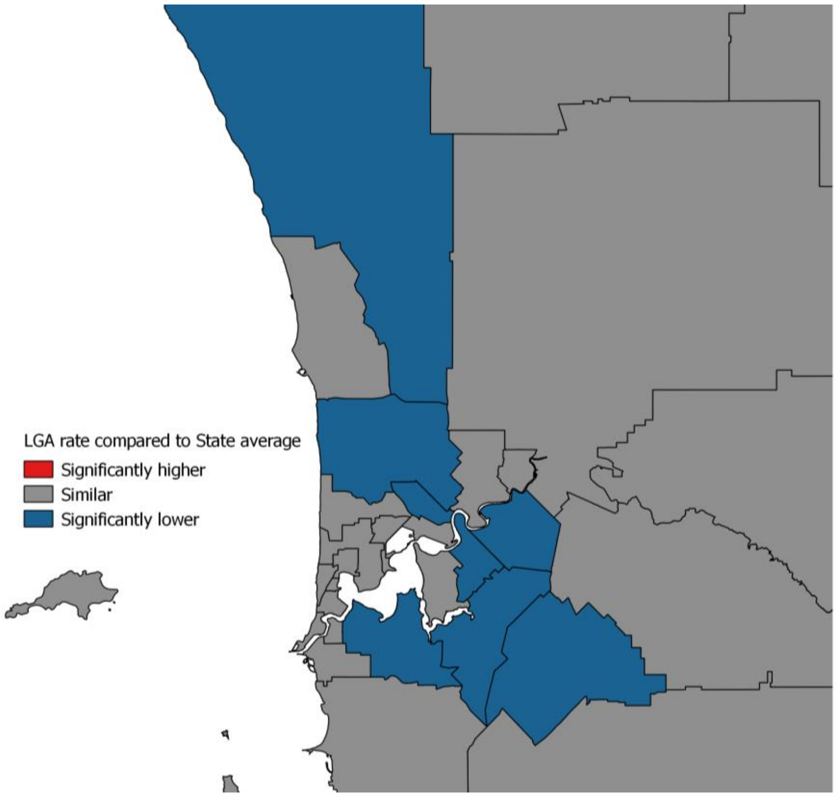



**Figure 5:** Map of the Perth metropolitan area showing Local Government areas shaded to indicate the rate of human cases of RRV per 100,000 population in 2015/16 compared to the State average rate.

## Barmah Forest virus (BFV)

Barmah Forest virus is the second most common arbovirus causing 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 29 human cases of BFV were notified in WA for 2015/16. The number of cases reported during July, October and December were greater than the monthly average from January 2014; reported numbers were below long term average for all the other months (Figure 6).

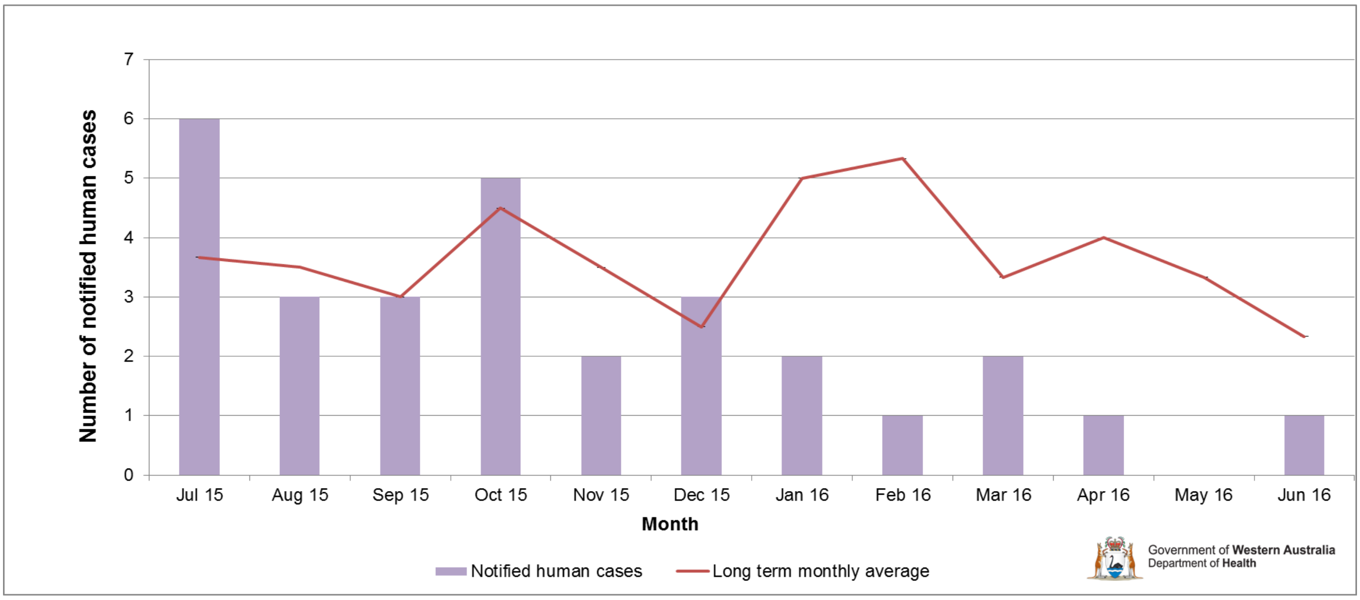



**Figure 6:** The total number of monthly notified human cases of BFV across WA from July 2015 to June 2016*.

**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 the monthly average is calculated only from January 2014 onwards.

## Age and sex distribution

Similar to RRV cases, BFV cases were most frequently reported in middle aged adults (median 47 years, range 10 – 79 years). Age and sex specific case numbers were highest among males aged 45 – 49 years, females aged 20 – 24 years (Figure 7).

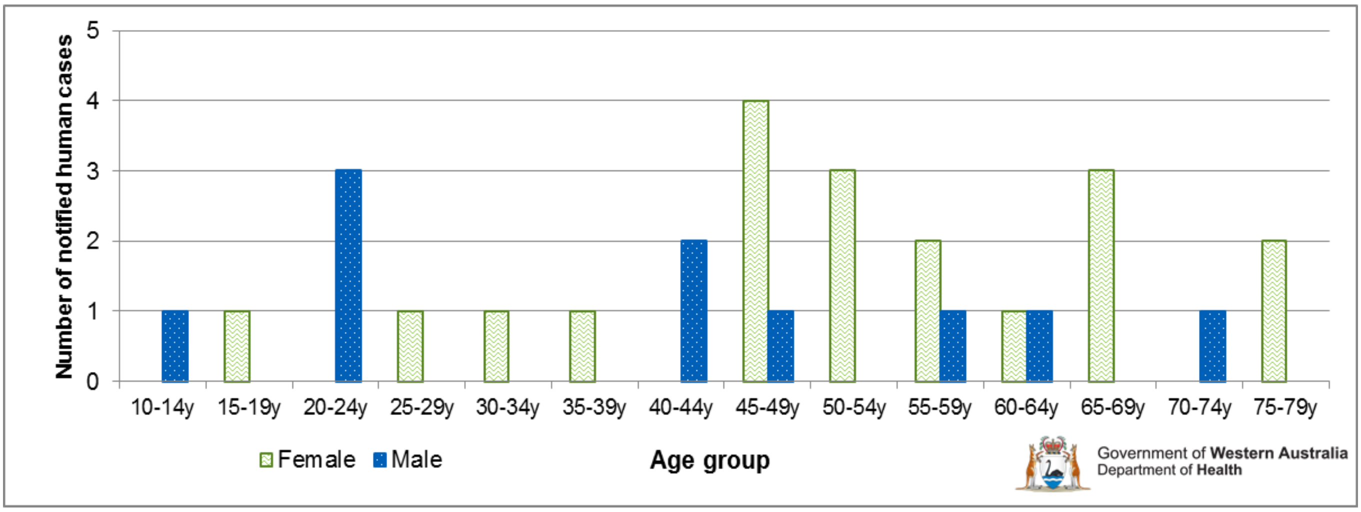



**Figure 7:** The total number of notified human cases of BFV across WA, by age group and sex from July 2015 to June 2016*.

**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 notified cases of BFV disease occurred in the Kimberley region, which also had the highest age standardised rates of 20.4 of BFV disease per 100,000 population (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 2015 to June 2016. 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 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 8 | 20.5 | 20.4 |
| Pilbara | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 3.0 | 2.2 |
| Gascoyne | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10.0 | 7.8 |
| Midwest | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 | 0.0 |
| Wheatbelt | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4.4 | 3.8 |
| Metro | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 4 | 0.2 | 0.2 |
| Southwest | 3 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1.4 | |
| *Peel* | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1.2 | 1.2 |
| *Leschenault* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1.3 | 1.1 |
| *Geographe* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1.9 | 2.0 |
| *Elsewhere SW* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2.2 | 2.2 |
| Great Southern | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1.7 | 1.2 |
| Goldfields-Esperance | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 6.5 | 6.6 |
| WA undetermined | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Interstate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| **WA Total (Does Not Include Interstate)** | **6** | **3** | **3** | **5** | **2** | **3** | **2** | **1** | **2** | **1** | **0** | **1** | **29** | | |

## Murray Valley encephalitis (MVE)

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

Approximately one person in a thousand people will develop disease symptoms after being bitten by a MVEV-carrying mosquito. 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 Department of Health (DoH) during 2015/16 (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 2010/11.

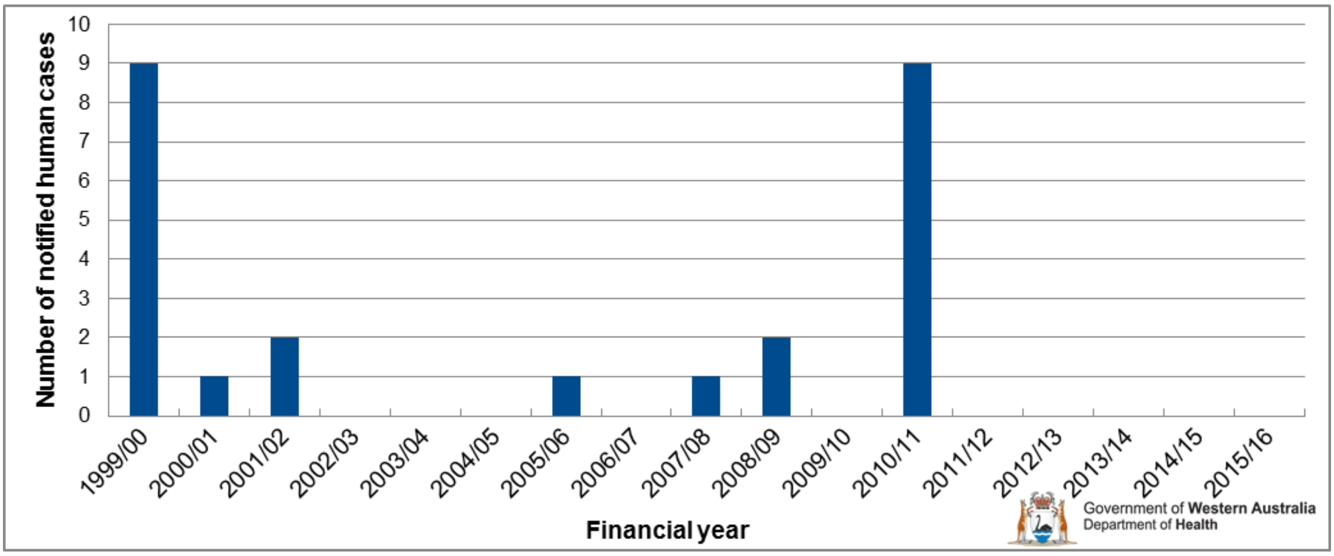



**Figure 8:** The number of notified human cases of MVE disease occurring in WA since 1999/00.

## 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 2015/16. The last known case of Kunjin disease in WA was reported in 2006 (Figure 9).

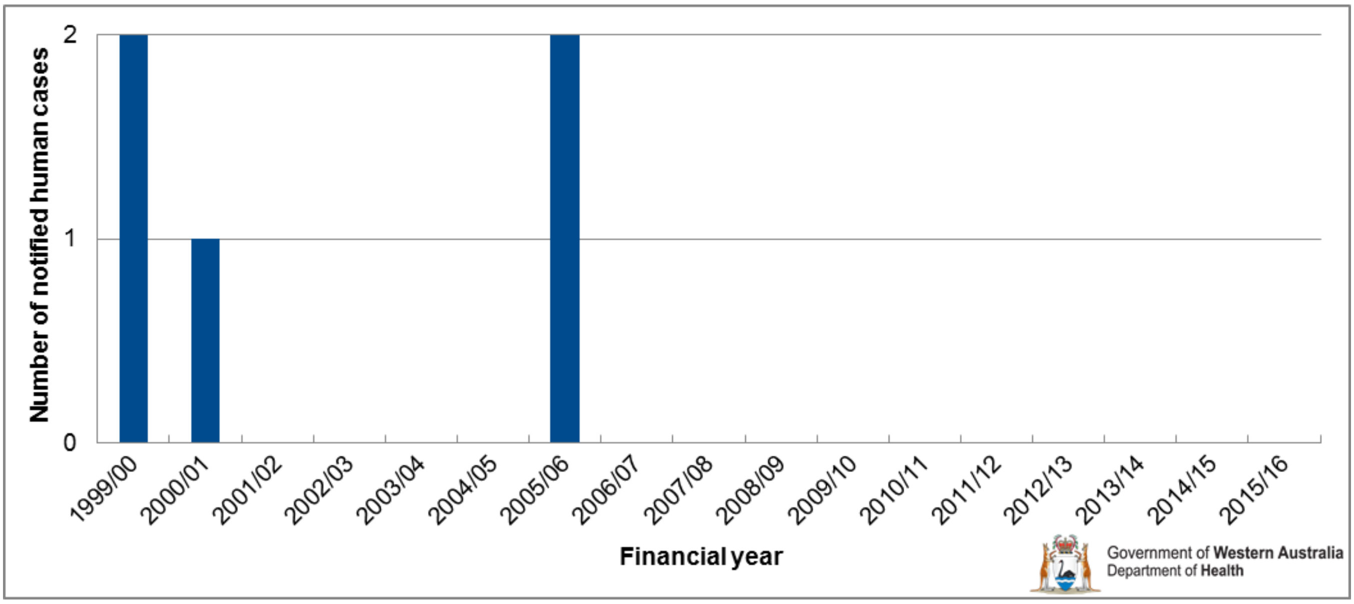



**Figure 9:** The number of notified human cases of Kunjin disease in WA since 1999/00.

# Exotic Mosquito-Borne Diseases

A number of mosquito-borne diseases are 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 DOH, 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 and chikungunya. 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. There is currently no vaccine available. Dengue is spread 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 2015/16 was 498. All cases reported during 2015/16 were acquired overseas.

The number of dengue cases acquired from overseas has increased in recent years. This is likely 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.

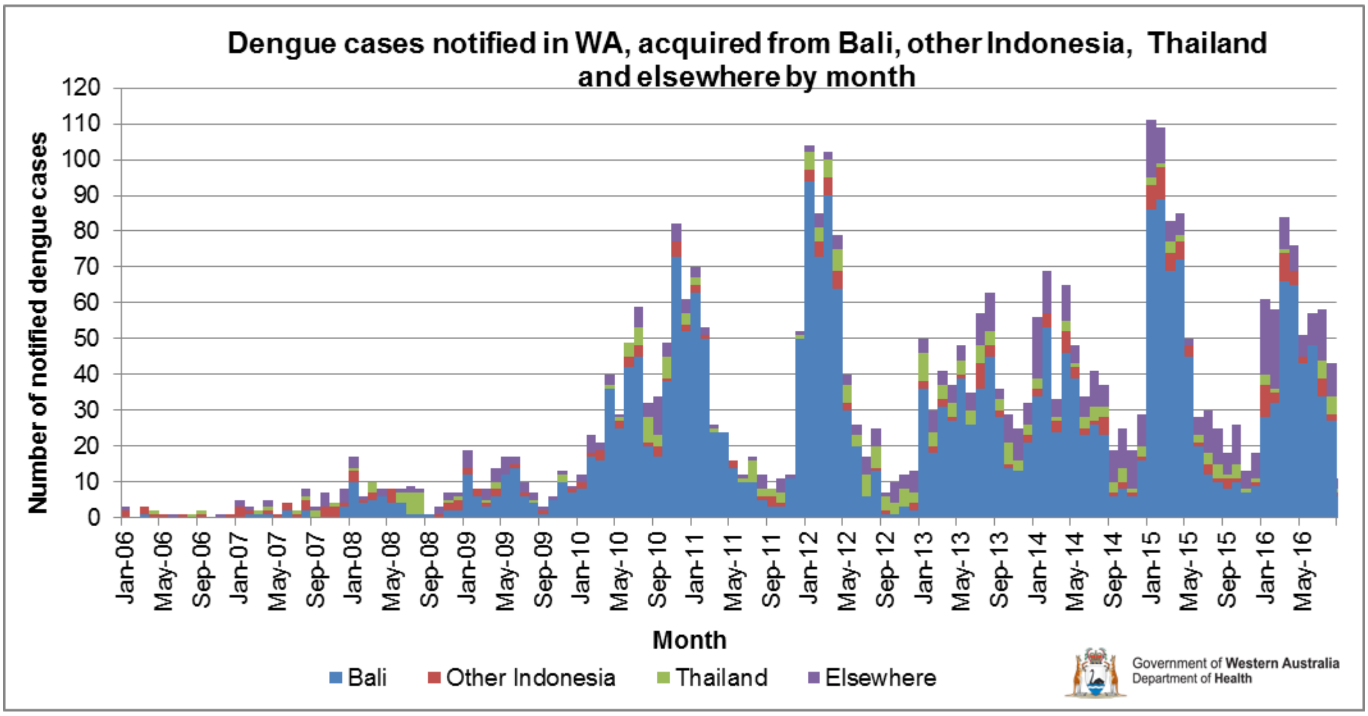



**Figure 10:** Monthly total number of notified cases of dengue reported in WA but acquired from overseas travel.

## 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 6 cases of chikungunya was notified in WA during 2015/16 (Figure 11), which represents a decrease in cases entering WA from overseas locations compared to the previous two years.

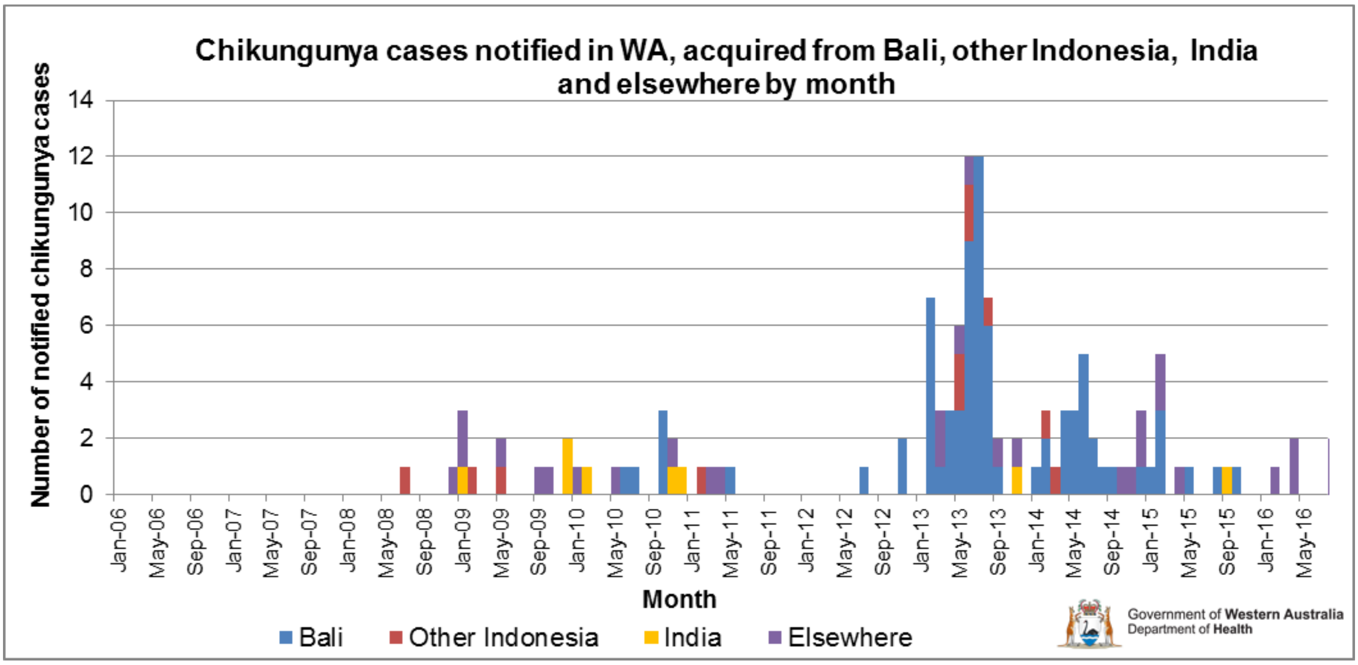



**Figure 11:** Monthly total number of human notifications of chikungunya reported in WA but acquired from overseas locations.

## 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.

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 2015/16 was 56 (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). Regardless, Africa remains the highest risk area for exposure to malaria.

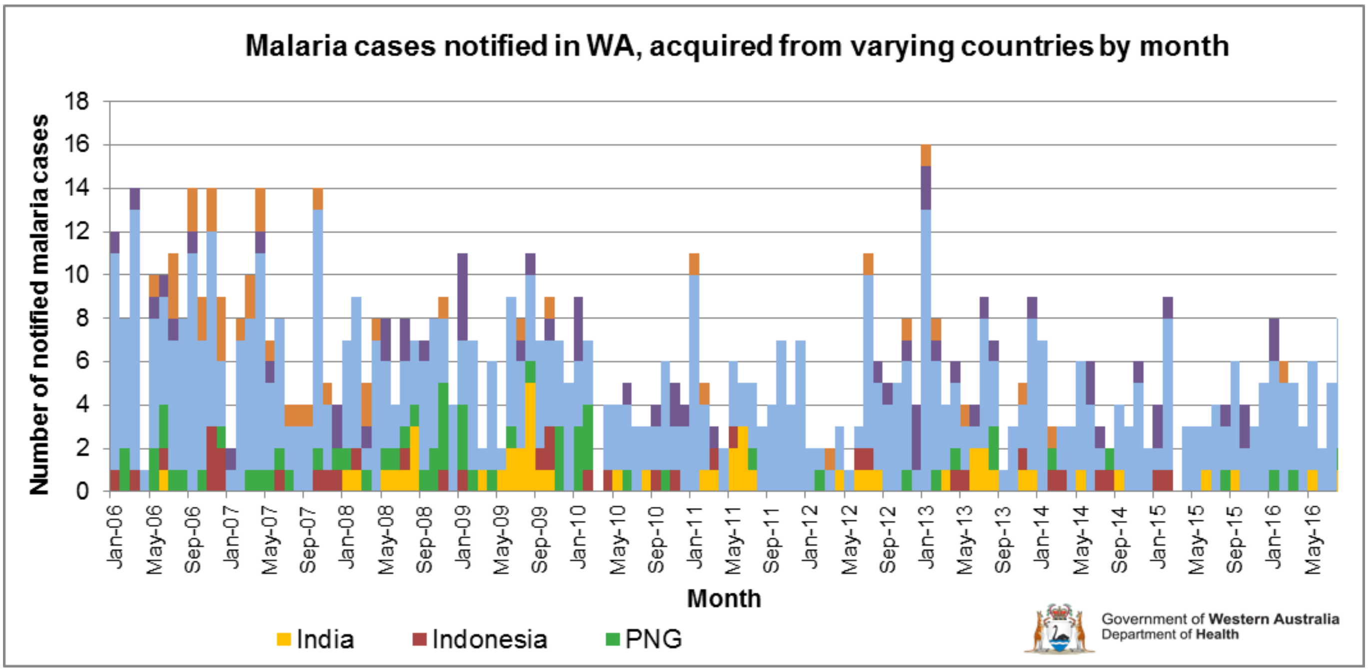



**Figure 12:** Monthly total number of notifications of Malaria reported in WA but acquired from overseas locations.

## ZIka

Zika virus infection causes an illness known as Zika virus disease which shows symptoms such as a mild fever, rash, conjunctivitis and muscle or joint pain. Research suggests that Zika virus infection in women during the first trimester of pregnancy may also be linked to abnormal foetal brain development, known as microcephaly, which can result in permanent brain damage to the unborn baby.

Since 1947, Zika virus activity was limited to parts of Africa, with occasional small outbreaks in Asia. However, it has recently spread to the Pacific Ocean, Central America, the Caribbean and South America. Due to this recent spread, Zika virus cases were started to be diagnosed in WA recently (Figure 13).

Six overseas acquired cases of Zika virus disease were reported in WA in 2015/16.

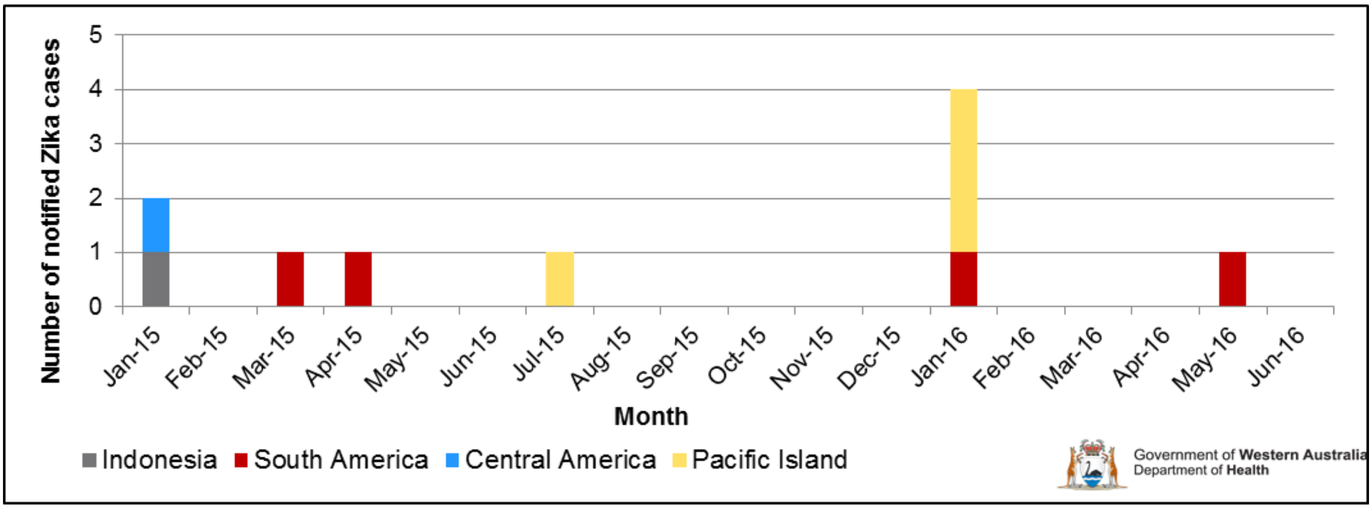



**Figure 13:** Monthly total number of notifications of Zika virus disease reported in WA but acquired from overseas locations.

# Climatic Conditions 2015/16

## 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. In the 2015/16 financial year, WA experienced strong El Niño conditions, which was associated with decreased rainfall and tidal activity over spring and summer months. These resulted in reduced populations of mosquitoes in WA.

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 presence of El Niño conditions during 2015/16 (Figure 14*) was associated a reduction in mosquito breeding. The Figure 14 shows the presence of strong El Niño levels during July to mid-October, mid-December to mid-February and mid-March to mid-April periods.

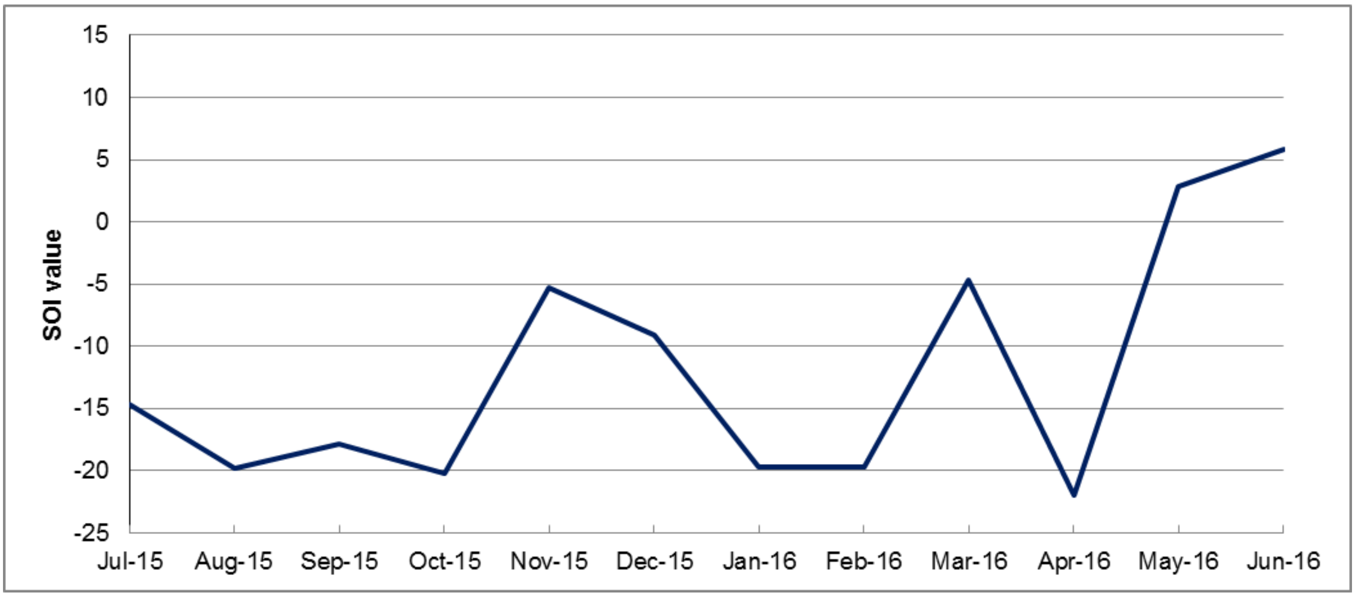



**Figure 14:** Southern Oscillation Index values (SOI) for the 2015/16 financial year. (source: Commonwealth Bureau of Meteorology)

*Sustained positive values of the SOI above +7 typically indicate La Niña while sustained negative values below −7 typically indicate El Niño. Values between about +7 and −7 generally indicate neutral conditions.

The collection of ENSO prediction models indicates near borderline La Niña level during summer 2016, then weakening to neutral in January 2017. (Figure 15).

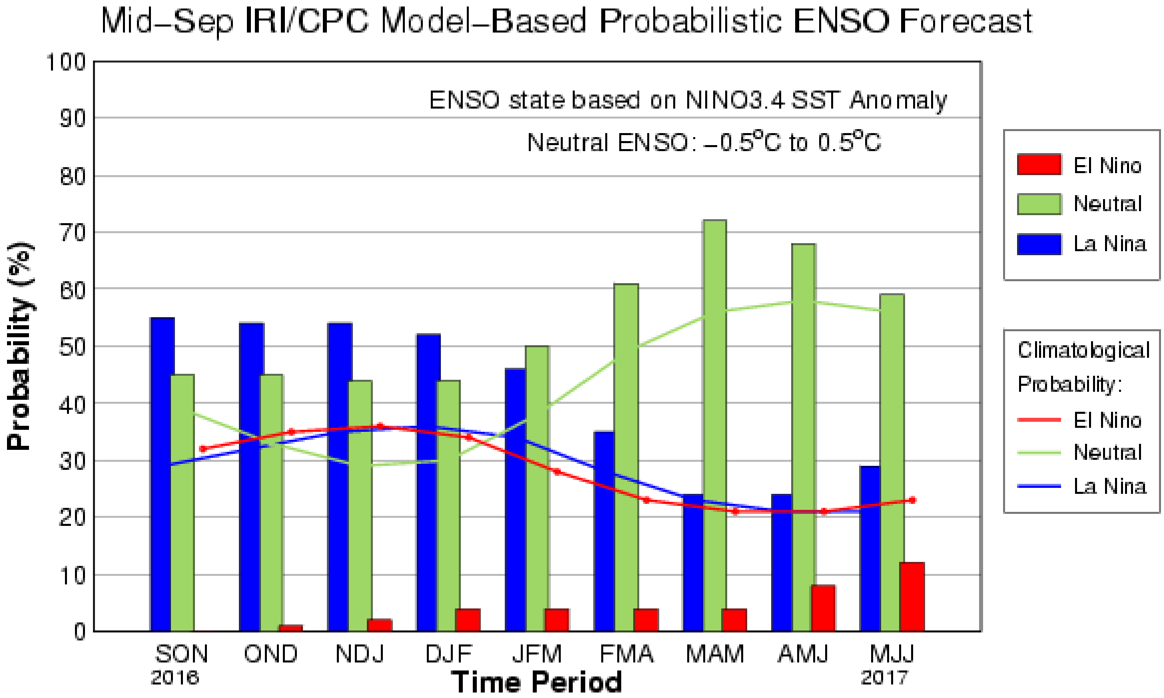
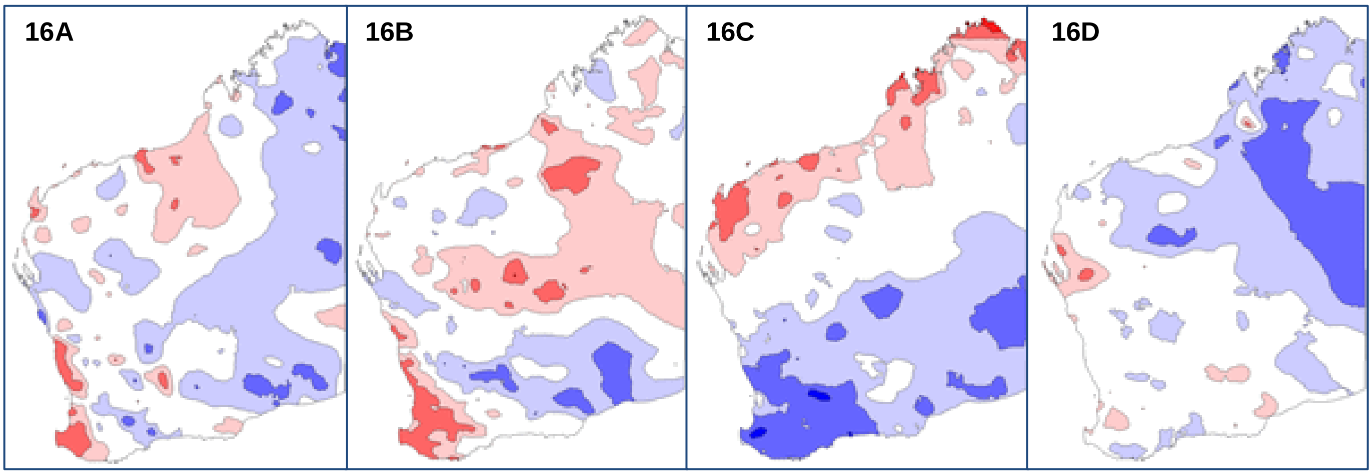
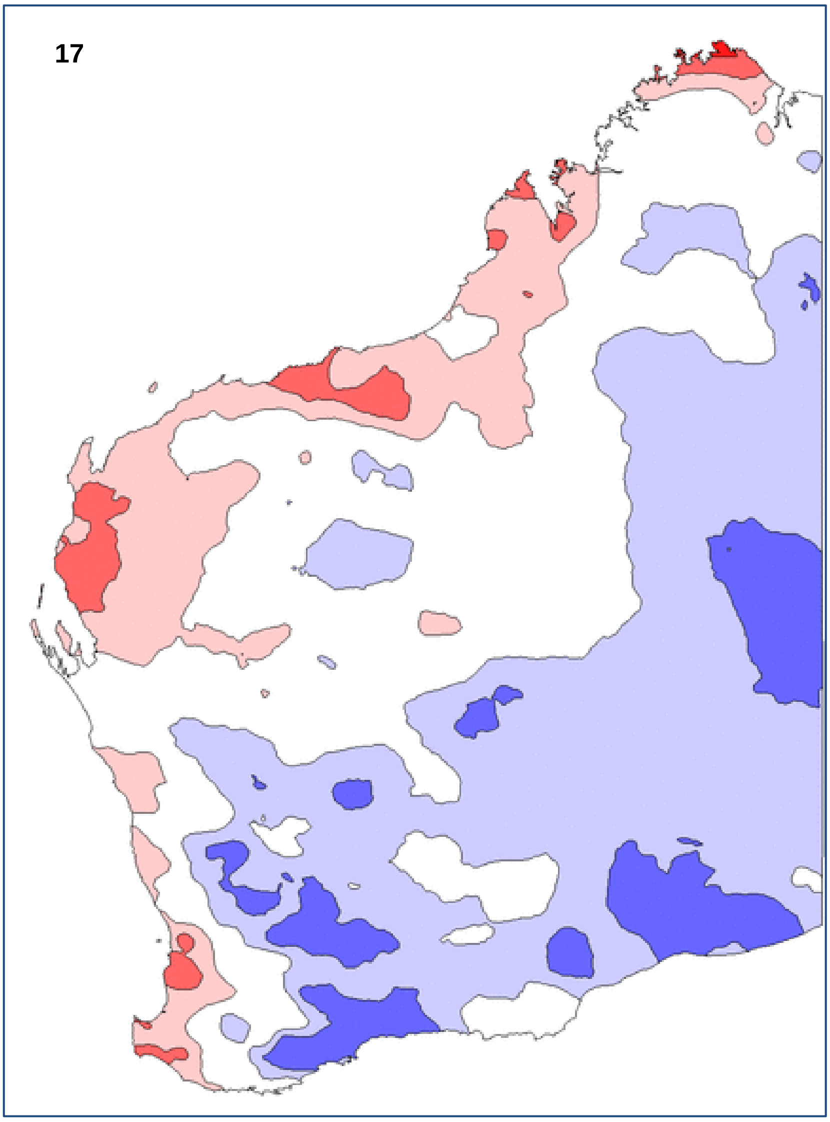



**Figure 15:** Probabilistic El Niño, La Niña and Southern Oscillation (ENSO) forecast for mid-September 2016 to May 2017. Courtesy of International Research Institute for Climate and Society, Earth Institute, Columbia University, U.S.

## Rainfall

Rainfall was average to very much above average for majority of the interior parts of WA. However, south-western and northern coastal parts of WA received below or very much below average rainfall for 2015/16 (Figures 16-17).



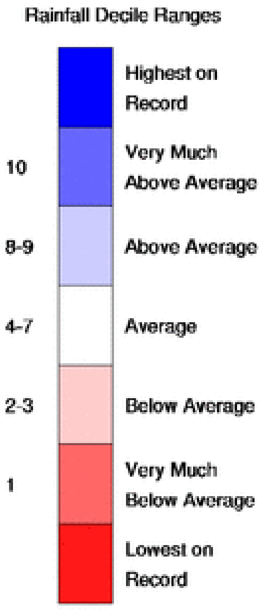



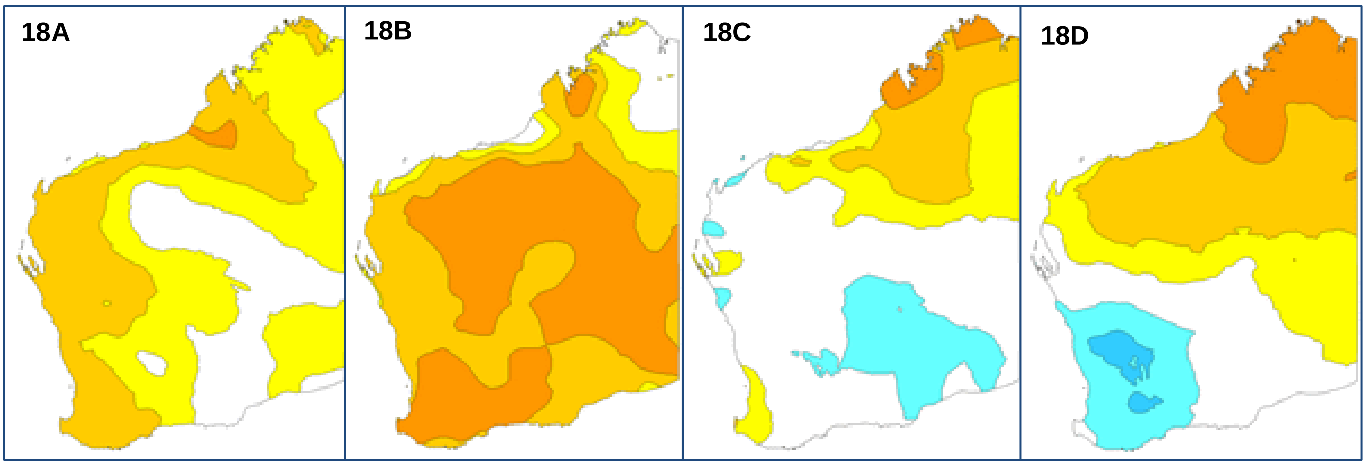

**Figure 16 A-D:** Three-monthly summary of Western Australian rainfall deciles. A: July-September 2015; B: October-December 2015; C: January-March 2016; D: April-June 2016 (source: Commonwealth Bureau of Meteorology).

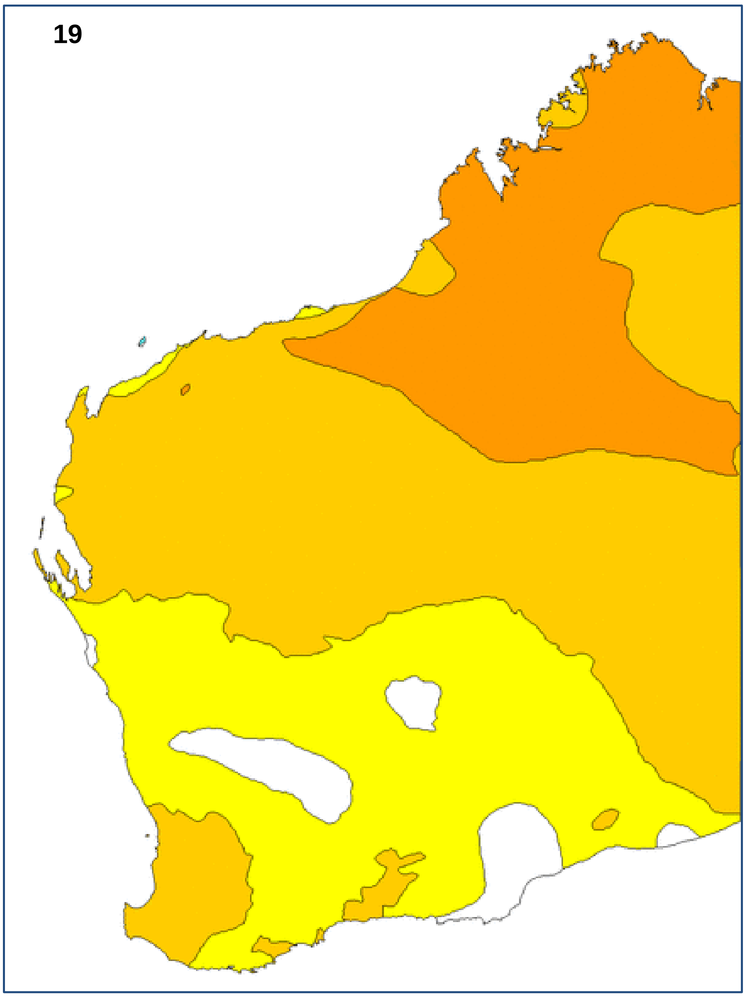
**Figure 17:** Western Australian Rainfall deciles for July 2015-June 2016 (source: Commonwealth Bureau of Meteorology).

## Temperature

### Maximum Temperature

Maximum temperatures were above average for the southern coastal third of the State; very much above average in the Pilbara and interior and highest on record for the Kimberley and north of the State (Figures 18-19).



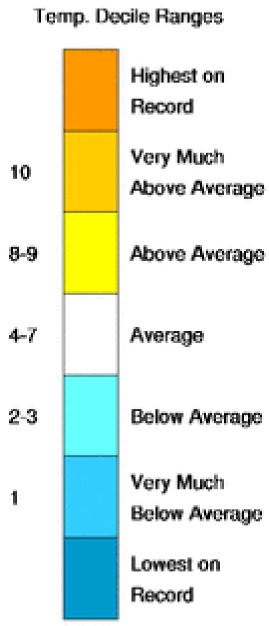



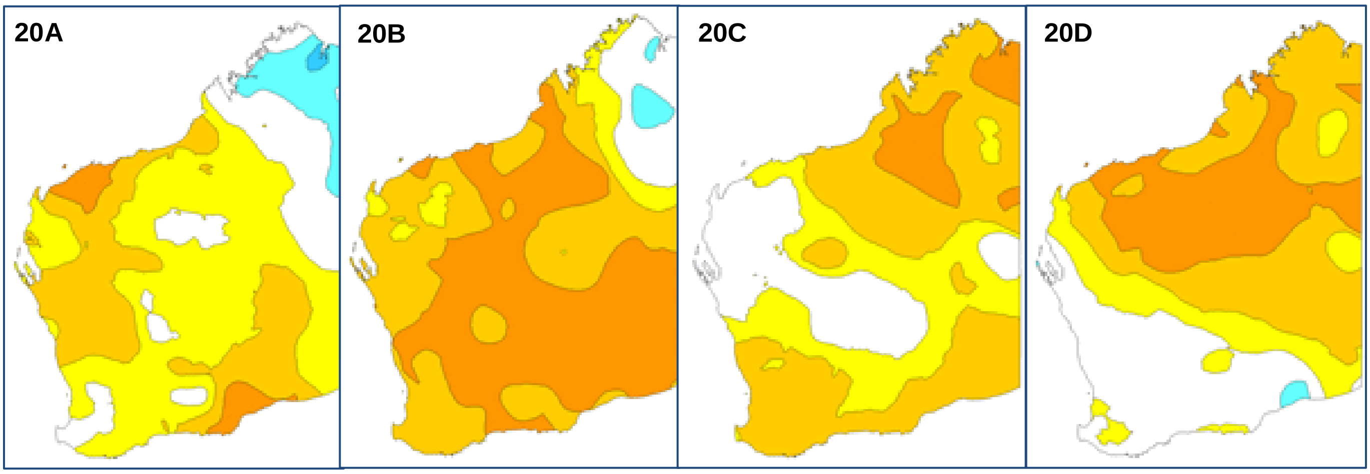

**Figure 18 A-D:** Three-monthly summaries of Western Australian maximum temperature deciles. A: July-September 2015; B: October-December 2015; C: January-March 2016; D: April-June 2016 (source: Commonwealth Bureau of Meteorology).

**Figure 19:** Western Australian maximum temperature deciles for July 2015-June 2016 (source: Commonwealth Bureau of Meteorology).

## Minimum Temperature

Minimum temperatures were also very much above average across most of WA over 2015/16. (Figure 20 and 21).

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.



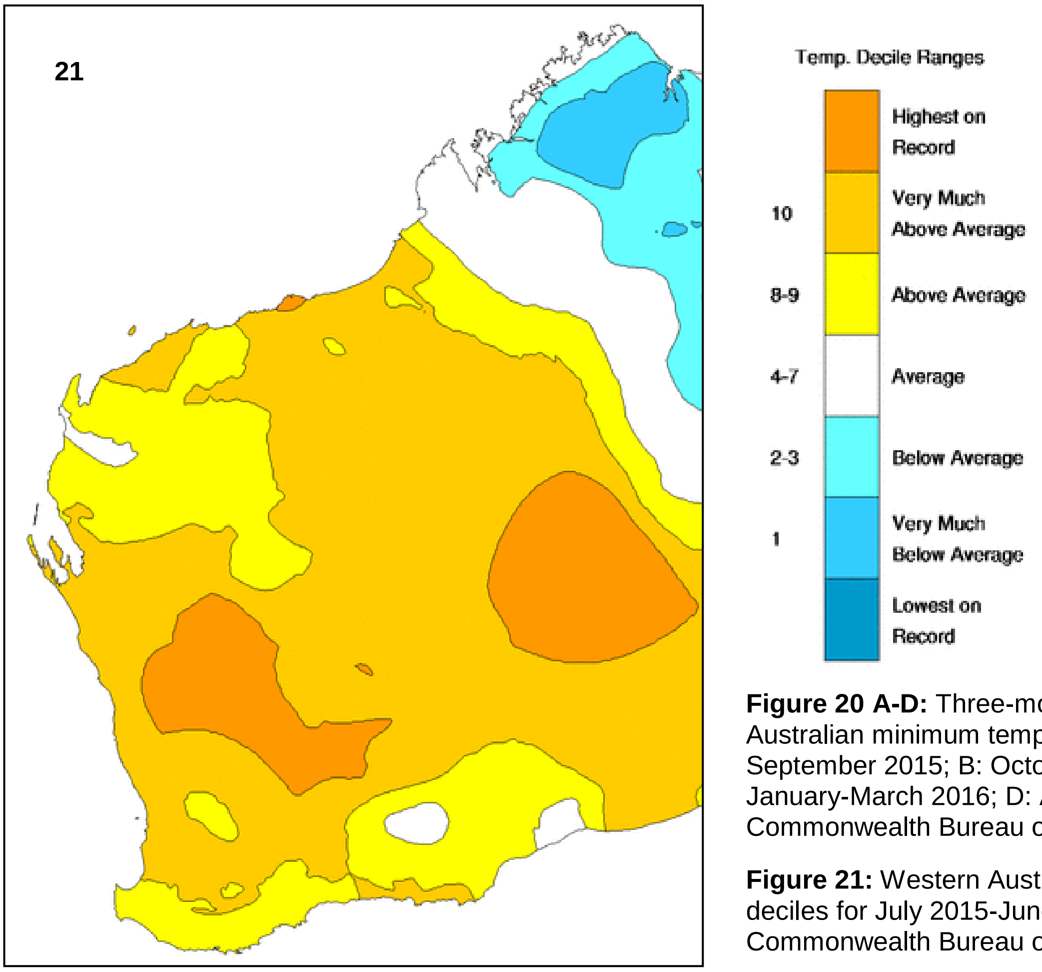




**Figure 20 A-D:** Three-monthly summaries of Western Australian minimum temperature deciles. A: July-September 2015; B: October-December 2015; C: January-March 2016; D: April-June 2016 (source: Commonwealth Bureau of Meteorology).

**Figure 21:** Western Australian minimum temperature deciles for July 2015-June 2016 (source: Commonwealth Bureau of Meteorology).

## 2015/16 Australian Tropical Cyclone Season Summary

Tropical cyclone Stan was the only cyclone that impacted on WA for the 2015/16 financial year.

### Tropical Cyclone Stan

Tropical Cyclone Stan was the first tropical cyclone to develop over Australian waters during 2015/16 (Figure 22). Heavy rainfall associated with Tropical Cyclone Stan was recorded in the Gascoyne River, Fortescue River and the De Grey River catchments. The highest 24 hour rainfall was recorded at Nullagine with a total of 97 mm, 50 mm of this was recorded within 1 hour. This heavy rainfall resulted in moderate to major flooding in the upper areas of the De Grey River catchment including the Oakover River, the Coongan River and the Nullagine River. Although Tropical Cyclone Stan brought heavy rainfall, it did not affect the number of mosquito-borne disease cases reported in the region.

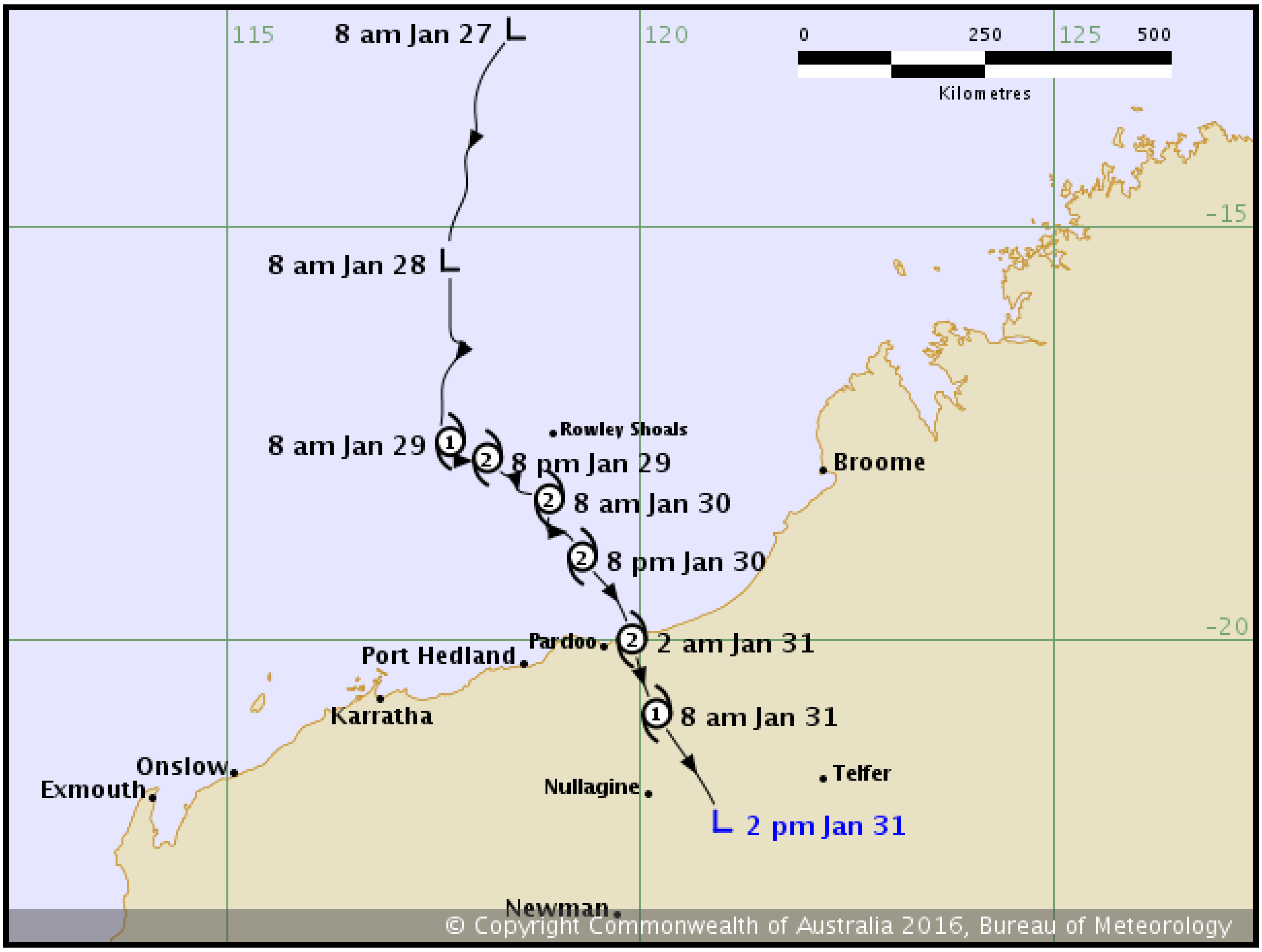



**Figure 22:** Documented path of Tropical Cyclone Stan National Climate Centre, Commonwealth of Australia, Bureau of Meteorology.

# Mosquito-borne Disease Surveillance Programs

## Southwest Arbovirus Surveillance Program

Outbreaks of RRV and BFV occur in the Southwest region every three to four years. The DoH undertakes regular arbovirus 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 El Niño conditions contributed to well below average mosquito abundance across the Southwest, with some of the lowest mosquito collections across the region since the 1999/00 season (Figure 23). The dominant species collected were *Aedes camptorynchus* and *Ae. notoscriptus* (Table 3-7). High numbers of *Ae. vigilax* are usually observed from December onward, however this did not occur during the 2015/16 summer due to the reduction in the frequency of tides and lack of inundation of low lying land along the wetlands during the warmest summer months (Figure 24).

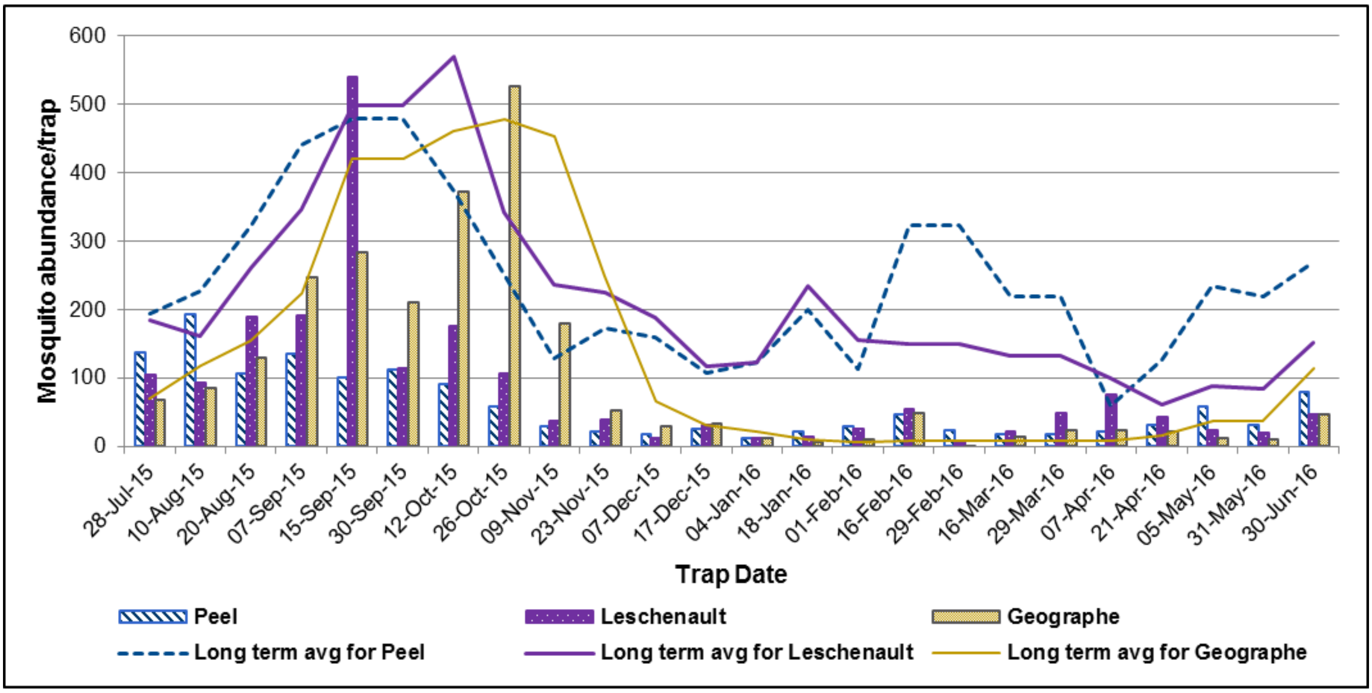



**Figure 23:** Mosquito abundance in Peel, Leschenault and Geographe in Southwest region of WA from July 2014 to June 2015.

For this season, a total of 39,691 mosquitoes were collected from fortnightly trapping at 21 sites across the Southwest of Western Australia (Table 3-7). In 2015/16 year there were 505 traps were set in Southwest. Out of 505 traps 447 traps were successful (88%).

Ross River virus was only detected at one of 21 routine surveillance sites in the Southwest of WA, with ten real-time RT-PCR detections of RRV from Point Douro on the 4th April 2016 from pools of *Ae. alboannulatus* (1), *Ae. camptorhynchus* (1), *Ae. vigilax* (6), *Culex annulirostris* (1) and *Cx. globocoxitus* (1). No BFV was detected from any of the routine surveillance sites in the Southwest during 2015/16 (table 5).

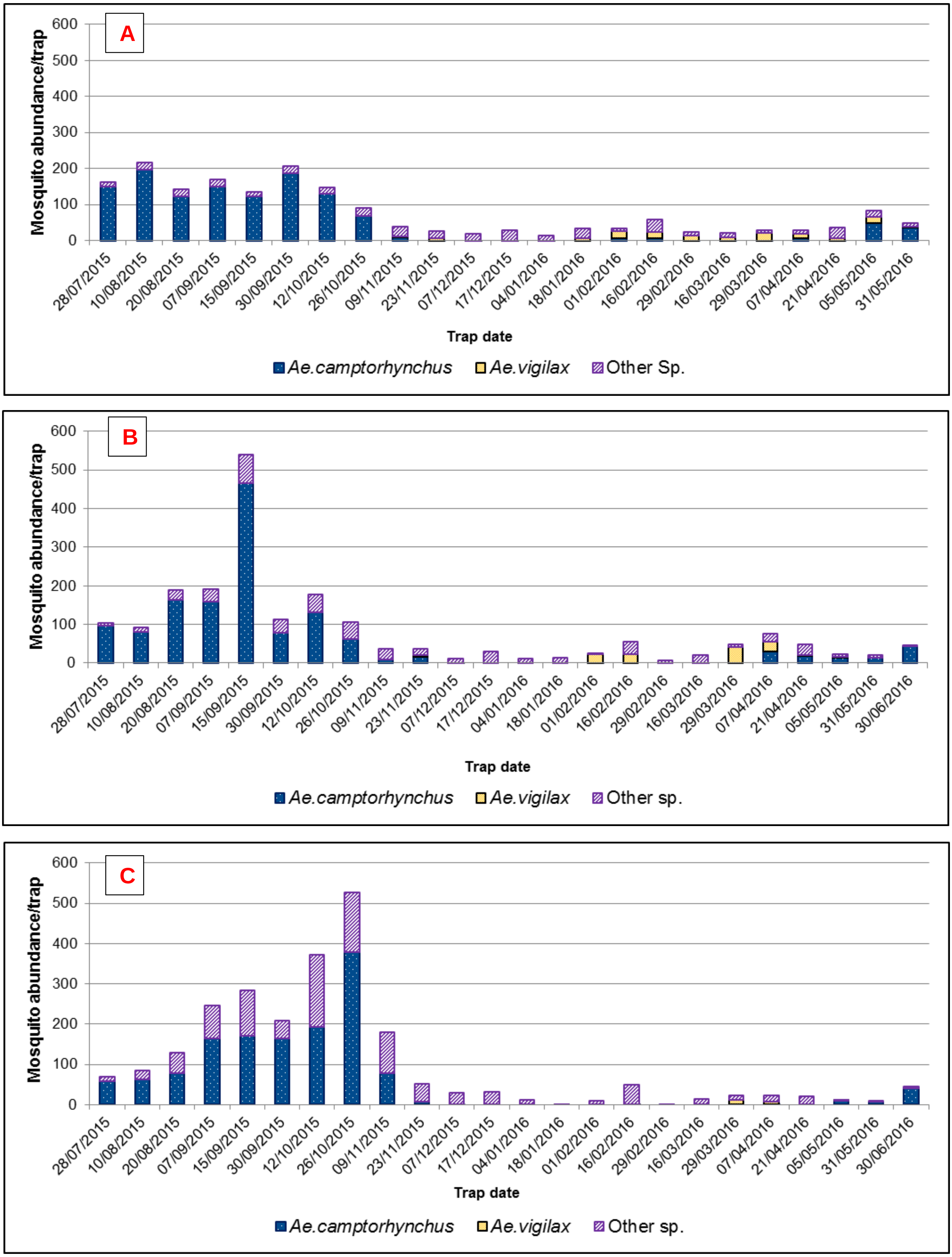



**Figure 24:** Proportion of *Ae camptorhynchus, Ae vigilax* and all other species for **A**: Peel **B**: Leschenault and **C**: Geographe regions of WA from July 2014 to June 2015

**Table 3:** Details of mosquitoes collected and processed for virus isolation, Peel inlet, southwest of Western Australia, 1 July 2015 to 30 June 2016.

| Species | Class | Total | % | Processed | Pools | Pinned |
|---|---|---|---|---|---|---|
| *Ae. (Finlaya) alboannulatus* | Female | 198 | 1.74 | 185 | 59 | 0 |
| *Ae. (Finlaya) notoscriptus* | Bloodfed | 2 | 0.02 | 0 | 0 | 0 |
| *Ae. (Finlaya) notoscriptus* | Female | 1717 | 15.10 | 1641 | 160 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Bloodfed | 44 | 0.39 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Female | 7470 | 65.70 | 6940 | 413 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* variant | Female | 32 | 0.28 | 32 | 2 | 0 |
| *Ae. (Ochlerotatus) vigilax* | Bloodfed | 11 | 0.10 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) vigilax* | Female | 646 | 5.68 | 646 | 76 | 0 |
| *Ae.* species (unidentified) - new or difficult to ID species | Male | 4 | <0.1 | 4 | 3 | 0 |
| *An. (Cellia) annulipes s.l.* | Female | 51 | 0.45 | 51 | 27 | 0 |
| *An. (Cellia) annulipes s.l.* | Male | 1 | <0.1 | 1 | 1 | 0 |
| *Cq. (Coquillettidia)* species near *linealis* | Female | 3 | <0.1 | 2 | 2 | 0 |
| *Cs. (Culicella) atra* | Female | 5 | <0.1 | 5 | 5 | 0 |
| *Cx. (Culex) annulirostris* | Female | 33 | 0.29 | 32 | 18 | 0 |
| *Cx. (Culex) australicus* | Bloodfed | 1 | 0.01 | 0 | 0 | 0 |
| *Cx. (Culex) australicus* | Female | 210 | 1.85 | 200 | 55 | 0 |
| *Cx. (Culex) globocoxitus* | Female | 541 | 4.76 | 518 | 73 | 0 |
| *Cx. (Culex) quinquefasciatus* | Bloodfed | 1 | <0.1 | 0 | 0 | 0 |
| *Cx. (Culex) quinquefasciatus* | Female | 299 | 2.63 | 289 | 77 | 0 |
| *Cx.* species (unidentified) - new or difficult to ID species | Male | 76 | 0.67 | 76 | 24 | 0 |
| *Tripteroides (Polylepidomyia) atripes* | Female | 10 | <0.1 | 8 | 4 | 0 |
| Unidentifiable *Aedes* 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 | 11 | 0.10 | 11 | 7 | 0 |
| **Total** | | **11369** | **100** | **10643** | **1008** | **0** |

**Table 4:** Details of mosquitoes collected and processed for virus isolation, Harvey Estuary sites, southwest of Western Australia, 1 July 2015 to 30 June 2016.

| Species | Class | Total | % | Processed | Pools | Pinned |
|---|---|---|---|---|---|---|
| *Ae. (Finlaya) alboannulatus* | Bloodfed | 4 | 0.10 | 0 | 0 | 0 |
| *Ae. (Finlaya) alboannulatus* | Female | 68 | 1.75 | 64 | 14 | 0 |
| *Ae. (Finlaya) notoscriptus* | Female | 108 | 2.78 | 104 | 29 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Bloodfed | 54 | 1.39 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Female | 3272 | 84.11 | 2952 | 169 | 0 |
| *Ae. (Ochlerotatus) ratcliffei* | Female | 1 | <0.1 | 1 | 1 | 0 |
| *Ae. (Ochlerotatus) vigilax* | Bloodfed | 3 | <0.1 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) vigilax* | Female | 303 | 7.79 | 303 | 25 | 0 |
| *An. (Cellia) annulipes s.l.* | Female | 37 | 0.95 | 37 | 13 | 0 |
| *Cq. (Coquillettidia)* species near *linealis* | Female | 12 | 0.31 | 12 | 7 | 0 |
| *Cs. (Culicella) atra* | Female | 1 | <0.1 | 1 | 1 | 0 |
| *Cx. (Culex) annulirostris* | Female | 9 | 0.23 | 9 | 8 | 0 |
| *Cx. (Culex) australicus* | Female | 8 | 0.21 | 8 | 6 | 0 |
| *Cx. (Culex) globocoxitus* | Female | 9 | 0.23 | 9 | 6 | 0 |
| *Cx. (Culex) quinquefasciatus* | Female | 1 | <0.1 | 1 | 1 | 0 |
| **Total** | | **3890** | **100** | **3501** | **280** | **0** |

**Table 5:** Details of mosquitoes collected and processed for virus isolation, Leschenault, southwest of Western Australia, 1 July 2015 to 30 June 2016.[1]

| Species | Class | Total | % | Processed | Pools | Pinned | RRV | (MIR) |
|---|---|---|---|---|---|---|---|---|
| *Ae. (Finlaya) alboannulatus* | Bloodfed | 8 | <0.1 | 0 | 0 | 0 | | |
| *Ae. (Finlaya) alboannulatus* | Female | 343 | 3.28 | 324 | 63 | 0 | 1 | 3.09 |
| *Ae. (Finlaya) alboannulatus* | Male | 1 | <0.1 | 1 | 1 | 0 | | |
| *Ae. (Finlaya) notoscriptus* | Bloodfed | 1 | <0.1 | 0 | 0 | 0 | | |
| *Ae. (Finlaya) notoscriptus* | Female | 530 | 5.07 | 516 | 65 | 0 | | |
| *Ae*. (*Macleaya*) E.N. Marks' species No. 147 | Female | 1 | <0.1 | 0 | 0 | 0 | | |
| *Ae. (Ochlerotatus) camptorhynchus* | Bloodfed | 60 | 0.57 | 0 | 0 | 0 | | |
| *Ae. (Ochlerotatus) camptorhynchus* | Female | 7123 | 68.15 | 6057 | 358 | 0 | 1 | 0.17 |
| *Ae. (Ochlerotatus) camptorhynchus* | Male | 1 | <0.1 | 1 | 1 | 0 | | |
| *Ae. (Ochlerotatus) clelandi* | Bloodfed | 2 | <0.1 | 0 | 0 | 0 | | |
| *Ae. (Ochlerotatus) clelandi* | Female | 209 | 2.00 | 208 | 16 | 0 | | |
| *Ae. (Ochlerotatus) hesperonotius* | Female | 252 | 2.41 | 202 | 13 | 0 | | |
| *Ae. (Ochlerotatus) nigrithorax* | Female | 54 | 0.52 | 40 | 4 | 0 | | |
| *Ae. (Ochlerotatus) ratcliffei* | Female | 13 | 0.12 | 12 | 7 | 1 | | |
| *Ae. (Ochlerotatus) turneri* | Female | 3 | <0.1 | 3 | 1 | 0 | | |
| *Ae. (Ochlerotatus) vigilax* | Bloodfed | 8 | <0.1 | 0 | 0 | 0 | | |
| *Ae. (Ochlerotatus) vigilax* | Female | 676 | 6.47 | 672 | 67 | 0 | 6 | 1.49 |
| *Ae*. species (unidentified) - new or difficult to ID species | Male | 1 | <0.1 | 1 | 1 | 0 | | |
| *An. (Anopheles) atratipes* | Female | 4 | <0.1 | 4 | 4 | 0 | | |
| *An. (Cellia) annulipes* s.l. | Female | 72 | 0.69 | 71 | 35 | 0 | | |
| *Cq*. (*Coquillettidia*) species near *linealis* | Female | 112 | 1.07 | 112 | 29 | 0 | | |
| *Cs. (Culicella) atra* | Female | 68 | 0.65 | 63 | 20 | 1 | | |
| *Cs. (Culicella) atra* | Male | 1 | <0.1 | 1 | 1 | 0 | | |
| *Cx. (Culex) annulirostris* | Bloodfed | 2 | <0.1 | 0 | 0 | 0 | | |
| *Cx. (Culex) annulirostris* | Female | 138 | 1.32 | 138 | 38 | 0 | 1 | 7.25 |
| *Cx. (Culex) australicus* | Bloodfed | 1 | <0.1 | 0 | 0 | 0 | | |
| *Cx. (Culex) australicus* | Female | 229 | 2.19 | 207 | 55 | 0 | | |
| *Cx. (Culex) globocoxitus* | Bloodfed | 2 | <0.1 | 0 | 0 | 0 | | |
| *Cx. (Culex) globocoxitus* | Female | 430 | 4.11 | 405 | 65 | 0 | 1 | 2.47 |
| *Cx. (Culex) quinquefasciatus* | Female | 84 | 0.80 | 78 | 35 | 0 | | |
| *Cx. (Neoculex) latus* | Female | 2 | <0.1 | 1 | 1 | 0 | | |
| *Cx*. species (unidentified) - new or difficult to ID species | Male | 8 | <0.1 | 7 | 5 | 0 | | |
| Unidentifiable *Aedes* sp. (too damaged/features missing) | Female | 3 | <0.1 | 3 | 3 | 0 | | |
| Unidentifiable *Culex* sp. (too damaged/features missing) | Female | 10 | 0.10 | 10 | 8 | 0 | | |
| **Total** | | **10452** | **100** | **9137** | **896** | **2** | **10** | **14.47** |

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

MIR = (Number of Positive pools/Total specimen tested)x1000

**Table 6:** Details of mosquitoes collected and processed for virus isolation, Capel forest sites, southwest of Western Australia, 1 July 2015 to 30 June 2016.

| Species | Class | Total | % | Processed | Pools | Pinned |
|---|---|---|---|---|---|---|
| *Ae. (Finlaya) alboannulatus* | Bloodfed | 2 | <0.1 | 0 | 0 | 0 |
| *Ae. (Finlaya) alboannulatus* | Female | 99 | 1.35 | 76 | 30 | 0 |
| *Ae. (Finlaya) notoscriptus* | Female | 116 | 1.58 | 106 | 25 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Bloodfed | 51 | 0.69 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Female | 6133 | 83.34 | 4970 | 270 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Male | 1 | <0.1 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) clelandi* | Female | 2 | 0.03 | 2 | 2 | 0 |
| *Ae. (Ochlerotatus) hesperonotius* | Female | 1 | <0.1 | 1 | 1 | 0 |
| *Ae. (Ochlerotatus) ratcliffei* | Bloodfed | 1 | <0.1 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) ratcliffei* | Female | 97 | 1.32 | 58 | 5 | 0 |
| *Ae. (Ochlerotatus) turneri* | Female | 3 | <0.1 | 2 | 2 | 0 |
| *Ae. (Ochlerotatus) vigilax* | Bloodfed | 1 | <0.1 | 0 | 0 | 0 |
| *An. (Cellia) annulipes s.l.* | Female | 377 | 5.12 | 337 | 37 | 0 |
| *An. (Cellia) annulipes s.l.* | Male | 1 | <0.1 | 1 | 1 | 0 |
| *An.* species (unidentified) - new or difficult to ID species | Male | 7 | 0.10 | 7 | 2 | 0 |
| *Cq. (Coquillettidia)* species near *linealis* | Female | 20 | 0.27 | 19 | 12 | 0 |
| *Cs. (Culicella) atra* | Female | 36 | 0.49 | 24 | 9 | 0 |
| *Cx. (Culex) annulirostris* | Bloodfed | 2 | <0.1 | 0 | 0 | 0 |
| *Cx. (Culex) annulirostris* | Female | 97 | 1.32 | 97 | 25 | 0 |
| *Cx. (Culex) australicus* | Female | 83 | 1.13 | 77 | 28 | 0 |
| *Cx. (Culex) globocoxitus* | Female | 204 | 2.77 | 177 | 39 | 0 |
| *Cx. (Culex) quinquefasciatus* | Female | 17 | 0.23 | 14 | 9 | 0 |
| *Cx.* species (unidentified) - new or difficult to ID species | Male | 3 | <0.1 | 3 | 3 | 0 |
| Unidentifiable *Aedes* sp. (too damaged/features missing) | Female | 1 | <0.1 | 0 | 0 | 0 |
| Unidentifiable *Culex* sp. (too damaged/features missing) | Female | 4 | <0.1 | 4 | 3 | 0 |
| **Total** | | **7359** | **100** | **5976** | **503** | **0** |

**Table 7:** Details of mosquitoes collected and processed for virus isolation, Busselton wetlands sites, southwest of Western Australia, 1 July 2015 to 30 June 2016.

| Species | Class | Total | % | Processed | Pools | Pinned |
|---|---|---|---|---|---|---|
| *Ae. (Finlaya) alboannulatus* | Bloodfed | 14 | 0.21 | 0 | 0 | 0 |
| *Ae. (Finlaya) alboannulatus* | Female | 321 | 4.85 | 320 | 44 | 0 |
| *Ae. (Finlaya) notoscriptus* | Bloodfed | 4 | <0.1 | 0 | 0 | 0 |
| *Ae. (Finlaya) notoscriptus* | Female | 96 | 1.45 | 89 | 15 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Bloodfed | 33 | 0.50 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) camptorhynchus* | Female | 2067 | 31.22 | 1931 | 114 | 0 |
| *Ae. (Ochlerotatus) clelandi* | Bloodfed | 1 | <0.1 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) clelandi* | Female | 54 | 0.82 | 49 | 11 | 0 |
| *Ae. (Ochlerotatus) clelandi* striped leg variant | Female | 1 | <0.1 | 0 | 0 | 1 |
| *Ae. (Ochlerotatus) hesperonotius* | Bloodfed | 2 | 0.03 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) hesperonotius* | Female | 261 | 3.94 | 258 | 19 | 1 |
| *Ae. (Ochlerotatus) ratcliffei* | Bloodfed | 1 | <0.1 | 0 | 0 | 0 |
| *Ae. (Ochlerotatus) ratcliffei* | Female | 16 | 0.24 | 16 | 4 | 0 |
| *Ae. (Ochlerotatus) turneri* | Female | 2 | 0.03 | 1 | 1 | 0 |
| *Ae. (Ochlerotatus) vigilax* | Female | 97 | 1.47 | 97 | 12 | 0 |
| *An. (Anopheles) atratipes* | Female | 1 | <0.1 | 1 | 1 | 0 |
| *An. (Cellia) annulipes s.l.* | Female | 361 | 5.45 | 345 | 40 | 0 |
| *An. (Cellia) annulipes s.l.* | Male | 3 | <0.1 | 3 | 3 | 0 |
| *Cq. (Coquillettidia)* species near *linealis* | Female | 6 | <0.1 | 6 | 4 | 0 |
| *Cs. (Culicella) atra* | Female | 40 | 0.60 | 39 | 10 | 0 |
| *Cs. (Culicella) atra* | Male | 1 | <0.1 | 1 | 1 | 0 |
| *Cx. (Culex) annulirostris* | Bloodfed | 2 | <0.1 | 0 | 0 | 0 |
| *Cx. (Culex) annulirostris* | Female | 194 | 2.93 | 189 | 30 | 0 |
| *Cx. (Culex) australicus* | Female | 954 | 14.41 | 872 | 73 | 0 |
| *Cx. (Culex) globocoxitus* | Female | 1934 | 29.21 | 1843 | 117 | 0 |
| *Cx. (Culex) quinquefasciatus* | Female | 57 | 0.86 | 57 | 14 | 0 |
| *Cx.* species (unidentified) - new or difficult to ID species | Male | 87 | 1.30 | 87 | 18 | 0 |
| Unidentifiable Culex sp. (too damaged/features missing) | Female | 11 | <0.1 | 11 | 5 | 0 |
| **Total** | | **6621** | **100** | **6215** | **536** | **2** |

## MVE virus and $WNV_{KUN}$ Surveillance

In WA, the DoH monitors flaviviruses in the northern two-thirds of the State via a sentinel chicken program and an annual mosquito collections and virus detections. The aim of these programs is to provide an early warning system for the detection of MVEV and $WNV_{KUN}$ activity to initiate proactive media campaigns when virus is detected to alert the public to take appropriate precautions against mosquito bites and alert LGs to undertake appropriate treatments for vector control.

### Sentinel Chicken Surveillance Program

Murray Valley encephalitis virus (MVEV) and $WNV_{KUN}$ are maintained in a bird – mosquito – bird cycle in northern WA. The Department of Health manages a sentinel chicken flavivirus surveillance program, which provides an early warning for MVEV and $WNV_{KUN}$ activity across the northern two-thirds of WA.

Chickens are bled by trained environmental health officers or volunteers and the blood samples are sent to PathWest to be tested for antibodies to the viruses. When antibodies to MVEV 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 2015/16, 28 sentinel chicken flocks were located in major towns and communities in the Kimberley, Pilbara, Gascoyne, Midwest, Wheatbelt and Goldfields regions of WA (Figure 25).

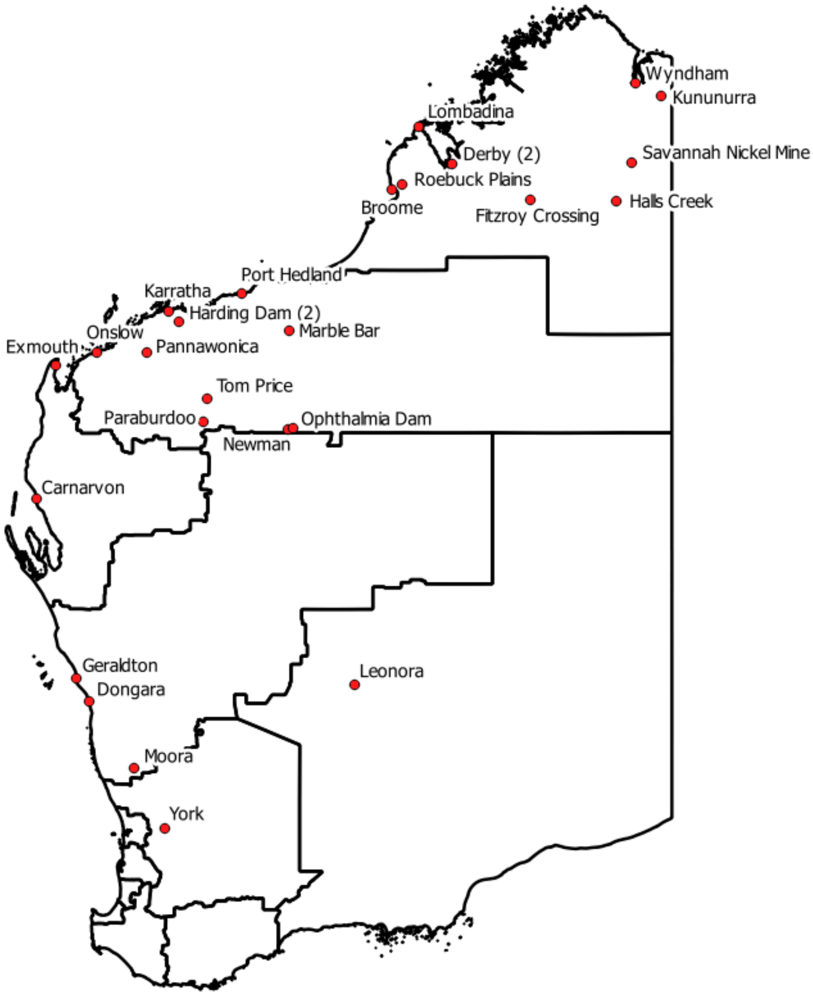



**Figure 25**: Locations of the sentinel chicken flocks in WA.

The level of flavivirus activity in sentinel chickens in northern WA in 2015/16 was moderate, with the Kimberley region experiencing the most activity (Table 8). Seroconversions were detected in 34 of the 3,998 samples tested (0.85%). This is comparable to 2014/15, but still relatively low compared to historical data.

**Table 8:** Number of sentinel chickens that developed antibody to flaviviruses during 2015/16. *Where MVEV = Murray Valley encephalitis virus; $WNV_{KUN}$ = West Nile virus (Kunjin strain).

| Regions | Town/Site | Virus* | Number of chickens flavivirus positive | Month(s) positive |
|---|---|---|---|---|
| Kimberley | **Kununurra** | MVEV | 3 | March - April 2016 |
| | | $WNV_{KUN}$ | 1 | April 2016 |
| | | MVEV+ $WNV_{KUN}$ | 1 | March - April 2016 |
| | **Halls Creek** | MVEV | 2 | March - April 2016 |
| | | $WNV_{KUN}$ | 2 | April 2016 |
| | | Undetermined Flavivirus | 1 | June 2016 |
| | **Wyndham** | MVEV | 2 | March – April 2016 |
| | | $WNV_{KUN}$ | 5 | March – April 2016 |
| | | Undetermined Flavivirus | 2 | April - June 2016 |
| | **Fitzroy Crossing** | $WNV_{KUN}$ | 3 | May - June 2016 |
| **Pilbara** | **Pannawonica** | $WNV_{KUN}$ | 1 | June 2016 |
| | **Ophthalmia Dam** | $WNV_{KUN}$ | 10 | March - May 2016 |
| | | Undetermined Flavivirus | 1 | April 2016 |

## Northern Mosquito Surveillance

During 2015/16, mosquito collection was conducted in the Kimberley regions of WA between 15th March to 15th April 2016.The trap sites were selected based on historical data of mosquito abundance, virus detection, proximity to sentinel chickens and proximity to mosquito breeding habitats. Traps were set in the following locations:

- Fitzroy Crossing
- Halls Creek
- Billiluna
- Kununurra
- Parry's Creek
- Derby
- Broome
- Willie Creek
- Roebuck Plains
- Lombadina
- Wyndham

The mosquitoes were collected in dry ice baited EVS $CO_2$ (encephalitis vector surveillance) traps. The traps were set at or before sunset and retrieved close to sunrise the following morning. The mosquitoes were then frozen on dry ice and transported to Perth.

The mosquitoes will be identified to species level in the laboratory and tested for arboviruses. Four specific arboviruses of public health significance are detected from mosquitoes including RRV, BFV, MVE virus and $WNV_{KUN}$. Additionally, reaction to monoclonal antibodies allows detection of a range of additional alpha and flaviviruses that may or may not cause illnesses in humans.

# Aerial Larviciding Program Across the Southwest of WA

The DoH funds the use of a helicopter for aerial application of mosquito larvicide in high mosquito-borne disease risk areas in the southwest of 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 DoH when a treatment is required.

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

A total of 25 aerial larvicide treatments covering over 2,500 hectares were undertaken during the 2015/16 financial year (Table 9).

**Table 9:** Number of aerial treatments and area treated by region during 2015/16.

| Regions | Treatments | Area treated (ha) |
|---|---|---|
| **Geographe** | 10 | 1701.6 |
| **Leschenault** | 6 | 108 |
| **Peel** | 9 | 737 |
| **Total** | **25** | **2546.0** |

The most commonly used larvicides were granulated forms of S-methoprene and *Bacillus thuringiensis israelensis* (Bti).This is the third 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 during spring in early summer.

# Exotic Mosquito Detections at Perth International Airport

The exotic mosquito surveillance program employed by the Commonwealth Department of Agriculture and Water Resources (DAWR) Science Support Program detected several importations of exotic mosquito species at the Perth International Airport between December 2015 and February 2016. The DOH 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 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 DoH

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, wheelie bins to collect water from leaking 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 become established.

# Medical Entomology Funding for Mosquito Management

## Contiguous Local Authorities Group (CLAG) Funding Scheme

Contiguous Local Authorities Groups are comprised of one or more (contiguous) Local Governments (LGs) 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 LGs and the DoH to share knowledge, experience and logistics to achieve enhanced mosquito management programs.

There were 14 active CLAGs in WA during 2015/16:

- Ashburton (Shire of Ashburton);
- Broome (Shire of Broome);
- Carnarvon (Shire of Carnarvon);
- Derby-West Kimberley (Shire of Derby-West Kimberley);
- East Pilbara (Shire of East Pilbara)
- 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);
- Peel (Cities of Mandurah and Rockingham and Shires of Murray and Waroona);
- Port Hedland (Town of Port Hedland);
- Roebourne (City of Karratha);
- Swan-Canning Rivers (Primary members - City of South Perth, City of Canning, City of Melville and City of Perth; Secondary members – City of Nedlands, City of Subiaco); and
- Wyndham/East Kimberley (Shire of Wyndham East Kimberley).

Department of Health provided funding to the amount of $250,801.65 to the CLAGs to assist with mosquito control in 2015/16. 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 2013/14 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 ($300,000), research grants ($155,000) and Capability Building Projects to encourage enhanced mosquito management into the future ($545,000.00).

### 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 2015/16 round, requests from 13 CLAGs were received and reviewed by the Mosquito Control Advisory Committee (MCAC). The MCAC approved budgets totaling $298,963.33. Funding was approved in August 2015 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.

Fourteen applications (totaling $395,755.08) were received and reviewed by a panel comprising of the MCAC and the former WA Chief Scientist (Prof. Lyn Beazley). The review panel supported six applications for funding which were subsequently endorsed by the Director of Environmental Health in July 2015, totaling $153,682.18 (Table 8).

**Table 10:** Successful research grants awarded in July 2015.

| Institution | Project | Grant |
|---|---|---|
| **DoH** | Backyard Breeding in Perth | **$19,850.99** |
| **JCU** | Surveillance using SMACKs and FTA cards | **$37,500.00** |
| **Uni of Sunshine Coast** | Single rapid detection kit for arboviruses | **$39,969.00** |
| **DoH** | Mosquito composition and abundance in City of Swan | **$17,579.00** |
| **DoH** | Risk assessment to reduce mortality in sentinel chickens | **$11,131.00** |
| **DoH** | Temporal and spatial patterns in mosquitoes in the Kimberley | **$32,178.51** |

## FIMMWA Capacity Building Projects

A proportion of FIMMWA funding is set aside each year to building capacity within LGs for the future and to ensure systems that are in place for the management of mosquitoes over the long-term. During the 2015/16 financial year capacity building projects totaling $545,000.00 were implemented or progressed.

**Communications campaign:** *Fight the Bite** is a communication campaign that partners with LG to actively raise awareness of mosquito-borne disease in WA. The campaign was launched by the Minister for Health, Hon. Dr Kim Hames, in the Peel region on 25th September, 2015. A second launch was conducted in Broome on 8th February 2016 to coincide with the peak mosquito season in northern WA. The campaign was intensively piloted by the DoH in these two regions over the 2015/2016 arbovirus season.

A range of *Fight the Bite* resources were developed to support the campaign, including brochures, posters and website material. Following an extensive KAP survey to ascertain the knowledge, attitudes and practices of individuals in relation to mosquitoes and mosquito-borne disease, targeted resources were developed to educate demographic groups considered at higher risk of mosquito exposure. *Fight the Bite* resources focus on providing simple ways for the individual to avoid mosquito exposure at home, on holiday in Australia and on holiday overseas.

The Peel and Broome campaigns actively promoted *Fight the Bite* through a range of media avenues including social media, targeted online advertising, regional newspapers, regional radio, shopalites, train station signage, a direct mail out and billboard advertising. An additional 25 LGs also integrated *Fight the Bite* into their own mosquito management programs during this time. The impact of the campaign will be rigorously evaluated in a follow up survey to determine its efficacy and ascertain whether changes need to be made to further improve the campaign**.**

**Fight the Bite is an initiative of the Government of South Australia. Campaign materials have been reprinted with permission from SA Health.*

**GAIA Health Atlas Launch to LG:** 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 26).

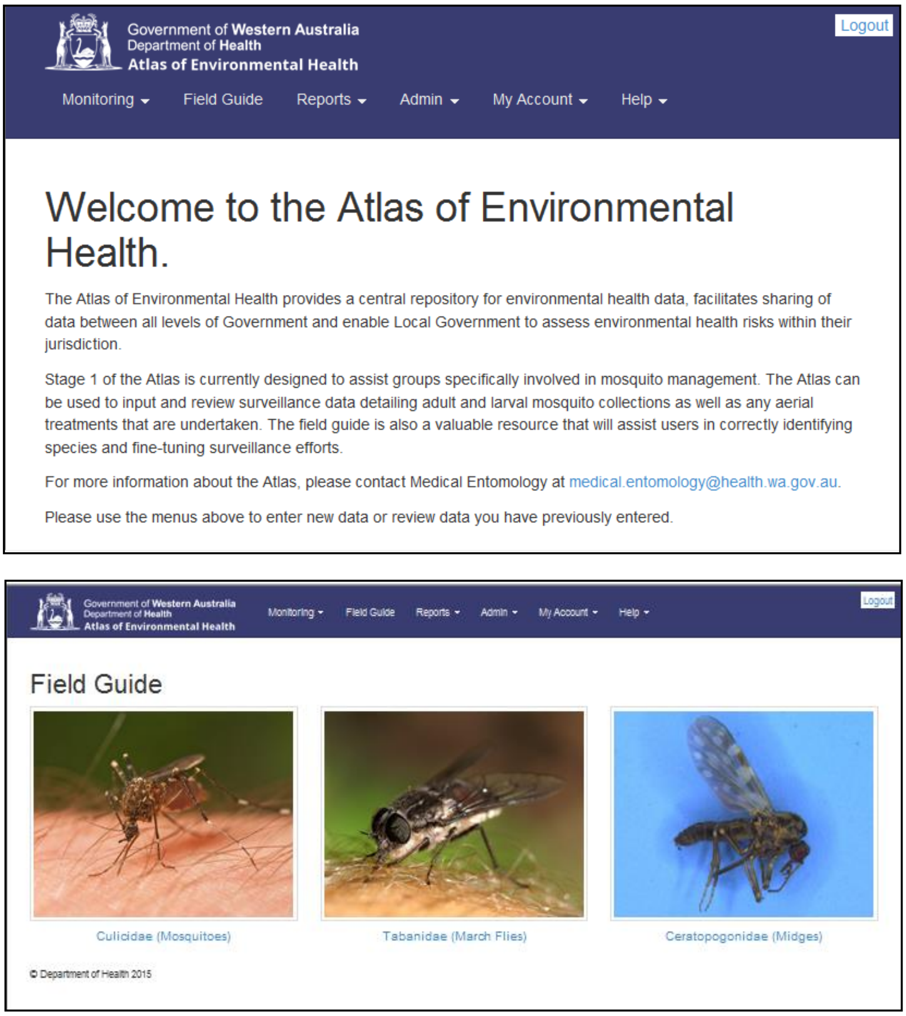



**Figure 26:** Screen snapshot of the newly developed online Environmental Health Atlas.

**Mosquito legislation project:** The *Public Health Act 2016* received Royal Assent on 25 July 2016. The WA Department of Health (DoH) is currently reviewing Health Regulations under the previous *Health Act 1911* to transfer under the new *Public Health Act 2016* or to request the creation of new Regulations for public health topics that are currently not included in legislation.

Mosquito management has not been included directly in existing Health Regulations; the only references are under provisions for the purposes of creating local laws made for preventing the breeding of and the management of mosquitoes and other pests.

The legislation reform process was a unique opportunity for the Department to present a business case to have new Regulations drafted that adequately included biting insects and required specific provisions to enable more effective mosquito management.

A discussion paper was drafted to examine the risks that biting insects present to public health and recommend the most appropriate options to implement management strategies which will reduce the risk. The main objective was to demonstrate that mosquitoes need to be explicitly defined in legislation as a public health risk, to reflect the thousands of locally acquired vector-borne disease cases that are reported in Australia every year.

A working group was formed, consisting of senior local government Environmental Health professionals with experience in mosquito management, to provide input into the discussion paper and guide the development of the business case. Further discussion occurred at CLAG meetings and the annual combined CLAG Forum to gather more comments and input from other Environmental Health Officers, for inclusion in the discussion paper.

The final discussion paper will be circulated through Government agencies and to the public towards the end of 2016, and the process for advocating for mosquito legislation will continue in early 2017.

Four further minor capacity building projects were also progressed:

- Sewerage System Review
- Tide Gauges
- Research Scholarships
- Emergency Management

# DoH Training Workshops

## Five day Mandurah and Three day Albany Mosquito Management Courses

Medical Entomology facilitated two Mosquito Management Courses for Local Government and other mosquito management professionals. The biennial five day live in Mandurah Mosquito Management Course was held from 21 - 25 September 2015 and was attended by 54 Environmental Health Officers, private consultants, military personnel and State Government employees from across Australia and New Zealand. Presenters include experts from the WA DoH; the University of Sydney, the Northern Territory, Local Government mosquito management personnel, and the pest control industry.

A second three day regional short course was hosted by the City of Albany from 24 - 26 February 2016. Eighteen people from the Kimberley, Pilbara, South West, Wheatbelt and Great Southern regions of Western Australia attended the course.

Both courses covered theoretical and practical components of mosquito management and provided participants with the knowledge and skills to implement a mosquito management program in their own jurisdictions.

Lectures were presented on mosquito biology, mosquito-borne diseases, methods of controlling mosquitoes and combining these to develop sustainable, integrated management programs. Participants also gained hands-on experience during practical demonstrations of surveillance and control equipment, field site visits to collect mosquito larvae and adult and laboratory mosquito identification sessions, and group work on specific mosquito management scenarios.

# Appendix 1: Map of WA State regions